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FINAL

REMEDIAL INVESTIGATION REPORT
OPERABLE UNIT NO. 5, SITE 2

MARINE CORPS BASE,
CAMP LEJEUNE, NORTH CAROLINA

CONTRACT TASK ORDER 0174

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LIST OF ACRONYMS AND ABBREVIATIONS

AQUIRE	Aquatic Retrieval Database
ARAR	Applicable or Relevant and Appropriate Requirement
AWQC	Federal Ambient Water Quality Criteria
B	Represents that the value is above the instrument detection limit but is below the contract required quantitation limit
Baker	Baker Environmental, Inc.
BCF	Bioconcentration Factor
BI	Biotic Index
BH	Bear Head Creek
CDI	Chronic Daily Intake
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CLEAN	Comprehensive Long-Term Environmental Action Navy
COC	Contaminant of Concern
COPCs	Contaminants of Potential Concern
CRDL	Contract Required Detection Limit
CTO	Contract Task Order
DEM	NC DEHNR Division of Environmental Management
DoN	U.S. Department of the Navy
DQO	Data Quality Objectives
EPA	United States Environmental Protection Agency
EPIC	USEPA Environmental Photographic Interpretation Center
ER-L	EPA Region IV Sediment Screening Value, Effects-Range-Low
ER-M	EPA Region IV Sediment Screening Value, Effects Range-Median
ERA	Ecological Risk Assessment
ESE	Environmental Science and Engineering, Inc.
FFA	Federal Facilities Agreement
FWS	U.S. Fish and Wildlife Service
H'	Species Diversity Coefficient
HI	Hazard Index
HQW	High Quality Water
IAS	Initial Assessment Study
ICR	Incremental Cancer Risk
IDL	Instrument Detection Limit
IDW	Investigative Derived Wastes
IRIS	Integrated Risk Information System
IRP	Installation Restoration Program
J	Represents that the value is estimated, either for a tentatively identified compound or when a compound is present but the value is below the contract required quantitation limit
JB	Represents that the value is estimated below the contract required detection limit, but greater than the instrument detection limit

K_{oc}	Organic Carbon Partition Coefficient
K_{ow}	Octanol-Water Partition Coefficient
LANTDIV	Atlantic Division
LOAEL	Lowest Observed Adverse Effect Level
MBI	Macroinvertebrate Biotic Index
MCB	Marine Corps Base
MDG	million gallons per day
mg/L	milligrams per liter
mg/kg	milligram per kilogram
msl	mean sea level
NACIP	Navy Assessment and Control of Installation Pollutants
NC DEHNR	North Carolina Department of Environment
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NEESA	Naval Energy and Environmental Support Activity
NOAA	National Oceanic and Atmospheric Administration
NOAEL	No Observed Adverse Effect Level
NPL	National Priorities List
NSCRF	National Study of Chemical Residues in Fish
NWI	National Wetlands Inventory
OU	Operable Unit
PAH	polynuclear aromatic hydrocarbon
PC	Pettiford Creek
PCB	polychlorinated biphenyls
PID	photoionization detector
ppt	parts per thousand
QA/QC	Quality Assurance/Quality Control
QI	Quotient Index
RA	Risk Assessment
RI/FS	Remedial Investigation/Feasibility Study
ROD	Record of Decision
RV	Ravine
SA	Site Assessment
SAP	Sampling and Analysis Plan
SCS	Soil Conservation Service
Sj	Jaccard Similarity Coefficient
SOP	Standard Operating Procedure
SSV	USEPA Region IV Sediment Screening Values
Ss	Sorenson Similarity Coefficient
S.U.	Standard Units
SVOCs	semivolatile organic compounds
SWQSVs	Surface Water Quality Screening Values
TAL	Target Analyte List
TCE	trichloroethene
TCL	Target Compound List

TCLP	Toxicity Characteristic Leaching Procedure
TCRA	Time-Critical Removal Action
TOC	top-of-casing
TPH	Total Petroleum Hydrocarbons
TRC	Technical Review Committee
TRV	Terrestrial Reference Value
µg/g	micrograms per gram
µg/L	micrograms per liter
µg/kg	micrograms per kilogram
USGS	United States Geological Service
UST	underground storage tank
VOCs	volatile organic compounds
Weston	Weston Geophysical Corporation
WC	Wallace Creek
WQS	North Carolina Water Quality Standards
WQSV	EPA Region IV Water Quality Screening Values

EXECUTIVE SUMMARY

This report describes the Remedial Investigation (RI) conducted at Operable Unit No. 5 which is comprised of Site 2, Former Nursery/Day Care Center. Site 2 is located at the intersection of Holcomb Boulevard and Brewster Boulevard in the northeast portion of Marine Corps Base (MCB), Camp Lejeune, North Carolina. The purpose of this RI is to evaluate the nature and extent of the threat to public health, welfare or the environment caused by the release or threatened release of hazardous substances, pollutants, or contaminants. The RI serves as the basis for the baseline risk assessment (RA) and provides information in support of the Feasibility Study (FS) and Record of Decision (ROD).

This RI was accomplished by sampling soil, groundwater, sediment, and surface water at Site 2, evaluating the analytical data, and performing a human health and ecological RA. This RI report contains the results of the field investigations and the human health and ecological RA.

Site Description

Site 2 is located at the intersection of Holcomb and Brewster Boulevards. The site is bisected by the Camp Lejeune Railroad tracks. Drainage ditches parallel the railroad tracks.

Only limited information is available on the former storage, handling, and dispensing activities conducted at this site. Based on the existing analytical database, soil, groundwater, surface water and sediment have been impacted by pesticides, volatile organics, semivolatile organics, and inorganic contaminants. Two areas of concern have been identified: the Building 712 Area (which includes the Lawn and Mixing Pad Areas) and the Former Storage Area. The two areas may be unrelated with respect to past waste handling activities. The Building 712 Area has documented usage of pesticides and herbicides. With respect to the Former Storage Area across the railroad tracks from Building 712, there is no information available to determine what kinds of waste handling activities occurred.

Remedial Investigation Field Activities

The majority of the RI field investigative activities at Site 2 were conducted during the period April - May 1993. Activities conducted during the field program consisted of a geophysical survey investigation; preliminary site survey; a soil investigation including drilling and sampling; a groundwater investigation including monitoring well installation, development and sampling; and a surface water and sediment investigation. Two additional monitoring wells were installed on site in February 1994. Groundwater samples were collected from these wells and the other on-site wells in March 1994. All field activities were conducted in Level D personal protection and in accordance with EPA Region IV field protocols.

The site is characterized by the following physical features. It has relatively flat topography. It is underlain by unconsolidated deposits of sand, silt, and clay. Groundwater was encountered approximately 6 feet below the surface. The water table is relatively flat (hydraulic gradient is 0.005 feet/feet). Shallow groundwater flow is to the northeast. Shallow groundwater is reportedly interconnected with the underlying Castle Hayne Aquifer.

Analytical Results

Based on the analytical data obtained during the RI, the following environmental media at Site 2 have been impacted by former site operation activities:

- Soil in the vicinity of the former mixing pads has been impacted by pesticide contamination. Detected pesticides include 4,4'-DDD, 4,4'-DDE, 4,4'-DDT, dieldrin, heptachlor, alpha-chlordane, and gamma-chlordane. Concentrations of these contaminants range from less than 10 µg/kg to 3,000,000 µg/kg. Soil in this area has also been impacted by semivolatile organic compound (SVOC) contamination. The majority of these contaminants are polycyclic aromatic hydrocarbons (PAHs). The maximum SVOC concentration detected in 14,000 µg/kg.

- Pesticide contamination (DDD, DDE, DDT) was detected in low concentrations (less than 10 µg/kg) throughout the remainder of Site 2. These concentrations are similar to base-specific background levels and are several orders-of-magnitude lower than pesticide contaminant concentrations detected in the vicinity of the former mixing pads.

- Shallow groundwater in the Former Storage Area has been impacted by volatile organic compound (VOC) contamination. Ethylbenzene (2 - 190 µg/L) and total xylenes (1 - 1,800 µg/L) were detected in groundwater samples collected from shallow monitoring wells in the Former Storage Area. The area of highest VOC concentration is at monitoring well 2GW3. VOCs have been detected in this monitoring well during previous investigations. The extent of VOC contamination appears to be limited to the vicinity of the Former Storage Area. Results of a second round of groundwater sampling confirmed this.

- Semivolatile organic compound (SVOC) contamination has also been detected in shallow groundwater at Site 2. These include low concentrations of naphthalene (3 - 15 µg/L), 2-methylnaphthalene (3 - 17 µg/L), 2,4-dimethylphenol (6J µg/L) and acenaphthene (2J µg/L). The area of highest SVOC concentration is within the Former Storage Area (monitoring well 2GW3).

- Trichloroethene (TCE) was detected at a low concentration (5 µg/L) in deep monitoring well 2GW3D. During the initial sampling event TCE was not detected in any of the shallow wells. TCE was not detected in this well during the second round of sampling.

- Sediment in the Railroad Track Drainage Ditch Area has been impacted by pesticide contamination. These contaminants include 4,4'-DDD, 4,4'-DDE, 4,4'-DDT, alpha-chlordane, and gamma-chlordane. The maximum concentrations of pesticide contamination (up to 250,000 µg/kg) are present in the immediate vicinity (i.e., adjacent to) of the former mixing pads. PAHs were also detected in low concentrations (less than 200 µg/kg) in sediment from this area.

- Trace levels (less than 3 µg/L) of pesticides (4,4'-DDD and 4,4'-DDT) were detected in surface water samples collected in the Railroad Track Drainage Ditches. Carbon disulfide, a volatile organic compound was detected (7 µg/L) in surface water from an upstream sampling station in Overs Creek. Copper was also detected (7 µg/L) above applicable (FWQSV, NCWQC, and AWQC) standards in Overs Creek.

Time-Critical Removal Action

The laboratory analytical data generated during this RI indicate the presence of elevated concentrations of pesticides in soil and sediment near the former washing/mixing pads. Pesticide concentrations in several samples in this area exceed the benchmark risk-based concentrations prepared by USEPA Region III (January 28, 1993). The benchmark risk-based concentration is a cleanup action level that equates to a 1 x 10^{-6} risk level. Site-specific cleanup action levels have been developed for individual contaminants (these are presented in the FS report). The pesticide concentrations were evaluated with respect to Removal Action Criteria outlined in the National Oil and Hazardous Substances Pollution Contingency Plan

(NCP). The NCP lists a number of criteria that are considered in determining the appropriateness of a removal action. Section 300.415 paragraph (b)(2)(i) directly applies to the conditions at Site 2.

300.415(b)(2)(i)	"Actual or potential exposure to nearby human populations, animals, or the food chain from hazardous substances or pollutants or contaminants."

The presence of pesticide contaminants in this area may pose an imminent and substantial endangerment to public health, or welfare, or the environment.

The Department of the Navy (DoN) is currently undertaking a Time-Critical Removal Action (TCRA) for this highly contaminated material. The proposed TCRA has impacted the RI reports as follows:

- The human health and ecological risk assessments have been conducted under two different scenarios. Under the first scenario, all of the laboratory data generated during the RI has been evaluated with the assumption that no TCRA will be implemented. The second scenario risk assessment does not include results of samples collected in the area affected by the proposed TCRA. The second scenario risk assessment has been conducted as though the highly contaminated material did not exist since this soil will be removed.

Migration and Exposure Pathways

Based on the evaluation of existing conditions at Site 2 the following potential contaminant transport pathways have been identified:

- On-site atmospheric deposition of windblown dust
- Surface soil runoff from the pesticide mixing/wash pads to the drainage ditches
- Surface soil runoff from the Building 712 area to the drainage ditches
- Surface soil runoff from the Former Storage Area to the drainage ditches
- Sediment migration in the drainage ditch and Overs Creek
- Leaching of sediment contaminants to surface water
- Migration of contaminants in surface water
- Leaching of contaminants in the concrete mixing pads to the soil
- Leaching of soil contaminants to groundwater

- Migration of groundwater contaminants off site
- Groundwater infiltration from the shallow aquifer to the deep aquifer

Risk Assessment

The receptors evaluated for the baseline RA assessment included current exposure scenarios for civilian base personnel, and future exposure scenarios for construction workers, and resident children and adults for both the Lawn and Mixing Pad Areas and the Former Storage Area. Soil, groundwater, surface water, and sediment were quantitatively evaluated. Note that a "future residential scenario" has been evaluated in the RA in accordance with EPA Region IV guidelines; however, future land use of this area is nonresidential based on the five-year Master Plan for MCB, Camp Lejeune.

Under the first RA scenario (before the TCRA), the total site risk in the Lawn and Mixing Pad Areas exceeded the target Incremental Cancer Risk (ICR) range of 1E-6 to 1E-4 for the residential child (2E-3) and adult (2E-3). The ICR for the civilian base personnel (1E-4) fell within the acceptable target risk range, and the ICR for the adult construction worker (6E-7) fell below the acceptable risk range. In addition, the Hazard Index (HI) exceeded unity (1.0) for all receptors except the adult constructiuon worker (0.1). The majority of the carcinogenic and noncarcinogenic risks were due to the ingestion of and the dermal contact with pesticide contaminated soil.. The results of the human health risk assessment under Scenario No. 1 indicate that the pesticide contaminated surface soil and sediment at the Lawn and Mixing Pad Areas, before the TCRA, have the potential to present the greatest adverse human health risks from all media evaluated at Site 2. ES-1 presents the ICRs and HIs for all areas quantitatively evaluated.

The second RA scenario (after the proposed TCRA) indicated that the risks calculated for the civilian base personnel and the construction worker decreased considerably after the proposed removal action. The civilian base personnel and adult construction worker were not quantitatively evaluated for groundwater ingestion and so the decrease in risks were directly influenced by the removal action of the soil and sediment in the Lawn and Mixing Pad Areas. In addition, the risks to the future child and adult receptors also were considerably reduced from soil and sediment exposure after the proposed removal action. However, unacceptable risk levels to the future child and adult initially were also influenced due to the exposure to groundwater. After the proposed TCRA, exposure to groundwater was the driving force behind the unacceptable risk levels that were calculated for these receptors in the Lawn and

TABLE ES-1

TOTAL SITE INCREMENTAL LIFETIME CANCER RISK AND HAZARD INDICES
OPERABLE UNIT NO. 5 - SITE 2
REMEDIAL INVESTIGATION - CTO-0174
MCB CAMP LEJEUNE, NORTH CAROLINA

Receptors	Lawn and Mixing Pad Areas		Lawn and Mixing Pad Areas - Time Critical Removal Action		Former Storage Area		Former Storage Area - Time Critical Removal Action		Overs Creek	
	ICR	HI	ICR	HI	ICR	HI	ICR	HI	ICR	HI
Civilian Base Personnel	1E-4	1.3	5E-7	0.008	3E-7	0.004	3E-8	3E-4	--	--
Construction Worker	6E-7	0.1	1E-10	6E-5	4E-8	.005	4E-8	.005	--	--
Child Resident	2E-3	111	3E-4	11	3E-4	12	3E-4	11	--	--
Adult Resident	2E-3	23	7E-4	5	7E-4	5	7E-4	5	--	--
Trespassing Child	--	--	--	--	--	--	--	--	1E-7	1E-3
Trespassing Adult	--	--	--	--	--	--	--	--	9E-8	3E-4

Notes: ICR = Incremental Lifetime Cancer Risk
HI = Hazard Index

Shading indicates that risk level is not within or fell above acceptable levels.

Mixing Pad Area. The elevated HI (i.e., greater than unity) was due to the direct ingestion of contaminated shallow groundwater, with arsenic, barium, and 4,4'-DDT driving the noncarcinogenic risks, and 4,4'-DDT and ethylbenzene driving the groundwater noncarcinogenic dermal contact risks. Arsenic and beryllium accounted for the increase of carcinogenic risks due to groundwater ingestion..

The Former Storage Area was evaluated separately from the Lawn and Mixing Pad Areas due to different contaminant concerns and land usage. The total site risks for this area included the risks from the soil and groundwater only. Before initiation of the proposed TCRA (i.e., RA Scenario No. 1), the civilian base personnel and construction worker risks fell below the acceptable target risk range (1E-6 to 1E-4), and the HIs for these two receptors fell below unity. The total ICR for the resident child (3E-4) and adult (7E-4) fell above the acceptable target risk range (1E-6 to 1E-4). The HIs for these two receptors exceeded unity, 12 and 5 for children and adults, respectively. The elevated HIs (i.e., greater than 1.0) were mainly due to the dermal contact of and the direct ingestion of shallow groundwater contaminated with inorganics and pesticides. After the proposed TCRA in the Former Storage Area (i.e., RA Scenario No. 2) the risks to the civilian base personnel and the construction worker slightly decreased. These receptors were not quantitatively evaluated for groundwater ingestion and so the decrease in risks were directly influenced by the removal action of the soil in the FSA. However, the risks to the future child and adult receptors remained relatively the same after the proposed removal action, since the unacceptable risk levels to these receptors were initially due to the exposure to groundwater and less so to the soil in the FSA. The HIs for both receptors still exceeded unity, 11 for the child and 5 for the adult.

Currently there are no receptors who are exposed to the shallow groundwater in this area. All groundwater used at MCB, Camp Lejeune is supplied by the deeper Castle Hayne aquifer from uncontaminated supply wells. Future development of the shallow aquifer for potable use is unlikely because of the general poor water quality in the shallow zone, poor flow rates, and the unlikely future development of the site for residential housing. The potential risk that could be due to groundwater exposure at this site was evaluated as a conservative estimation of exposure.

The results of the sampling at Overs Creek indicate that contamination from Site 2 is not appreciably migrating to the creek, and that adverse human health risks are not expected to occur due to contamination at Overs Creek.

Conclusions

Based on the results of the various environmental investigations at Site 2 and the baseline RA, the following conclusions were developed:

- The soil and sediment in the Mixing Pad Area are contaminated with elevated levels of pesticides and SVOCs that may be associated with former site operation activities. Releases to the environment from mixing of pesticides and from petroleum-based solvents that were used to mix herbicides and operate and clean pesticide/herbicide spraying equipment is likely the source of this contamination.

- Soil, sediment and surface water throughout the site appear to have been impacted by the former practice of general base-wide spraying of pesticides. Generally, pesticide concentrations in the Lawn Area and in the Former Storage Area environmental media are similar to base-specific background levels and are several orders of magnitude less than the pesticide concentrations in the Mixing Pad Area.

- The environmental media in the Lawn Area has not been impacted by site operation activities.

- Carbon disulfide was detected (7 µg/L) in surface water in an upstream sampling station in Overs Creek. Carbon disulfide was not detected in the soil or sediment samples collected within the boundaries of Site 2. There is no record of its use on site. It is doubtful that the presence of carbon disulfide is due to site activities.

- Shallow groundwater in the Former Storage Area has been impacted by VOC contamination. Ethylbenzene and xylenes (total) have been detected in three monitoring wells in this area. The highest level of VOC contamination was detected in a groundwater sample collected from monitoring well 2GW3. VOCs were detected in this well during previous investigations. The extent of VOC contamination appears to be limited to the vicinity of the Former Storage Area. Low levels of SVOC have been detected in this area. The second round of groundwater sampling confirmed this.

- The source of shallow groundwater VOC contamination is undetermined. Similar contaminants were detected at low concentrations (8 µg/kg maximum) in a soil sample collected in the vicinity of monitoring well 2GW3, indicating a surface or near surface source may have been present in this area.

- TCE was detected in a low concentration (5 µg/L) in deep monitoring well 2GW3D during the initial groundwater sampling. There is no evidence (documentation, soil samples, shallow groundwater samples) to indicate that the presence of TCE is related to operation activities at Site 2. TCE and other chlorinated hydrocarbons have been detected in deep groundwater in other parts of MCB Camp Lejeune. TCE was not detected during the second round of sampling.

- A TCRA is currently being planned for the pesticide contaminated soil and sediment in the Mixing Pad Area and Former Storage Area. The human health and ecological risk assessment were each conducted under two scenarios: (1) a TCRA will not take place; and (2) a TCRA will take place. The results of the human health risk assessment indicate that the overall carcinogenic health risk to civilian at Site 2 ranges from 1E-4 in the Lawn and Mixing Pad Areas, to 3E-7 in the Former Storage Area. However, when the analytical results are evaluated under the second scenario, the risk was estimated to range 3E-7 in the Lawn and Mixing Pad Area, to 3E-8 in the Former Storage Area. In addition, after the TCRA, overall systemic health risks to civilian base personnel were estimated at levels below a HI of 1.0 in the Lawn and Mixing Pad Areas, which indicates that systemic health are not likely. The HIs for the Former Storage Area fell below 1.0 before the TCRA.

- The results of the ecological risk assessment indicate the following:
  - Pesticides in sediments along the drainage ditch and Overs Creek results in a potential decrease in the viability of aquatic receptors under both RA scenarios.
  - Pesticides in the soil in the Mixing Pad Area results in a potential decrease in the viability of terrestrial receptors under the no TCRA scenario. Under the TCRA scenario, there is no decrease in the viability of terrestrial receptors.
  - There is no decrease in viability of aquatic or terrestrial receptors in the Former Storage Area under either RA scenario.

Recommendations

Based on the results of the various environmental investigations at Site 2, the following recommendations were developed.

1. A TCRA should be conducted on the pesticide contaminated soil and sediment in the Mixing Pad Area. The concrete pads should also be removed.

2. Until the TCRA takes place, access to the Mixing Pad Area should be restricted.

3. The general vicinity of Site 2 has been proposed to be a groundwater preservation area for consideration as a potential water supply well field site (Geophex, 1991; page 32). This should be reevaluated in light of the results of the RI, particularly the analytical results from deep monitoring well 2GW3D.

1.0 INTRODUCTION

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

The Fiscal Year 1994 Site Management Plan for MCB Camp Lejeune, a primary document identified in the FFA, identifies 27 sites requiring Remedial Investigation/Feasibility Study (RI/FS) activities. These 27 sites have been divided into 13 operable units to simplify proceeding with RI/FS activities. This report describes the RI conducted at Operable Unit (OU) No. 5 which is comprised of Site 2, Former Nursery/Day Care Center.

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

This was accomplished by sampling environmental media (soil, groundwater, sediment, and surface water) at Site 2, evaluating the analytical data, and performing a human health and ecological RA. This RI report contains the results of all field investigations and the human health and ecological RA.

Site 2 is located at the intersection of Holcomb Boulevard and Brewster Boulevard in the northeast portion of MCB Camp Lejeune (Figure 1-1). Detailed site background and site history descriptions follow in Section 1.2 of this RI Report.

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

1.1 Operable Unit Description

Operable units are formed as an incremental step toward addressing individual site problems. There are currently 27 Installation Restoration Program (IRP) sites on MCB Camp Lejeune which have been grouped into 13 operable units to simplify the specific problems associated with a site or a group of sites. Figure 1-2 shows all of the operable units on MCB Camp Lejeune. OU No. 5 is comprised of Site 2. Because of the specific characteristics of the waste disposed of at the site and its geographical location, Site 2 is the only site comprising OU No. 5.

1.2 Site Background

This section provides a description of Site 2 and its specific areas of concern as well as the history of the site.

1.2.1 Site Description

Site 2 (Figure 1-3) can be divided into two general areas:

- Building 712 Area (includes Lawn and Mixing Pad Area)
- Former Storage Area

Although the Building 712 Area was used for the storage, handling, and dispensing of pesticides, there is no indication that the Former Storage Area actually had pesticides stored on it. Historical aerial photographs indicate that the Former Storage Area was used to store bulk material. The operational histories of the Former Storage Area and the Building 712 Area may be unrelated.

The land at Site 2 is primarily flat, but dips sharply at the drainage ditches which run parallel to the Lejeune Railroad. There is a drainage ditch on both the east and west side of the railroad tracks. Drainage along the eastern edge of the Building 712 area is toward these drainage ditches which runs in a north-northwest direction toward Overs Creek. Drainage along the western edge of the Former Storage Area is also toward these drainage ditches.

Another drainage ditch extends westward from the Building 712 area, underneath Holcomb Boulevard.

1.2.2 Site History

From 1945 to 1958 Building 712 was used for the storing, handling, and dispensing of pesticides. Building 712 was later used as a children's day care center. Chemicals known to have been used include chlordane, DDT, diazinon, and 2,4-D. Chemicals known to have been stored on-site include dieldrin, lindane, malathion, silvex, and 2,4,5-T. Areas of suspected contamination are the mixing pad, the wash pad, and railroad drainage ditches. Aboveground horizontal storage tanks were detected near the mixing pad area in a 1952 aerial photograph included in the Environmental Photographic Interpretation Center (EPIC) Study (USEPA, 1992). Contamination is believed to have occurred as a result of small spills, washout and excess product disposal. During the years of operation, it is reasonable to assume several gallons per year were involved; therefore, estimated quantity involved is on the order of 100 to 500 gallons of liquids containing various concentrations of product. Solid residues in cracks and crevasses may total 1 to 5 pounds. Disposal to Overs Creek is undocumented (Water and Air Research, 1983).

The following items, within the Former Storage Area, were identified in aerial photographs included in the EPIC Study:

- A railroad siding, extending from the main line into the Former Storage Area.
- A crane, possibly located on the railroad siding, that was apparently used to unload materials from railroad cars.
- An area of possibly stained surface soil, present along the eastern border of this area.

1.3 Previous Investigations

In response to the passage of CERCLA in 1980, the DoN initiated the Navy Assessment and Control of Installation Pollutants (NACIP) program to identify, investigate, and clean up past hazardous waste disposal sites at Navy installations. The NACIP investigations were conducted by the Navy Energy and Environmental Support Activity (NEESA) and consisted of Initial Assessment Studies (IAS) and Confirmation Studies. Initial Studies are similar to the

USEPA's Preliminary Assessments/Site Investigations (PA/SI). Confirmation studies are similar to EPA's RI/FS. When the Superfund Amendment and Reauthorization Act (SARA) was passed in 1986, the DoN dissolved the NACIP in favor of the IRP, which adopted EPA Superfund terminology and procedures (ESE, 1991).

The IAS was conducted by Water and Air Research, Inc., in 1983. The IAS identified a number of sites at MCB Camp Lejeune as potential sources of contamination, including Site 2. As a result of this study, Environmental Science and Engineering, Inc. (ESE) was contracted by LANTDIV to investigate these sites. Since then, Baker Environmental, Inc. (Baker) was contracted in 1991 under DoN's Comprehensive Long-Term Environmental Action Navy (CLEAN) Program to continue RI/FS activities.

The initial ESE investigation, referred to as a Confirmation Study, focused on those areas identified in the IAS. The Confirmation Study is divided into two investigation steps: the Verification Step and the Characterization Step. A final investigation, referred to as a Supplemental Characterization, was added to collect additional information to complete a Site Assessment (SA). These investigations are summarized in this section. Additional information can be obtained from Site Assessment Report for Site 2, Site Summary Report Final (ESE, 1990).

1.3.1 Soil Investigation

In August of 1984, as part of the Verification Step, ESE hand augured three soil borings. Exact soil sampling locations are unknown. Three composite soil samples [0-1'(A), 1-2'(B), 2-3'(C)] were collected from each boring and analyzed for organochlorine pesticides and herbicides. Only these contaminants were analyzed for since only pesticides and herbicides were reportedly stored at Site 2.

In November 1986, ESE collected four soil samples. These samples were analyzed for 4,4'-DDD; 4,4'-DDE; 4,4'-DDT; 2,4-D; and 2,4,5-T. The analytical results indicate that 4,4'-DDD was detected in two samples (2SO-8 and 2SO-9) and 4,4'-DDE and 4,4'-DDT were detected in three samples (2SO-7, 2SO-8, and 2SO-9). The analytical findings (see Table 1-1) indicate that 2,4-D was detected in three samples (2SO-6, 2SO-7, and 2SO-8), and 2,4,5-T was not detected in any of the four soil samples. The maximum detected concentration for each contaminant was: 4,4'-DDD (1,320 µg/kg); 4,4'-DDE (1,380 µg/kg); 4,4'-DDT (147,000 µg/kg); and 2,4-D (131 µg/kg). No information is available to assess the analytical methods employed

TABLE 1-1

DETECTED TARGET CONTAMINANTS IN THE SOIL AT SITE 2 - REMEDIAL INVESTIGATION CTO-0174 MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Sample ID/Date Sampled			
	2SO-6 11/11/86 (µg/kg)	2SO-7 11/11/86 (µg/kg)	2SO-8 11/11/86 (µg/kg)	2SO-9 11/11/86 (µg/kg)
4,4'-DDD	<11.4	<11.8	11.5	1320
4,4'-DDE	<11.4	50.2	25.9	1380
4,4'-DDT	<17.2	115	87.4	147,000
2,4-D	49.1	48.9	131	<10.1
2,4,5-T	<39.9	<44.3	<44.5	<40.4

Note: There are no NC pesticide soil standards.

Source: ESE, 1990.

or the Quality Assurance/Quality Control (QA/QC) protocols used in the field or laboratory. In addition, no background soil samples were collected to compare with the results.

1.3.2 Groundwater Sampling

As part of the Verification Step conducted in July 1984, five shallow monitoring wells were installed and sampled. In addition, four water supply wells in the vicinity of Site 2 were sampled to characterize the deeper aquifer. These samples were analyzed for organochlorine pesticides and chlorinated herbicides. Trace amounts of 4,4'-DDD (0.029 µg/L); 4,4'-DDE (0.016 µg/L); and 4,4'-DDT (0.15 µg/L) were reported in monitoring well 2GW1. Analytical findings are presented in Table 1-2. No detected compounds were reported for the supply wells (ESE, 1990). Well construction details are presented on Table 1-3.

In December of 1986, a second round of groundwater samples were collected from the five monitoring wells. These samples were analyzed for organochlorine pesticides, chlorinated herbicides, tetrachlorodioxin, and volatile organic compounds. Trace amounts of 4,4'-DDD (0.03 µg/L) were reported in monitoring well 2GW1. Trace amounts of 4,4'-DDD (0.097 µg/L); 4,4'-DDE (0.057 µg/L); and 4,4'-DDT (0.554 µg/L) were reported in monitoring well 2GW3. In addition, ethylbenzene was reported in monitoring well 2GW3 (330 µg/L) above the North Carolina Water Quality Standard (NCWQS) of 29 µg/L. Toluene was reported in monitoring well 2GW3 (12 µg/L) at a concentration below the NCWQS of 1,000 µg/L. Analytical findings are presented in Table 1-2.

In March of 1987, three monitoring wells (2GW2, 2GW3, and 2GW4) were resampled. Samples were analyzed for organochlorine pesticides, chlorinated herbicides, and VOCs. Low levels (0.02 µg/L) of 4,4'-DDE were reported in monitoring well 2GW3. Ethylbenzene (510 µg/L) was reported in monitoring well 2GW3. The level of ethylbenzene reported in monitoring well 2GW3 exceeded the NCWQS of 29 µg/L. Analytical findings are presented in Table 1-2.

1.3.3 Surface Water Sampling

Two surface water samples were collected in December 1986 from the drainage ditch which parallels the railroad tracks along the eastern boundary of the site. The ditch drains in a north-northwest direction toward Overs Creek. The surface water samples were analyzed for organochlorine pesticides, tetrachlorodioxin, and VOCs.

TABLE 1-2

DETECTED TARGET CONTAMINANTS IN THE GROUNDWATER AT SITE 2 - REMEDIAL INVESTIGATION CTO-0174 MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Federal MCLs(1) (μg/L)	North Carolina WQS(2) (μg/L)	Sample ID/Date Sampled							
			2GW1 7/5/84 (μg/L)	2GW1 12/02/86 (μg/L)	2GW2 7/5/84 (μg/L)	2GW2 12/02/86 (μg/L)	2GW2 3/03/87 (μg/L)	2GW3 7/5/84 (μg/L)	2GW3 12/02/86 (μg/L)	2GW3 3/03/87 (μg/L)
4,4'-DDD	NS	NS	0.029	0.03	<0.003	<0.013	<0.012	<0.003	0.097	<0.012
4,4'-DDE	NS	NS	0.016	<0.013	<0.0008	<0.013	<0.012	<0.0008	0.057	0.02
4,4'-DDT	NS	NS	0.15	<0.013	<0.005	<0.013	<0.012	<0.005	0.554	<0.012
Ethylbenzene	700	29	NRQ	<7.2	NRQ	<7.2	<7.2	NRQ	330	510
Toluene	1,000	1,000	NRQ	<6.0	NRQ	<6.0	<6.0	NRQ	12	<60

(1) Federal Maximum Contaminant Levels (MCLs) established under the Safe Drinking Water Act of 1986.

(2) NCWQS - North Carolina Administrative Code, Title 15, NC DEHNR, Subchapter 2L, Section .0202 - Water Quality Standards for Groundwater, August 4, 1989. Class GA Standards.

NRQ = Analysis not requested.

NS = No standard established.

Source: ESE, 1990.

TABLE 1-2 (Continued)

DETECTED TARGET CONTAMINANTS IN THE GROUNDWATER AT SITE 2 - REMEDIAL INVESTIGATION CTO-0174 MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Federal MCLs[(1)] (µg/L)	North Carolina WQS[(2)] (µg/L)	Sample ID/Date Sampled					
			2GW4 7/5/84 (µg/L)	2GW4 12/02/86 (µg/L)	2GW4 3/03/87 (µg/L)	2GW5 7/07/86 (µg/L)	2GW5 12/02/86 (µg/L)	2GW5 3/03/87 (µg/L)
4,4'-DDD	NS	NS	<0.003	<0.013	<0.012	<0.003	<0.013	<0.012
4,4'-DDE	NS	NS	<0.0008	<0.013	<0.012	<0.0008	<0.013	<0.012
4,4'-DDT	NS	NS	<0.005	<0.013	<0.012	<0.005	<0.013	<0.012
Ethylbenzene	700	29	NRQ	<7.2	<7.2	NRQ	<7.2	<7.2
Toluene	1,000	1,000	NRQ	<6.0	<6.0	NRQ	<6.0	<6.0

(1) Federal Maximum Contaminant Levels (MCLs) established under the Safe Drinking Water Act of 1986.

(2) NCWQS - North Carolina Administrative Code, Title 15, NC DEHNR, Subchapter 2L, Section .0202 - Water Quality Standards for Groundwater, August 4, 1989. Class GA Standards.

NRQ = Analysis not requested.

NS = No standard established.

Source: ESE, 1990.

TABLE 1-3

EXISTING MONITORING AND SUPPLY WELL CONSTRUCTION SPECIFICATIONS SITE 2 - REMEDIAL INVESTIGATION CTO-0174 MCB CAMP LEJEUNE, NORTH CAROLINA

Well #	Depth (feet)	Screened Interval(s) (feet)	Well Diameter (inches)
2GW1(1)	25	10-25	2
2GW2(1)	25	10-25	2
2GW3(1)	25	10-25	2
2GW4(1)	25	10-25	2
2GW5(1)	25	10-25	2
616(2)	170	95-115 130-140 160-170	8
645(2)	245	90-100 138-148 230-240	10
646(2)	270	90-100 240-250 255-265	10
647(2)	200	105-115 138-143 175-190	10

Notes:
(1) Existing site monitoring well
(2) Water supply well

Low levels of 4,4'-DDD were reported in the surface water sample 2SW1 (0.742 µg/L) and 2SW2 (0.027 µg/L). Additionally, 4,4'-DDT (0.560 µg/L) was detected in sample 2SW1 at a level greater than the North Carolina Surface Water Standard (NCSWS) of 0.00588 µg/L. Analytical findings are presented in Table 1-4.

1.3.4 Sediment Sampling

In August 1984 two sediment samples (2S4, 2S5) were collected at Site 2. In December of 1986 two sediment samples (2SE1 and 2SE2) were collected from the same locations as the surface water samples.

Sediment samples were analyzed for organochlorine pesticides, chlorinated herbicides, and tetrachlorodioxin. Levels of 4,4'-DDD (0.011 µg/g); 4,4'-DDE (0.056 µg/g); and 4,4'-DDT (0.150 µg/g) were reported in sediment sample 2S4 (1984). Table 1-4 presents the analytical findings for the four sediment samples.

1.3.5 Pre-Investigation Sampling

In July of 1992, Baker collected groundwater samples from three existing monitoring wells (2GW2, 2GW3, and 2GW5) in order to aid in characterizing current site conditions and design of the RI Field programs. Sample collection locations were selected on the basis of attaining site-wide coverage, previous sampling results, and accessibility.

Groundwater samples collected from these wells were analyzed for full Target Compound List (TCL) organics (i.e., VOCs, semivolatile organic compounds [SVOCs], polychlorinated biphenyls [PCBs], and pesticides) and for both total and dissolved Target Analyte List (TAL) inorganics using Contract Laboratory Program (CLP) protocols (Level IV Data Quality).

Ethylbenzene (190 µg/L) and total xylenes (1,800 µg/L) were detected in monitoring well 2GW3. Prior investigations also detected ethylbenzene and toluene in this well. The concentration of ethylbenzene and total xylenes exceeds the NCWQS of 29 µg/L and 400 µg/L, respectively. Low levels of SVOCs including 2,4-dimethylphenol (10 µg/L), 2-methylnaphthalene (15 µg/L), and naphthalene (24 µg/L) were also detected in monitoring well 2GW3. Low levels of total xylenes (5 µg/L) were also detected in monitoring well 2GW2.

TABLE 1-4

DETECTED TARGET CONTAMINANTS IN THE SURFACE WATER AND SEDIMENTS AT SITE 2 - REMEDIAL INVESTIGATION CTO-0174 MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Ambient Water Quality Criteria(1) (µg/L)	North Carolina SWS(2) (µg/L)	Sample ID/Date Sampled					
			Surface Water		Sediment			
			2SW1 12/02/86 (µg/L)	2SW2 12/02/86 (µg/L)	2S4 08/03/84 (µg/g)	2S5 08/03/84 (µg/g)	2SE1 12/02/86 (µg/g)	2SE2 12/02/86 (µg/g)
4,4'-DDD	NS	NS	0.742	0.027	0.011	<0.0007	4.16	1.570
4,4'-DDE	NS	NS	NR	NR	0.056	<0.0003	0.805	0.861
4,4'-DDT	0.001	0.001	0.560	<0.013	0.150	<0.0010	3.53	0.168
2,4 -D	NS	NS	NRQ	NRQ	<0.0042	<0.0043	<0.0332	<0.0343
2,4,5-T	NS	NS	NRQ	NRQ	<0.0014	<0.0014	<0.0197	0.024

(1) Ambient Water Quality Criteria pursuant to Clean Water Act (saltwater).

(2) NCSWS - North Carolina Administrative Code, Title 15A, NCAC, Subchapter 2B, Section .0020 - Classification and Water Quality Standards Applicable to Surface Waters of North Carolina. April 1, 1991. Class SW waters.

NS = No standard established
NRQ = Analysis not requested
NR = Not Reported
SW = Surface water samples
SE = Sediment samples (1986)
S = Sediment samples (1984)

Source: ESE, 1990.

Prior to purging and sampling monitoring well 2GW3, a bailer (apparently from a previous investigation) was removed from the well. The bailer contained a considerable amount of silt. The well recharged very slowly during purging with the water produced appearing very turbid. Analytical results for total metals indicated concentrations that were significantly elevated over those expected. The elevated levels of total metals may not correspond with any known site activity. The highest concentrations of total metals were detected in monitoring well 2GW2. The arsenic concentration (711 µg/L) exceeds the NCWQS of 50 µg/L. The cadmium concentration (148 µg/L) exceeds both the Federal MCL (5.0 µg/L) and the NCWQS (5.0 µg/L). The lead concentration (85.4 µg/L) exceeded the Action Level for treatment of 15 µg/L, and the NC WSQ (5.0 µg/L). Analyses conducted using dissolved (filtered) samples showed no contaminants in concentrations above MCLs. The analytical findings are presented in Table 1-5.

A geophysical investigation was conducted at Site 2 in July 1992. The investigation focused on the Former Storage Area. Detailed results of the geophysical investigation are included in Appendix A. The purpose of the investigation was to determine the source of groundwater contamination near monitoring well 2GW3 (e.g., underground storage tank). No subsurface features (tanks, drums) that could serve as sources of groundwater contamination were detected during this investigation.

1.4 Proposed Time-Critical Removal Action

The laboratory analytical data generated during this RI indicate the presence of elevated concentrations of pesticides in soil and sediment near the former mixing pads (see Section 4.2). Pesticide concentrations in several samples in this area exceed the benchmark risk-based concentrations prepared by USEPA Region III (January 28, 1993). The benchmark risk-based concentration is a cleanup action level that equates to a 1 x 10^{-6} risk level. Site specific cleanup levels have been determined for individual contaminants (these are presented in the FS report).

In a July 13, 1993, correspondence to LANTDIV, Baker evaluated the laboratory analytical results with respect to Removal Action Criteria outlined in the National Oil and Hazardous Substances Pollution Contingency Plan (NCP). This correspondence is included in Appendix B of this report.

TABLE 1-5

DETECTED TARGET CONTAMINANTS IN THE GROUNDWATER PRE-INVESTIGATION SAMPLING (BAKER, 1992) AT SITE 2 - REMEDIAL INVESTIGATION CTO-0174 MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Federal MCLs(1) (µg/L)	North Carolina WQS(2) (µg/L)	Sample Identification/Date Sampled		
			2GW2 7/9/92 (µg/L)	2GW3 7/9/92 (µg/L)	2GW5 7/9/92 (µg/L)
Ethylbenzene	700	29	ND	190	ND
Total Xylenes	10,000	400	5	1,800	ND
2,4-Dimethylphenol	NS	NS	ND	10	NA
2-Methylnaphthalene	NS	NS	ND	15	NA
Napthalene	NS	NS	ND	24	NA
Aluminum	NS	NS	149,000/ND(a)	1,120/ND	2,390/1,240
Arsenic	50	NS	711/ND	ND/ND	ND/ND
Barium	2,000	1,000	85/21	28/ND	100/75
Cadium	5.0	5.0	148/ND	ND/ND	ND/ND
Calcium	NS	NS	25,600/24,900	6,880/7,250	20,900/18,000
Chromium	100	50	39/ND	ND/ND	ND/ND
Cobalt	NS	NS	13/ND	8/ND	7/ND
Copper	1,300 (P)	1,000	10/ND	5/ND	ND/9
Iron	NS	300	81,400/169	2,610/1,860	8,310/6,460
Lead	15	15	85.4/ND	ND/1.8	ND/2.3
Magnesium	NS	NS	725/959	921/1,010	4,310/3,860
Manganese	NS	50	ND/ND	9/ND	42/36
Potassium	NS	NS	1,940/3,370	960	2,550/2,350
Sodium	NS	NS	25,300/4,780	5,820/6,300	8,870/7,380
Vanadium	NS	NS	1,550/ND	ND/ND	ND/ND
Zinc	NS	400	252/ND	ND/ND	ND/ND

(1) Federal Maximum Contaminant Levels (MCLs) established under the Safe Drinking Water Act of 1986.

(2) NCWQS - North Carolina Administrative Code, Title 15, N.C. DEHNR, Subchapter 2L, Section .0202 - Water Quality Standards for Groundwater, August 4, 1989. Class GA Standards.

(P) =Proposed
ND =Not Detected at Method Detection Limit
NS = No Standard Established
NA =Not Analyzed
(a) Total/Dissolved metal concentrations.
Source: Baker Environmental, July 1992.

The NCP lists a number of criteria that are considered in determining the appropriateness of a removal action. Section 300.415 paragraph (b)(2)(i) directly applies to the conditions at Site 2.

300.415(b)(2)(i)	"Actual or potential exposure to nearby human populations, animals, or the food chain from hazardous substances or pollutants or contaminants."

The presence of pesticide contaminants in this area may pose an imminent and substantial endangerment to public health, or welfare, or the environment.

Baker has recommended a time critical removal action (TCRA) for this highly contaminated material. Assuming that it will be implemented, the TCRA would impact the RI and FS reports as follows:

- The human health and ecological RAs will be conducted under two different scenarios. The first scenario RAs will evaluate all of the laboratory data generated during the RI. The second scenario RA will not include results of samples collected in the proposed TCRA area. The second scenario RAs will be conducted as though the highly contaminated material did not exist (it will be removed).

- The FS will be conducted as though the highly contaminated material within the TCRA area did not exist (it will be removed). Remedial alternatives for soil and sediment within the TCRA area will not be evaluated.

1.5 Report Organization

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

- Section 2.0 Study Area Investigation
- Section 3.0 Physical Characteristics of the Study Area
- Section 4.0 Nature and Extent of Contamination
- Section 5.0 Contaminant Fate and Transport
- Section 6.0 Baseline Human Health Risk Assessment
- Section 7.0 Baseline Ecological Risk Assessment
- Section 8.0 Conclusions and Recommendations
- Section 9.0 References

Section 2.0 describes the field sampling activities conducted during the RI at Site 2. This section describes the purpose of the study of individual media, sampling procedures, sampling grids, and sampling locations for all media. Figures are included to show sampling locations. This section also discusses quality control conducted during the sampling.

Section 3.0 addresses the physical features of Site 2. This section discusses the surface features, meteorology, surface water hydrology, geology, soils, hydrogeology, land use and demography, ecology, and identification of water supply wells of the Site 2 area.

Section 4.0 presents the nature and the extent of contamination found at Site 2. This section presents the results of the field sampling activities conducted as part of this RI. The results are presented by media: soil, groundwater, surface water, and sediments. This section also discusses the potential sources of contaminants detected during the sampling activities.

Section 5.0 characterizes the contaminants found at Site 2. This characterization includes: potential routes of contaminant migration, contaminant persistence, and contaminant migration.

Sections 6.0 and 7.0 contain the baseline risk assessments conducted for the site. The baseline human health risk assessment (Section 6.0) contains a human health evaluation and an environmental evaluation. An ecological risk assessment is included in Section 7.0.

Section 8.0 includes the Conclusions and Recommendations. This section summarizes the nature and extent of contamination, contaminant fate and transport, and the RA. In addition, the conclusions address any data limitations and recommended remedial action objectives.

References are included in Section 9.0.

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

2.0 STUDY AREA INVESTIGATION

2.1 Introduction

The field program at Site 2 was initiated to characterize potential environmental impacts and threats to human health resulting from previous site activities.

Only limited information is available on the former storage, handling, and dispensing activities conducted at this site. Based on the existing analytical database, soil, groundwater, surface water and sediment have been impacted by pesticides, volatile organics, semivolatile organics, and inorganic contaminants. Two areas of concern have been identified: the area surrounding Building 712 (including the mixing pads behind the building); and the area across the railroad tracks that was formerly used as a storage area. The two areas may be unrelated with respect to past waste handling activities. The area associated with Building 712 has documented usage of pesticides and herbicides. With respect to the Former Storage Area across the railroad tracks from Building 712, there is no information available to determine what kinds of waste handling activities occurred. However, groundwater at the Former Storage Area is contaminated with ethylbenzene and xylenes.

RI/FS objectives are summarized in Table 2-1.

The majority of the RI field investigative activities at Site 2 were conducted in April - May 1993. Activities conducted during the field program consisted of a geophysical survey investigation; preliminary site survey; a soil investigation including drilling and sampling; a groundwater investigation including monitoring well installation, development and sampling; and a surface water and sediment investigation. All field activities were conducted in Level D personal protection. The following sections discuss these investigative activities, in addition to the decontamination procedures employed and the methods used to handle the investigation derived wastes (IDW) generated during the field program.

2.2 Aerial Photographic Investigation

In August of 1992 an interim aerial photographic investigation report was completed by the USEPA's Environmental Photographic Interpretation Center (EPIC) in Warrenton, Virginia. Under the direction of the Advanced Monitoring Systems Division in Las Vegas, Nevada, EPIC conducted an aerial photographic investigation of OU No.5, Site 2. The investigation

TABLE 2-1

RI/FS OBJECTIVES
SITE 2 - REMEDIAL INVESTIGATION CTO-0174
MCB CAMP LEJEUNE, NORTH CAROLINA

Medium or Area of Concern	RI/FS Objective	Criteria for Meeting Objective	Proposed Investigation/Study
Building 712 and Mixing Pad Areas 1. Soil	1a. Assess the extent of pesticide/herbicide contamination at Building 712 and the mixing pad areas.	Characterize pesticide and herbicide levels in surface and subsurface soils at areas potentially impacted by pesticide/herbicide storage and handling.	Soil Investigation
	1b. Assess human health and ecological risks associated with exposure to surface soils.	Characterize organic and inorganic contaminant levels in surface soils.	Soil Investigation Risk Assessment
	1c. Assess areas of surface soil contamination resulting from site runoff.	Characterize contaminant levels in surface soil at downslope drainage areas.	Soil Investigation
Building 712 and Mixing Pad Areas 2. Groundwater	2a. Assess health risks posed by future usage of the shallow groundwater near Site 2.	Evaluate groundwater quality and compare to ARARs and health based action levels	Groundwater Investigation Risk Assessment
	2b. Assess potential impact to groundwater from contaminated soil or unknown releases.	Characterize on-site groundwater quality Identify possible sources of unknown releases	Groundwater Investigation Soil Gas Survey
	2c. Define hydrogeologic characteristics for fate and transport evaluations and remedial technology evaluation, if required.	Estimate hydrogeologic characteristics of the shallow aquifer (flow direction, transmissivity, permeability).	Groundwater Investigation
Building 712 and Mixing Pad Areas 3. Sediment	3a. Assess human health and ecological risks associated with exposure to contaminated sediments	Characterize nature and extent of sediment contamination in drainage ditches.	Sediment Investigation in Drainage Ditches and Overs Creek. Risk Assessment
	3b. Assess potential ecological impacts posed by contaminated sediments.	Identify whether site-related contaminants have migrated to Overs Creek.	Sediment Investigation
	3c. Determine the extent of sediment contamination for purposes of identifying areas of remediation.	Identify extent of sediment contamination where pesticide levels exceed health based action levels.	Sediment Investigation (Drainage Ditch Along Lejeune Railroad)
Building 712 and Mixing Pad Areas 4. Surface Water	4a. Assess the presence or absence of surface water contamination in drainage ditch along site.	Determine surface water quality along drainage ditch. Identify whether site-related contaminants have migrated to Overs Creek.	Surface Water Investigation

TABLE 2-1 (Continued)

RI/FS OBJECTIVES
SITE 2 - REMEDIAL INVESTIGATION CTO-0174
MCB CAMP LEJEUNE, NORTH CAROLINA

Medium or Area of Concern	RI/FS Objective	Criteria for Meeting Objective	Proposed Investigation/Study
Former Storage Area 1. Soil	1a. Assess potential impacts to soil from past storage activities.	Characterize contaminant levels in surface and subsurface soils at the former storage area.	Soil Investigation
	1b. Assess human health and ecological risks associated with exposure to surface soils.	Characterize contaminant levels in surface and subsurface soils.	Soil Investigation Risk Assessment
	1c. Assess areas of surface soil contamination resulting from site runoff.	Characterize contaminant levels in surface soil at downslope drainage area.	Soil Investigation
Former Storage Area 2. Groundwater	2a. Assess health risks posed by future usage of the shallow groundwater near Site 2.	Evaluate groundwater quality and compare to ARARs and health based action levels	Groundwater Investigation Risk Assessment
	2b. Define vertical and horizontal extent of contamination.	Characterize on-site groundwater quality in shallow and deeper positions of the aquifer. Characterize off-site groundwater quality.	Groundwater Investigation
	2c. Assess potential impact to groundwater from contaminated soil or unknown releases.	Characterize on-site groundwater quality Identify possible sources of unknown releases	Groundwater Investigation Geophysical Investigation
	2d. Define hydrogeologic characteristics for fate and transport evaluations and remedial technology evaluation, if required.	Estimate hydrogeologic characteristics of the shallow aquifer (flow direction, transmissivity, permeability).	Groundwater Investigation
Former Storage Area 3. Sediment	3a. Assess human health and ecological risks associated with exposure to contaminated sediments	Characterize nature and extent of contamination in sediment	Sediment Investigation in Drainage Ditches and Overs Creek. Risk Assessment
	3b. Assess potential ecological impacts posed by contaminated sediments.	Identify whether site-related contaminants have migrated to Overs Creek.	Sediment Investigation
	3c. Determine the extent of sediment contamination for purposes of identifying areas of remediation.	Identify extent of sediment contamination where pesticide levels exceed health based action levels.	Sediment Investigation (Drainage Ditch Along Lejeune Railroad)

TABLE 2-1 (Continued)

RI/FS OBJECTIVES
SITE 2 - REMEDIAL INVESTIGATION CTO-0174
MCB CAMP LEJEUNE, NORTH CAROLINA

Medium or Area of Concern	RI/FS Objective	Criteria for Meeting Objective	Proposed Investigation/Study
Former Storage Area 4. Surface Water	4a. Assess the presence or absence of surface water contamination in drainage ditch along site.	Determine surface water quality along drainage ditch. Identify whether site-related contaminants have migrated to Overs Creek.	Surface Water Investigation

was performed at the request of the Superfund Support Section, USEPA Region IV. Aerial photographs included in the interim report detail operations at OU No.5 during the period from 1938 to 1990. Investigation results were employed to locate and assess potential sources of contamination and to document past waste disposal and storage activities within the study area.

Information supplied by USEPA Region IV was used to identify areas of concern within the study area and to verify the occurrence of waste handling, disposal, and storage activities. Where possible, such activities were noted in the report and annotated on the photographs.

Black-and-white aerial photographs from 1938, 1944, 1952, 1956, 1960, 1964, 1970, 1980, 1988, and 1990 were used for the analysis of OU No.5, Site 2. The 1938 round of photographs established a basis of comparison, prior to the development of the Marine Corps Base, Camp Lejeune.

The analysis was performed by viewing backlit transparencies of aerial photographs through a stereoscope. Stereoscopic viewing of aerial photographs creates a perceived three-dimensional effect which enables the analyst to identify visible characteristics (e.g., color, tone, shadow, texture, size, shape, and pattern). These visible characteristics permit a specific object or condition to be recognized on aerial photographs (EPIC, 1992).

The following subsections describe selected aerial photographs from the photographic investigation. Appendix C contains reproductions of those annotated photographs that best illustrate conditions and delineate areas of concern within the study area.

2.2.1 Aerial Photograph - November 1944

Clearing is evident within the study area, east of Holcomb Boulevard, see Appendix C. A drainage analysis was performed as part of the 1944 investigation and annotated on the aerial photograph. Drainage extends northwest from the study area and enters Northeast Creek.

A building has been annotated on the aerial photograph. The building was first evident in 1943 and remains through 1993.

Light-toned linear objects have been noted in the south central portion of the site, south of the building. The linear objects are uniformly situated in the south end of a parking or storage area.

2.2.2 Aerial Photograph - October 1949

Light-toned material is visible in the southeast corner of the study area, refer to Appendix C. A crane (not annotated), which may have been used to load or unload the light-toned material from rail cars, is visible near the northwest corner of the piled material. Two dark-toned square objects have been noted to the east and adjacent to the piled material. Probable stains are evident and appear to emanate from the northern edge of the dark-toned objects. Previously-noted light-toned linear objects are no longer visible in the south central portion of the study area.

2.2.3 Aerial Photograph - February 1952

Several light-toned linear objects are visible where the dark-toned objects and probable staining were noted in the 1949 aerial photograph, see Appendix C. The piled light-toned material is no longer evident. Staining is visible along the eastern edge of the light-toned linear objects. A single linear object, east of the other objects, appears to be emanating a possible liquid. Several of the same objects are located south of the study area boundary. The area (not annotated) within and surrounding the southeastern portion of the study area has been partially cleared and the ground has been disturbed.

Two additional linear objects are located in the south central portion of the site, adjacent to the northwest corner of the parking or storage area. In the northern portion of the study area, four possible horizontal tanks are visible next to several parked vehicles (not annotated).

2.2.4 Aerial Photograph - February 1956

The light-toned linear objects, the associated staining, and possible liquid that were noted in 1952 are no longer apparent, see Appendix C. The four possible horizontal tanks that were also noted during the previous investigation have been removed. Two dark-toned linear objects, a pile of probable material, and possible staining are visible in the southeast corner of the study area.

The partially cleared and disturbed area (not annotated) within and surrounding the southeast corner of the study area has, by 1956, begun to revegetate. No additional significant activity is noted within the study area through 1990.

2.3 Geophysical Survey Investigation

A surface geophysical survey was conducted on August 29, 1992, at Site 2 in the Former Storage Area in an attempt to determine the source of shallow groundwater contamination in monitoring well 2GW3. The survey was conducted by Weston Geophysical Corporation (Weston). Non-invasive geophysical techniques that were utilized included electromagnetic terrain conductivity and ground penetrating radar techniques.

Ground penetrating radar detected several small objects buried along the site perimeter and tree line. These are likely debris or utilities associated with previous structures on site.

Only at one location on the south end of the site, near monitoring well 2GW3 (MW 192S), did the radar records indicate a buried object. However, the data was not conclusive to ascertain whether or not it was a tank, large diameter utility line, or other buried structure. Additional geophysical investigation activities were conducted in this area in January 1994. The result of this additional investigation indicate that there are no subsurface features in this area.

Results of Weston's geophysical investigation are presented in Appendix A.

2.4 Preliminary Site Survey

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

2.5 Soil Investigation

A summary of the soil sampling program at Site 2 describing the sample locations, the number of sampling points, and analytical methods is provided on Table 2-2. Soil sampling locations are presented on Figure 2-1.

TABLE 2-2

SUMMARY OF SOIL SAMPLING PROGRAM
SITE 2
REMEDIAL INVESTIGATION CTO-0174
MCB CAMP LEJEUNE, NORTH CAROLINA

Sample Location	Depth of Borehole (feet, bgs)	Number of Samples	Sampling Intervals (feet, bgs)	Analytical Parameters
2FSA-SB07	6	1	0 - 0.5	BTEX
		1	4 - 6	BTEX
2FSA-SB03	6	1	0 - 0.5	BTEX
		1	4 - 6	BTEX
2FSA-SB02	8	1	0 - 0.5	BTEX
		1	6 - 8	BTEX
2FSA-SB01	6	1	0 - 0.5	BTEX
		1	4 - 6	BTEX
2FSA-SB05	6	1	0 - 0.5	BTEX
		1	4 - 6	BTEX
2FSA-SB09	6	1	0 - 0.5	TCL Organics, TAL Inorganics
		1	4 - 6	TCL Organics, TAL Inorganics
2FSA-SB08	6	1	0 - 0.5	BTEX
		1	4 - 6	BTEX
2FSA-SB10	4	1	0- 0.5	BTEX
		1	2 - 4	BTEX
2FSA-SB06	8	1	0 - 0.5	TCL Organics, TAL Inorganics
		1	4 - 6	TCL Organics, TAL Inorganics
2FSA-SB04	6	1	0 - 0.5	TCL Organics, TAL Inorganics
		1	4 - 6	TCL Organics, TAL Inorganics
2MP-SB11	6	1	0 - 0.5	TCL Pest, Herbicides
		1	4 -6	TCL Pest, Herbicides
2MP-SB10	6	1	0 - 0.5	TCL Pest, Herbicides
		1	4 - 6	TCL Pest, Herbicides
2MP-SB09	6	1	0 - 0.5	TCL Pest, Herbicides
		1	4 - 6	TCL Pest, Herbicides
2MP-SB02	6	1	0 - 0.5	TCL Pest, Herbicides
		1	4 - 6	TCL Pest, Herbicides
2MP-SB06	6	1	0 - 0.5	TCL Pest, Herbicides
		1	4 - 6	TCL Pest, Herbicides
2MP-SB08	6	1	0 - 0.5	TCL Organics, TAL Metals
		1	4 - 6	TCL Organics, TAL Metals
2MP-SB12	6	1	0 - 0.5	TCL Pest, Herbicides
		1	4 - 6	TCL Pest, Herbicides
2MP-SB13	6	1	0 - 0.5	TCL Pest, Herbicides
		1	4 - 6	TCL Pest, Herbicides
2LA-SB12	4	1	0 - 0.5	TCL Pest, Herbicides
		1	2 - 4	TCL Pest, Herbicides
2LA-SB09	6	1	0 - 0.5	TCL Organics, TAL Inorganics
		1	4 - 6	TCL Organics, TAL Inorganics

Notes: FSA borings advanced near the Former Storage Area.
MP borings advanced near the mixing pad area.
LA borings advanced near the lawn area.
bgs = below ground surface.

TABLE 2-2 (Continued)

SUMMARY OF SOIL SAMPLING PROGRAM
SITE 2
REMEDIAL INVESTIGATION CTO-0174
MCB CAMP LEJEUNE, NORTH CAROLINA

Sample Location	Depth of Borehole (feet, bgs)	Number of Samples	Sampling Intervals (feet, bgs)	Analytical Parameters
2LA-SB05	6	1	0 - 0.5	TCL Pest, Herbicides
		1	4 - 6	TCL Pest, Herbicides
2LA-SB01	6	1	0 - 0.5	TCL Pest, Herbicides
		1	4 - 6	TCL Pest, Herbicides
2LA-SB02	6	1	0 - 0.5	TCL Organics, TAL Inorganics
		1	2 - 4	TCL Organics, TAL Inorganics
2LA-SB03	6	1	0 - 0.5	TCL Pest, Herbicides
		1	4 - 6	TCL Pest, Herbicides
2LA-SB04	8	1	0 - 0.5	TCL Organics, TAL Inorganics
		1	4 - 6	TCL Organics, TAL Inorganics
2LA-SB06	6	1	0 - 0.5	TCL Pest, Herbicides
		1	4 - 6	TCL Pest, Herbicides
2LA-SB07	6	1	0 - 0.5	TCL Organics, TAL Inorganics
		1	2 - 4	TCL Organics, TAL Inorganics
2LA-SB08	6	1	0 - 0.5	TCL Pest, Herbicides
		1	4 - 6	TCL Pest, Herbicides
2LA-SB10	6	1	0 - 0.5	TCL Organics, TAL Inorganics
		1	2 - 4	TCL Organics, TAL Inorganics
2LA-SB11	6	1	0 - 0.5	TCL Pest, Herbicides
		1	4 - 6	TCL Pest, Herbicides
2MP-SB14	6	1	0 - 0.5	TCL Pest, Herbicides
		1	2 - 4	TCL Pest, Herbicides
2MP-SB15	6	1	0 - 0.5	TCL Pest, Herbicides
		1	4 - 6	TCL Pest, Herbicides
2MP-SB16	6	1	0 - 0.5	TCL Organics, TAL Inorganics
		1	4 - 6	TCL Organics, TAL Inorganics
2MP-SB21	8	1	0 - 0.5	TCL Pest, Herbicides
		1	6 - 8	TCL Pest, Herbicides
2MP-SB22	6	1	0 - 0.5	TCL Pest, Herbicides
		1	4 - 6	TCL Pest, Herbicides
2MP-SB23	8	1	0 - 0.5	TCL Pest, Herbicides
		1	4 - 6	TCL Pest, Herbicides
2MP-SB27	6	1	0 - 0.5	TCL Pest, Herbicides
		1	2 - 4	TCL Pest, Herbicides
2MP-SB26	8	1	0 - 0.5	TCL Pest, Herbicides
		1	4 - 6	TCL Pest, Herbicides
2MP-SB17	6	1	0 - 0.5	TCL Pest, Herbicides, CL, FL, N, Alkal
		1	4 - 6	TCL Pest, Herbicides, CL, FL, N, Alkal
2MP-SB18	8	1	0 - 0.5	TCL Pest, Herbicides, CL, FL, N, Alkal
		1	4 - 6	TCL Pest, Herbicides, CL, FL, N, Alkal

TABLE 2-2 (Continued)

SUMMARY OF SOIL SAMPLING PROGRAM
SITE 2
REMEDIAL INVESTIGATION CTO-0174
MCB CAMP LEJEUNE, NORTH CAROLINA

Sample Location	Depth of Borehole (feet, bgs)	Number of Samples	Sampling Intervals (feet, bgs)	Analytical Parameters
2MP-SB-24	6	1	0 - 0.5	TCL Organics, TAL Inorganics
		1	4 - 6	TCL Organics, TAL Inorganics
2MP-SB25	6	1	0 - 0.5	TCL Pest, Herbicides
		1	2 - 4	TCL Pest, Herbicides
2MP-SB28	6	1	0 - 0.5	TCL Organics, TAL Inorganics
		1	2 - 4	TCL Organics, TAL Inorganics
2LA-SB13	6	1	0 - 0.5	TCL Pest, Herbicides
		1	2 - 4	TCL Pest, Herbicides
2LA-SB15	6	1	0 - 0.5	TCL Pest, Herbicides
		1	2 - 4	TCL Pest, Herbicides
2LA-SB16	6	1	0 - 0.5	TCL Pest, Herbicides
		1	2 - 4	TCL Pest, Herbicides
2LA-SB18	6	1	0 - 0.5	TCL Pest, Herbicides
		1	2 - 4	TCL Pest, Herbicides
2LA-SB19	6	1	0 - 0.5	TCL Organics, TAL Inorganics
		1	2 - 4	TCL Organics, TAL Inorganics
2FSA-SB12	6	1	0 - 0.5	BTEX
		1	2 - 4	BTEX
2FSA-SB11	6	1	0 - 0.5	TCL Organics, TAL Inorganics
		1	2 - 4	TCL Organics, TAL Inorganics
2FSA-SB13	6	1	0 - 0.5	TCL Organics, TAL Inorganics
		1	2 - 4	TCL Organics, TAL Inorganics
2MP-SB05	4	1	0 - 0.5	BTEX
		1	2 - 4	BTEX
2MP-SB17A	4	1	0 - 0.5	BTEX
		1	2 - 4	BTEX
2MP-SB07	6	1	0 - 0.5	BTEX
		1	4 - 6	BTEX
2MP-SB04	6	1	0 - 0.5	TCL Organics, TAL Inorganics
		1	2 - 4	TCL Organics, TAL Inorganics
2MP-SB03	6	1	0 - 0.5	TCL Pest, Herbicides
		1	2 - 4	TCL Pest, Herbicides
2MP-SB01	6	1	0 - 0.5	TCL Pest, Herbicides
		1	2 - 4	TCL Pest, Herbicides
2LA-SB17	6	1	0 - 0.5	TCL Pest, Herbicides
		1	2 - 4	TCL Pest, Herbicides
2LA-SB14	6	1	0 - 0.5	TCL Pest, Herbicides
		1	2 - 4	TCL Pest, Herbicides
2GW6	12.5	1	0 - 0.5	TCL Organics, TAL Inorganics
		1	2 - 4	TCL Organics, TAL Inorganics
2GW7	16.0	1	2 - 4	TCL Organics, TAL Inorganics
		1	6 - 8	TCL Organics

TABLE 2-2 (Continued)

SUMMARY OF SOIL SAMPLING PROGRAM
SITE 2
REMEDIAL INVESTIGATION CTO-0174
MCB CAMP LEJEUNE, NORTH CAROLINA

Sample Location	Depth of Borehole (feet, bgs)	Number of Samples	Sampling Intervals (feet, bgs)	Analytical Parameters
2GW8	12.5	1	2 - 4	TCL Organics, TAL Inorganics
		1	2 - 4	TCL Organics, TAL Inorganics
2GW9	13.0	1	2 - 4	TCL Organics, TAL Inorganics
		1	4 - 6	TCL Organics, TAL Inorganics
2GW3D	100.0	1	2 - 4	TCL Organics, TAL Inorganics
		1	46 - 48	TCL Organics, TAL Inorganics

In general, the field procedures and sampling methods employed for the soil investigation were implemented in accordance with USEPA Region IV standard operating procedures. These procedures also included sample handling and preservation, documentation, and chain-of-custody procedures. Specific sampling procedures are outlined in the Final RI/FS Work Plan for Site 2.

The soil investigation program for Site 2 included drilling, soil sampling, and field screening and air monitoring. These activities are discussed in the following subsections. Table 2-3 summarizes field QA/QC sample types, frequency and analytical methods for the soil investigation.

2.5.1 Drilling Procedures

Drilling activities at Site 2 commenced in late April 1993 and continued through early May 1993. The firm of Hardin and Huber, Inc. was retained to perform the drilling services. During the drilling program, soil borings were advanced in the vicinity of Site 2 with six of the boreholes converted into shallow Type II monitoring wells (i.e., wells without surface casing). One boring was converted into a deep Type III monitoring well (well with surface casing). Figures 2-1 through 2-4 show the locations of the soil boring points for the various areas investigated.

The drilling and sampling program implemented at Site 2 focused on the following areas:

- Building 712 Area
    - Lawn Area
    - Former Mixing Pad Area
- Former Storage Area

The boreholes were advanced using a truck-mounted drill rig employing the hollow-stem auger technique. During drilling, 3-1/4 inch inside diameter (ID) augers were used to advance the boreholes. Split-spoon samples were collected from inside the augers per ASTM Method D 1586-84 (ASTM, 1984). For installation of soil borings, soil samples were collected from the surface (ground surface to 6 inches below ground surface [bgs]) then at continuous 2-foot intervals until the water table was encountered, where the borings were terminated (approximately 6 feet bgs). In areas that could not be accessed by the drill rig, a power hand

TABLE 2-3

SUMMARY OF FIELD QUALITY ASSURANCE/QUALITY CONTROL SAMPLING PROGRAM FOR THE SOIL INVESTIGATIONS
SITE 2
REMEDIAL INVESTIGATION CTO-0174
MCB CAMP LEJEUNE, NORTH CAROLINA

QA/QC Sample(1)	Frequency of Collection	Number of Samples	Analytical Parameters(3)
Trip Blanks(2)	One per Cooler	8	TCL Volatiles
Field Blanks	One per Event(3)	1	TCL Organics/TAL Inorganics
Equipment Rinsates	One per Day	3	TCL Organics/TAL Inorganics
Field Duplicates	10% of Sample Frequency	15	TCL Organics/TAL Inorganics

Notes:
(1) QA/QC sample types defined in text.
(2) Trip blanks submitted with coolers which contained samples for volatile analysis. Samples analyzed for TCL volatiles only.
(3) An event is defined as one 14 day period. Field blank collected during soils investigation.

auger was used to advance the borehole. In these cases, split-spoons were driven by hand with a sledge hammer.

Samples collected during installation of monitoring wells were obtained at continuous 2-foot intervals until the water table was encountered, then at approximate 5-foot intervals thereafter. These borings (for well installation) were terminated from 10 to 15 feet bgs. One deep (100-foot) monitoring well was installed (using combination of hollow stem auger and mud rotary drilling techniques) in the Former Storage Area (2GW3D). Two-foot samples were obtained to ensure a sufficient quantity of sample was retained for analysis. Soil cuttings and drilling mud generated during the drilling program were containerized and handled according to the procedures outlined in Section 2.11.

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

2.5.2 Soil Sampling

2.5.2.1 Sampling Procedures

Surface (0 to 6 inches bgs) and subsurface (deeper than 6 inches bgs) soil samples were collected for chemical analysis at all boring and monitoring well locations. Surface samples were collected for RA evaluation while subsurface samples were collected to evaluate the horizontal and vertical extent of potentially impacted soils and for risk assessment evaluation purposes. Figures 2-1 through 2-4 depict the locations of the sampling points. Table 2-2 summarizes the sample depths, locations, and parameters analyzed.

Soil samples were obtained by employing two methods. For the surface samples, hollow-stem augers were slowly advanced to approximately six inches bgs so that soil cuttings could be retained for the grab sample. The first few inches of top soil and matted roots were removed prior to advancing the augers (much of the area is covered with grass and is maintained on a periodic basis). Deeper subsurface soil samples were collected with a split-spoon sampler in accordance with ASTM Method D 1586-84 as detailed in Section 2.5.1. In general, samples collected from the soil borings for chemical analysis were obtained from the surface and just above the water table; samples collected during drilling of the monitoring wells for chemical analysis were obtained from just above and just below (so that groundwater results can be correlated with soil conditions) the water table. Both the hollow-stem augers and split-spoon sampler were decontaminated prior to sample collection according to the procedures outlined in Section 2.10.

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

2.5.2.2 Analytical Requirements

The analytical program for the soils investigation is summarized on Table 2-2.

2.5.3 Field Screening and Air Monitoring

Several air monitoring and field screening procedures were implemented during drilling and sampling activities for health and safety and initial contaminant monitoring. During drilling, ambient air monitoring in the vicinity of the borehole was performed with a photoionization detector (PID) to monitor for airborne contaminants. Samples (i.e., split-spoon samples) were screened with the PID to measure for VOC vapor. Data obtained in the field were recorded in a field logbook, and PID measurements are provided on the Soili Boring Logs and Well Construction Records in Appendix D. Prior to daily monitoring, the instruments were calibrated. Calibration documentation was recorded in field log books and on calibration forms.

2.6 Soil Gas Survey

A soil gas survey was conducted in the Former Storage Area by Target Environmental, Inc. (Target). The purpose of the soil gas survey was to delineate the extent of shallow groundwater contamination in this area, specifically with respect to those contaminants previously detected in monitoring well 2GW3 (ethylbenzene, toluene, and xylene). Results of the soil gas survey were used in determining locations of selected monitoring wells installed during this RI.

A complete description of the procedures utilized during the soil gas survey, and the results of the survey, are presented in the Soil Gas Survey Report (Appendix E).

The soil gas samples were analyzed for the following parameters:

- Vinyl chloride
- Benzene
- Toluene
- Ethylbenzene
- Xylenes

None of these parameters were detected in any of the soil gas samples analyzed at Site 2.

2.7 Groundwater Investigation

The environmental sampling program developed for Site 2 was intended to identify contaminants of potential concern (COPCs) and evaluate their distribution at the site. The primary objective of this investigation was to determine if former site activities adversely impacted the quality of groundwater. Moreover, the program was developed to consider potential human health and ecological risks associated with the COQLs. A summary of the groundwater sampling program at Site 2 describing the sample locations, well screen intervals, and analytical parameters is provided on Table 2-4.

Several types of field QA/QC samples were collected and analyzed during the groundwater investigation including duplicate samples, equipment rinsates, and trip blanks. These sample types are defined in Section 2.9. Table 2-5 summarizes field QA/QC sample types, frequencies, and analytical parameters.

TABLE 2-4

MONITORING AND SUPPLY WELL CONSTRUCTION SPECIFICATIONS
SITE 2 - REMEDIAL INVESTIGATION CTO-0174
MCB CAMP LEJEUNE, NORTH CAROLINA

Well #	Depth (feet)	Screened Interval(s) (feet)	Well Diameter (inches)	Analytical Parameters
2GW1(1)	25	10-25	2	Full TCL/TAL
2GW2(1)	25	10-25	2	Full TCL/TAL
2GW3(1)	25	10-25	2	Full TCL/TAL
2GW3D(2)	100	90-100	4	Full TCL/TAL
2GW4(1)	25	10-25	2	Full TCL/TAL
2GW5(1)	25	10-25	2	Full TCL/TAL
2GW6(2)	12.5	2.6-11.6	4	Full TCL/TAL
2GW7(2)	13	3-13	4	Full TCL/TAL
2GW8(2)	12.5	2.5-12.5	4	Full TCL/TAL
2GW9(2)	13.0	3.2-12.2	4	Full TCL/TAL

(1) Existing monitoring well.

(2) Monitoring wells installed during this investigation.

TABLE 2-5

SUMMARY OF FIELD QUALITY ASSURANCE/QUALITY CONTROL SAMPLING PROGRAM FOR THE GROUNDWATER INVESTIGATION
SITE 2 - REMEDIAL INVESTIGATION CTO-0174
MCB CAMP LEJEUNE, NORTH CAROLINA

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

Notes: (1) QA/QC sample types defined in text.
(2) Trip blanks submitted with coolers which contained samples for volatile analysis. Samples analyzed for TCL volatiles only.

In general, 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 outlined in the Final RI/FS Work Plan for Site 2.

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

2.7.1 Monitoring Well Installation

Shallow Monitoring Wells

Shallow Type II monitoring wells (denoted as 2GW6 through 2GW9) were installed at Site 2 at the locations shown on Figure 2-5 (existing monitoring well locations are also included on this figure). The monitoring wells were installed to collect shallow groundwater samples for characterizing the nature and horizontal extent of potentially impacted groundwater and to evaluate groundwater flow patterns at the site.

Four shallow monitoring wells were initially installed during this RI. In response to EPA comments on the Draft version of this RI report, two additional shallow monitoring wells were installed in February 1994 (2GW10 and 2GW11).

The shallow monitoring wells were installed upon completion of advancing the boreholes. Each borehole was over-drilled with 8-1/4 inch ID augers prior to well installation. Shallow monitoring wells depths ranged from 12.5 feet bgs to 13 feet bgs. In general, the wells were installed approximately 7 feet below where the water table was first encountered during drilling. The shallow monitoring wells were installed at depths to compensate for seasonal variations in the water table which may vary from 1 to 5 feet.

Well construction details for the newly installed shallow wells are summarized on Table 2-6 and well construction diagrams are shown on the Well Construction Records provided in Appendix D. The wells were constructed of 4-inch nominal diameter Schedule 40, flush-joint and threaded PVC casing with a 10-foot long, 0.01-inch slot screen section. A medium-grained sand pack (Number 2 sand), extending approximately 2 feet (where conditions permitted) above the top of the screen, was placed in the annulus between the screen and the borehole wall (12-inch borehole diameter) from inside the hollow-stem augers. A 1- to 2-foot bentonite

TABLE 2-6

SUMMARY OF WELL CONSTRUCTION DETAILS
SITE 2 - REMEDIAL INVESTIGATION CTO-0174
MCB CAMP LEJEUNE, NORTH CAROLINA

Well No.	Date Installed	Top of PVC Casing Elevation(1) (feet, above MSL)	Ground Surface Elevation (feet, above MSL)	Boring Depth(2) (feet, bgs)	Well Depth (feet, bgs)	Screen Interval Depth (feet, bgs)	Depth to Sand Pack (feet, bgs)	Depth to Bentonite (feet, bgs)	Stick-Up (feet, ags)
2GW7	04/22/93	34.03	31.6	16.0	13.0	3.0 to 13.0	2.0	1.0	2.43
2GW8	04/23/93	34.92	31.9	12.5	12.5	2.5 to 12.5	1.5	0.5	3.02
2GW6	04/24/93	34.40	31.8	12.5	12.5	2.68 to 11.64	1.5	0.5	2.60
2GW9	04/24/93	35.02	32.6	13.0	13.0	3.19 to 12.30	2.0	1.0	2.42
2GW3D	04/23/93	36.07	33.1	100.0	100.0	90.26 to 99.39	85.0	83.0	2.97

Note: (1) MSL - mean sea level
(2) bgs - below ground surface
(3) ags - above ground surface

pellet seal was then placed above the sand pack and hydrated with potable water. The seal was installed to prevent cement from intruding onto the sand pack. The remaining annular space (approximately one foot) was backfilled with Portland cement for construction of the pad. An above ground ("stick-up") steel protective casing and a PVC locking cap were fitted at the top of each well. Monitoring well 2GW10 was completed with a flush-mount protective casing. The wells were tagged with well construction information and marked "Not for Consumptive Use." Typical shallow well construction details are shown on Figure 2-6.

Deep Monitoring Wells

Monitoring well 2GW3D was installed as a deep Type III (i.e., outer casing installed) monitoring well. Hollow stem augers were advanced to 20 feet bgs. A clay layer was encountered at this depth. An 8-inch PVC casing was installed at this depth and was grouted in place. The grout was allowed to set for 17 hours. The casing was installed to prevent migration of shallow groundwater, through the borehole, to the deeper portions of the aquifer.

The borehole was then advanced through the 8-inch casing using mud rotary drilling techniques. Subsequent monitoring well installation and construction procedures were the same as those employed for the shallow monitoring wells. The well was installed at a depth of 100 feet so that the upper portion of the Castel Hayne aquifer could be sampled. Well construction details for this deep monitoring well (2GW3D) are included in Table 2-6. Figure 2-7 is a typical deep (Type III) monitoring well construction diagram.

2.7.2 Well Development Procedures

Following well construction and curing of the bentonite and grout seals, each newly installed well was developed to remove fine-grained sediment from the screen and to establish interconnection between the well and the formation. The monitoring wells were developed by a combination of surging and compressed air (note that an air filter was installed on the compressor to prevent oil/grease from entering the well). Pumping hoses were dedicated for each well to minimize the potential for cross contamination. These hoses were moved up and down during development to promote surging.

Measurements of pH, specific conductance, and temperature were recorded to assist in determining well stabilization. Periodic flow and volume measurements were also recorded during development to evaluate flow rates of the shallow water-bearing zone. Well Development Forms summarizing this information are provided in Appendix F.

2.7.3 Water Level Measurements and Surveying

Static water level measurements were collected on three different dates (May 17, 1993; May 20, 1993; and June 5, 1993) from top-of-casing (TOC) reference points at each well. Water level data was used to evaluate groundwater flow patterns at the site. Measurements were recorded using an electric measuring tape to the nearest 0.01-foot. Water level data was collected at the site within a one hour period.

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

Three surface water staff gauges were installed on site in the following locations: drainage ditch on each side of railroad tracks, drainage ditch on west side of railroad tracks, and Overs Creek. The staff gauges were also surveyed to establish vertical and horizontal control. Surface water elevation measurements were collected in conjunction with groundwater elevation measurements in order to determine if there was any relationship between surface water and groundwater. Measurements were recorded to the nearest 0.1 - foot.

2.7.4 Groundwater Sampling

2.7.4.1 <u>Sampling Procedures</u>

Groundwater samples were collected from the five newly installed and the five previously existing monitoring wells on May 20, 1993. The samples were collected to confirm the presence or absence of contaminants and evaluate overall groundwater chemistry. Groundwater sampling procedures were performed in accordance with USEPA Region IV SOPs.

Groundwater samples were collected from monitoring wells 2GW10 and 2GW11 on March 3, 1994. Groundwater samples were also collected from the other site monitoring wells on this date. Samples were analyzed for the sample parameters as in the May 20, 1993 sampling event (see Section 2.7.4.2).

The second round of groundwater samples was collected to provide additional information for remedial design. The results of the additional groundwater analyses have not been submitted for data validation and were not incorporated in the human health or ecological risk assessment.

Prior to groundwater purging, water levels from each well were measured according to procedures outlined in Section 2.7.3. The total well depth was also recorded from each well to the nearest 0.1-foot using a steel tape. Water level and well depth measurements were used to calculate the volume of water in each well and the minimum volume of water necessary to purge the well.

Following well volume calculations, a minimum of three to five well volumes were purged from each well prior to sampling. Water was purged from each well using a decontaminated submersible pump (low flow) and teflon hoses. A constant flow rate of 1 to 2 gallons per minute (GPM) was maintained during purging. Purge water was containerized and handled as described in Section 2.11. Measurements of pH, specific conductance, and temperature were made prior to purging and after each well volume was removed to ensure the groundwater stabilized before sampling. These measurements were recorded in a field log book.

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

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

2.7.4.2 Analytical Requirements

Groundwater samples were obtained from the monitoring wells for analysis of TCL organics and TAL inorganics (total and dissolved metals, cyanide). USEPA Method 524 was implemented for analysis of VOCs. Additionally, a groundwater sample was collected from monitoring well 2GW6 for analysis of biological oxygen demand, chemical oxygen demand, total suspended solids, total dissolved solids, total volatile solids, and total organic carbon to evaluate the general groundwater chemistry for potential treatment options.

2.8 Surface Water and Sediment Investigations

Surface water and sediment samples were collected on April 26-27, 1993, to assess human health and ecological impacts associated with the railroad track drainage ditches, and Overs Creek. The environmental sampling program developed for Site 2 was intended to identify contaminants of concern and evaluate their distribution at the site. A summary of the surface water/sediment sampling program at Site 2 describing the sample locations, sample designations, and analytical methods is provided on Table 2-7.

Several types of field QA/QC samples were collected and analyzed including duplicate samples, equipment rinsates, and trip blanks. Table 2-8 summarizes field QA/QC sample types, frequencies, and analytical parameters.

In general, the field procedures and sampling methods employed for this study were implemented in accordance with USEPA Region IV SOPs. These procedures also included sample handling and preservation, documentation, and chain-of-custody procedures. Specific sampling procedures are outlined in the Final RI/FS Work Plan for Site 2.

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

TABLE 2-7

SUMMARY OF SURFACE WATER/SEDIMENT SAMPLING PROGRAM
SITE 2 - REMEDIAL INVESTIGATION CTO-0174
MCB CAMP LEJEUNE, NORTH CAROLINA

Sampling Activity	Sample Location	Sample Station	Number of Samples	Analytical Parameters	Depth (Sediment Only Feet)
Surface Water	Overs Creek (OC)	2-OCSW01	1	TCL Organics, TAL Metals(1)(2)	
		2-OCSW02	1	TCL Pesticides, Herbicides	
		2-OCSW03	1	TCL Organics, TAL Metals	
		2-OCSW01D	1	TCL Organics, TAL Metals	
	Railroad (RR)	2-RRSW04	1	TCL Pesticides, Herbicides	
		2-RRSW05	1	TCL Pesticides, Herbicides	
		2-RRSW06	1	TCL Organics, TAL Metals	
		2-RRSW17	1	TCL Pesticides, Herbicides	
Sediment	Overs Creek (OC)	2-OCSD01-06D	1	TCL Organics, TAL Metals	0 - 0.5
		2-OCSD01-612D	1	TCL Organics, TAL Metals	0.5 - 1.0
		2-OCSD03-06	1	TCL Organics, TAL Metals	0 - 0.5
		2-OCSD03-612	1	TCL Organics, TAL Metals	0.5 - 1.0
		2-OCSD02-06	1	TCL Pesticides, Herbicides	0 - 0.5
		2-OCSD02-612	1	TCL Pesticides, Herbicides	0.5 - 1.0
	Railroad (RR)	2-RRSD21-06	1	TCL Pesticides/PCB, TAL Metals, TCL SVOA	0 - 0.5
		2-RRSD21-612	1	TCL Pesticides/PCB, TAL Metals, TCL SVOA	0.5 - 1.0
		2-RRSD20-06	1	TCL Organics, TAL Metals	0 - 0.5
		2-RRSD20-612	1	TCL Organics, TAL Metals	0.5 - 1.0
		2-RRSD19-06	1	TCL Pesticides, Herbicides	0 - 0.5
		2-RRSD19-612	1	TCL Pesticides, Herbicides	0.5 - 1.0

Notes: (1) Target Analyte List (TAL) inorganics (total metals and cyanide) analyzed by Contract Laboratory Program (CLP) protocols.
(2) Target Compound List (TCL) organics (VOCs, SVOCs, and pesticide/PCBs) analyzed by CLP protocols.

TABLE 2-7 (Continued)

SUMMARY OF SURFACE WATER/SEDIMENT SAMPLING PROGRAM
SITE 2 - REMEDIAL INVESTIGATION CTO-0174
MCB CAMP LEJEUNE, NORTH CAROLINA

Sampling Activity	Sample Location	Sample Station	Number of Samples	Analytical Parameters	Depth (Sediment Only Feet)
Sediment (continued)	Railroad (RR) (continued)	2-RRSD18-06	1	TCL Pesticides, Herbicides	0 - 0.5
		2-RRSD18-612	1	TCL Pesticides, Herbicides	0.5 - 1.0
		2-RRSD17-06	1	TCL Pesticides, Herbicides	0 - 0.5
		2-RRSD17-612	1	TCL Pesticides, Herbicides	0.5 - 1.0
		2-RRSD16-06	1	TCL Pesticides, Herbicides	0 - 0.5
		2-RRSD16-612	1	TCL Pesticides, Herbicides	0.5 - 1.0
		2-RRSD15-06	1	TCL Organics, TAL Metals	0 - 0.5
		2-RRSD15-612	1	TCL Organics, TAL Metals	0.5 - 1.0
		2-RRSD14-06	1	TCL Pesticides, Herbicides	0 - 0.5
		2-RRSD14-612	1	TCL Pesticides, Herbicides	0.5 - 1.0
		2-RRSD13-06	1	TCL Pesticides, Herbicides	0 - 0.5
		2-RRSD13-612	1	TCL Pesticides, Herbicides	0.5 - 1.0
		2-RRSD12-06	1	TCL Organics, TAL Metals	0 - 0.5
		2-RRSD12-612	1	TCL Organics, TAL Metals	0.5 - 1.0
		2-RRSD11-06	1	TCL Pesticides, Herbicides	0 - 0.5
		2-RRSD11-612	1	TCL Pesticides, Herbicides	0.5 - 1.0
		2-RRSD10-06	1	TCL Pesticides, Herbicides	0 - 0.5
		2-RRSD10-612	1	TCL Pesticides, Herbicides	0.5 - 1.0
		2-RRSD09-06	1	TCL Organics, TAL Metals	0 - 0.5
		2-RRSD09-612	1	TCL Organics, TAL Metals	0.5 - 1.0
		2-RRSD08-06	1	TCL Organics, TAL Metals	0 - 0.5
		2-RRSD08-612	1	TCL Organics, TAL Metals	0.5 - 1.0

Notes: (1) Target Analyte List (TAL) inorganics (total metals and cyanide) analyzed by Contract Laboratory Program (CLP) protocols.
(2) Target Compound List (TCL) organics (VOCs, SVOCs, and pesticide/PCBs) analyzed by CLP protocols.

TABLE 2-7 (Continued)

SUMMARY OF SURFACE WATER/SEDIMENT SAMPLING PROGRAM
SITE 2 - REMEDIAL INVESTIGATION CTO-0174
MCB CAMP LEJEUNE, NORTH CAROLINA

Sampling Activity	Sample Location	Sample Station	Number of Samples	Analytical Parameters	Depth (Sediment Only Feet)
Sediment (continued)	Railroad (RR) (continued)	2-RRSD07-06	1	TCL Organics, TAL Metals	0 - 0.5
		2-RRSD07-612	1	TCL Organics, TAL Metals	0.5 - 1.0
		2-RRSD06-06	1	TCL Organics, TAL Metals	0 - 0.5
		2-RRSD06-612	1	TCL Organics, TAL Metals	0.5 - 1.0
		2-RRSD05-06	1	TCL Pesticides, Herbicides	0 - 0.5
		2-RRSD05-612	1	TCL Pesticides, Herbicides	0.5 - 1.0
		2-RRSD04-06	1	TCL Pesticides, Herbicides	0 - 0.5
		2-RRSD04-612	1	TCL Pesticides, Herbicides	0.5 - 1.0
		2-RRSD03-06	1	TCL Pesticides, Herbicides	0 - 0.5
		2-RRSD03-612	1	TCL Pesticides, Herbicides	0.5 - 1.0
		2-RRSD02-06	1	TCL Organics, TAL Metals	0 - 0.5
		2-RRSD02-612	1	TCL Organics, TAL Metals	0.5 - 1.0
		2-RRSD01-06	1	TCL Organics, TAL Metals	0 - 0.5
		2-RRSD01-612	1	TCL Organics, TAL Metals	0.5 - 1.0

Notes: (1) Target Analyte List (TAL) inorganics (total metals and cyanide) analyzed by Contract Laboratory Program (CLP) protocols.
(2) Target Compound List (TCL) organics (VOCs, SVOCs, and pesticide/PCBs) analyzed by CLP protocols.

TABLE 2-8

SUMMARY OF FIELD QUALITY ASSURANCE/QUALITY CONTROL SAMPLING PROGRAM FOR THE SURFACE WATER AND SEDIMENT INVESTIGATION
SITE 2 - REMEDIAL INVESTIGATION CTO-0174
MCB CAMP LEJEUNE, NORTH CAROLINA

Sampling Activity	QA/QC Sample[1]	Frequency of Collection	Number of Samples	Analytical Parameters
Surface Water	Trip Blanks[2]	One per Cooler	1	TCL Volatiles
	Field Duplicates	10% of Sample Frequency	1	TCL Organics/TAL Inorganics
Sediment	Trip Blanks	One per Cooler	2	TCL Volatiles
	Equipment Rinsates	One per Day	1	TCL Organics/TAL Inorganics
	Field Duplicates	10% of Sample Frequency	4	TCL Organics/TAL Inorganics

Notes: (1) QA/QC sample types defined in text.
(2) Trip blanks submitted with coolers which contained samples for VOC analysis. Samples analyzed for TCL VOCs only.

2.8.1 Surface Water

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

2.8.1.1 Sample Locations

Seven surface water samples were collected at Site 2; three were collected in Overs Creek and four were collected in the railroad track drainage ditches. All the samples were collected from areas which contained surface water less than three feet in depth. The sampling locations are shown on Figures 2-8 and 2-9.

2.8.1.2 Sampling Procedures

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

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

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

2.8.1.3 Analytical Requirements

Table 2-7 summarizes the surface water sample analytical parameters.

2.8.2 Sediments

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

2.8.2.1 Sample Locations

Sediment samples were collected from 24 sampling stations (21 in drainage ditch and 3 in Overs Creek) at Site 2 (Figures 2-8 and 2-9). Table 2-7 provides a summary of the sample locations, sample designations, sample depths, and analytical parameters for the sediment samples.

2.8.2.2 Sampling Procedures

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

The coring device was pushed into the sediments to a depth of 12 inches, or until refusal. The liner was removed from the sampler and the sediments were extruded into the appropriate sample jars using a decontaminated extruder.

In areas where surface water was not present, a decontaminated stainless steel spoon was used to collect the sediment samples.

2.8.2.3 Analytical Requirements

Sediment sample analytical requirements are outlined in Table 2-7.

2.9 Quality Assurance/Quality Control Samples

Field quality assurance and quality control (QA/ QC) samples were also collected during the sampling program (see Table 2-8). These samples were obtained to: (1) ensure that decontamination procedures were properly implemented (i.e., equipment rinsate samples); (2) evaluate field methodology (i.e., duplicate samples); (3) establish field background conditions (i.e., field blanks); and, (4) evaluate whether cross-contamination occurred during sampling and/or shipping (i.e., trip blanks). Data Quality Objectives (DQOs) for the QA/QC samples were implemented in accordance with DQO Level IV as defined in the Environmental Compliance Branch Standard Operating Procedures and Quality Assurance Manual, EPA Region IV (USEPA, 1991).

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

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

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

- Field Blanks: Organic-free water is taken to the field in sealed containers and poured into the appropriate sample containers at predesignated locations. This is done to determine if any contaminants present in the area may have an affect on the sample integrity.

- Trip Blanks: Trip blanks are prepared prior to the sampling event in the actual sample container and are kept with the investigative samples throughout the sampling event. They are then packaged for shipment with the other samples and sent for analysis. At no time after their preparation are the trip blank sample containers opened before they reach the laboratory.

2.10 Decontamination Procedures

Decontamination procedures performed in the field were initiated in accordance with USEPA Region IV guidelines. In general, sampling and drilling equipment were divided into two decontamination groups: heavy equipment and routine sample collection equipment. Heavy equipment included: the drill rig, hollow-stem augers, and drill rods; routine sample collection equipment included: split-spoons, stainless-steel spoons, bailers, bailer wire, and sediment corer. In addition, the well screens for each newly installed well were steam cleaned prior to installation.

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 potable water
- Rinse thoroughly with deionized water
- Rinse twice with 10 percent nitric acid
- Rinse thoroughly with deionized water
- Rinse twice with pesticide-grade isopropanol alcohol
- Air dry
- Wrap in aluminum foil

Temporary decontamination pads, constructed of wood and plastic, were constructed for both procedures to minimize spillage onto the ground surface. Decontamination fluids generated during the field program were containerized and handled according to the procedures outlined in Section 2.11.

2.11 Investigative Derived Waste (IDW) Handling

A large volume of solids (approximately 18 cubic yards) and liquids (approximately 2,000 gallons) were generated during the field program at Site 2. Solids included soil cuttings and excess split-spoon samples; liquids included well development and purge water, and decontamination fluids (i.e., water, Alconox soap solution, isopropanol alcohol, and 10 percent nitric acid).

Containerization and handling of solids were performed in two phases. At the completion of drilling activities, soils were temporarily stockpiled on plastic sheeting and covered.

Afterwards, the soils were transported and emptied into a roll-off box for final containerization. Composite samples were then collected from the roll-off box for disposal purposes. The analyses performed were full TCLP and RCRA hazardous waste characteristics.

Liquids generated during the field program were also containerized and handled in two phases. Liquids were initially contained in 55-gallon steel drums, then pumped into a tanker for final containerization. Decontamination fluids, however, remained in drums due to the small volume of liquid and because of the isopropanol alcohol and nitric acid content. Samples of the generated fluids were also collected and analyzed for disposal purposes. These analyses included TCL volatiles and TAL metals (total only). The IDW characterization results and recommended disposal options are provided in Appendix G. These options were implemented at MCB Camp Lejeune the week of July 25, 1993.

3.0 PHYSICAL CHARACTERISTICS OF THE STUDY AREA

This section contains a discussion of the physical characteristics of Site 2 including: surface features, meteorology, surface water hydrology, geology, soils, hydrogeology, land use, ecology, and supply well inventories. This information was obtained from the RI field activities and available literature pertaining to MCB Camp Lejeune.

3.1 Surface Features

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.

The topography of MCB Camp Lejeune is relatively flat with ground surface elevations ranging from msl to 72 feet above msl. Most of MCB Camp Lejeune lies between 20 and 40 feet above msl. The terrain of MCB Camp Lejeune is typical of North Carolina coastal plains. Drainage at MCB Camp Lejeune is generally to the New River and the Atlantic Ocean via the Intracoastal Waterway. Site 2 is a predominantly flat area at approximately 30 feet above msl.

3.2 Meteorology

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

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

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 58° F to 38° F in January and 86° F to 72° F in July. The average relative humidity, between 75 and 80 percent, does not vary greatly from season to season. Observed percentages of relative humidity range from 100 down to 10 or lower.

Observations of sky conditions indicate yearly averages of approximately 112 days clear, 105 partly cloudy, and 148 cloudy. Measurable amounts of rainfall occurs 120 days per year, on the average. Prevailing winds are generally from the south-southwest 10 months of the year, and from the north-northwest during September and October. The average wind speed for coastal observation points in North Carolina is 12 m.p.h (Water and Air Research, 1983).

3.3 Surface Water Hydrology

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

Surface water drainage from Site 2 is predominantly to the north, through drainage ditches which parallel the railroad tracks. Surface water runs intermittently through these ditches during precipitation events. Some small ponding occurs in depressed areas within the ditches.

The drainage ditches empty into Overs Creek, which is located north of Site 2. Overs Creek is a small stream which appears to be fed primarily by discharge from the nearby water treatment plant (Building 670).

The drainage ditch along the railroad tracks drains to Overs Creek which is a tributary to Northeast Creek. This portion of Northeast Creek is classified as SC HQW NSW (NC DEHNR, 1992a, 1992b). The SC classification is for tidal salt waters protected for aquatic life propagation and survival, fishing, wildlife, and secondary recreation. This portion of Northeast Creek has a HQW (High Quality Water) classification because it is designated as a primary fish nursery area by the Marine Fisheries Commission. Finally, the NSW classification is for Nutrient Sensitive Waters which are waters subject to growths of microscopic or macroscopic vegetation requiring limitations on nutrient inputs (NC DEHNR, 1992a, 1992b). Northeast Creek is classified as Inland Waters above, and Coastal Waters below the railroad bridge (NCMFC, 1992).

Overs Creek is classified as an unnamed stream (since it is not named on the USGS Camp Lejeune quadrangle). According to the regulations (NC DEHNR, 1992a, 1992b), any stream which is not named in the schedule of stream classifications carries the same classification as that assigned to the stream segment to which it is a tributary. An exception would be an unnamed freshwater tributary to tidal saltwaters which would be designated as Class C which are freshwaters with the same use designation as Class SC waters. There is not enough data to classify Overs Creek as freshwater, and, therefore for this RI, Overs Creek will be designated as a Class SC saltwater when evaluating the water quality standards. The drainage area along the railroad tracks is intermittent and not tidally influenced, therefore, it will be designated as a Class C freshwater when evaluating the water quality standards. The New River, downstream of Northeast Creek, is designated as Class SC NSW.

The New River, north of a line beginning at a point on Mumford Point at 34° 43' 15" - 77° 25' 00" W; to a point on the west shore at 34° 43' 14" N - 77° 25' 49" W is designated as Class SC, High Quality Water (HQW) (N.C. DEHNR 1992, N.C. MFC 1992). HQW are waters that are rated as excellent based on biological and physical/chemical characteristics through division monitoring or special studies, native and special trout waters (and their tributaries) designated by the Wildlife Resources Commission, primary nursery areas designated by the Marine Fisheries Commission, and other functional nursery areas designated by the Wildlife Resources Commission, critical habitat designated by the Wildlife Resources Commission or the Department of Agriculture, all water supply watersheds which are classified as WS-I or WS-II or those for which a formal petition for reclassification as WS-I or WS-II have been received from the appropriate local government and accepted by the Division of Environmental Management and all Class SA waters (NC DEHNR, 1992). This section of the New River is classified as a primary nursery area, but it is not a water supply.

The 100-year flood plain elevation for this area of MCB Camp Lejeune is approximately 10 feet above msl. Site 2 lies between elevations 30 and 35 feet above msl, therefore, all of Site 2 is above the 100-year flood plain.

Staff gauges were used to determine surface water elevation. Surface water elevation data are presented in Table 3-1. Staff gauge SG6 was installed in surface water on the east side of the

TABLE 3-1

SURFACE WATER ELEVATION
SITE 2 - REMEDIAL INVESTIGATION CTO-0174
MCB CAMP LEJEUNE, NORTH CAROLINA

Staff Gauge	Location	Surface Water Elevation(1), feet above msl (June 5, 1993)	Surface Water Elevation(1), feet above msl (July 30, 1993)
SG5	West side of railroad tracks	28.78	29.74
SG6	East side of railroad tracks	Dry	Dry
SG7	Overs Creek	17.50	15.05

(1) msl - mean sea level

railroad tracks. This water either evaporated or infiltrated into the ground prior to measurements (June 5, 1993, and July 30, 1993). Surface elevation at SG5 is higher than the groundwater elevations in this area (Section 3.6). This indicates that the surface water in this area is most likely related to seasonal precipitation (i.e., ponding of water during rainy periods) and is not a surficial expression of the water table.

There are no monitoring wells in the immediate vicinity of Overs Creek. Groundwater and surface water elevations cannot be compared in this area.

3.4 Geology

The following sections contain the regional geology of MCB Camp Lejeune and the site-specific geology of Site 2.

3.4.1 Regional Geology

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

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

TABLE 3-2

GEOLOGIC AND HYDROGEOLOGIC UNITS IN THE COASTAL PLAIN OF NORTH CAROLINA
REMEDIAL INVESTIGATION CTO-0174
MCB CAMP LEJEUNE, NORTH CAROLINA

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

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

Source: Harned et al., 1989 a or b

3.4.2 Site Geology

Sixty-seven (67) soil borings were advanced (to depths less than 20 feet bgs) within the vicinity of Site 2 to collect soil samples for laboratory analyses and classification purposes. In general, the site is underlain by unconsolidated deposits of silt, sand and clay. These deposits are part of the Quaternary Age "undifferentiated" formation which makes up the surficial aquifer.

One boring was advanced to 100 feet bgs as part of the installation of deep monitoring well 2GW3D. The subsurface geology in the 25 to 95 feet bgs interval is characterized by fine-grained sand with some silt and clay. At 95 feet bgs, fine-grained sand with weathered limestone fragments was detected. This particular lithology (encountered in other MCB Camp Lejeune investigations) is characteristic of the top portion of the Tertiary Age Castle Hayne aquifer.

Hydrogeologic cross-sections depicting shallow subsurface lithologic conditions underlying the site were developed based on information obtained during the drilling program. As shown on Figure 3-2, three cross sections at the site were traversed. In general, cross section A to A' (Figure 3-3) traverses north to south while cross sections B to B' (Figure 3-4) and C to C' (Figure 3-5) traverse east to west.

3.5 Soils

Information regarding the site soil conditions was obtained from the Soil Survey publication prepared by the U.S. Department of Agriculture - Soil Conservation Service (SCS) for MCB Camp Lejeune, North Carolina (SCS, 1984). Due to past grading and surface activities at Site 2, however, the soils described in the SCS publication may differ from current site conditions.

According to the SCS Soil Survey, Site 2 is underlain by a single distinct soil unit. The Baymeade (BmB) fine sand unit is extensive throughout MCB Camp Lejeune and occurs in areas with moderately convex slopes (0 to 6 percent) near major drainageways. Commonly found in wooded areas, BmB fine sands exhibit rapid infiltration and slow surface water runoff. Typically, available water capacity is low and the seasonal high water table ranges from 4 to 5 feet below ground surface. The BmB unit is well suited for unsurfaced roads and light duty traffic areas.

The soil unit bordering Site 2 on three sides, to the east, north, and south, is the Woodington (Wo) loamy fine sand. This nearly level, poorly-drained soil is commonly found on broad interdrainage uplands. Infiltration of this soil unit tends to be moderate and surface water runoff slow. Woodington soils typically have a seasonal high water table that approaches 0.5 feet below ground surface and are subjected to occasional surface water ponding. Compaction of its loamy surface and the relatively high moisture content of the WO unit limits its use to that of light-duty vehicle and foot traffic.

A summary of soil physical properties is presented on Table 3-3.

3.6 Hydrogeology

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

3.6.1 Regional Hydrogeology

The surficial aquifer is a series of sediments, primarily sand and clay, which commonly extend to depths of 50 to 100 feet. This unit is not used for water supply (Harned et al., 1989 a or b).

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

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 upcoming of saltwater to occur. The aquifer contains water having less than 250 milligrams per liter (mg/L) chloride throughout the area of MCB Camp Lejeune (Harned et al., 1989 a or b).

TABLE 3-3

SUMMARY OF PHYSICAL PROPERTIES
Site 2 - REMEDIAL INVESTIGATION CTO-0174
MARINE CORPS BASE, CAMP LEJEUNE, NORTH CAROLINA

Soil Name	Soil Symbol	Depth (inches)	USCS Classification	Moist Bulk Density (g/cc)	Permeability (cm/s)	Soil Reaction (pH)	Shrink-Swell Potential	Organic Matter (percent)
Baymeade	BmB	0 - 30	SM, SP-SM	1.60 - 1.75	4.2×10^{-2} - 1.4×10^{-1}	4.5 - 6.5	Low	0.5 - 1.0
Baymeade	BmB	30 - 56	SC, SM, SM-SC	1.45 - 1.60	1.4×10^{-2} - 4.2×10^{-2}	4.5 - 6.5	Low	--
Baymeade	BmB	56 - 80	SM, SP-SM	1.60 - 1.75	4.2×10^{-2} - 1.4×10^{-1}	4.5 - 6.5	Low	--
Woodington	Wo	0 - 12	SM	1.50 - 1.70	4.2×10^{-2} - 1.4×10^{-1}	3.6 - 5.5	Low	2 - 4
Woodington	Wo	12 - 80	SM	1.45 - 1.65	1.4×10^{-2} - 4.2×10^{-2}	3.6 - 5.5	Low	--

Source: Soil Survey: Camp Lejeune, North Carolina, U.S. Department of Agriculture - Soil Conservation Service (SCS,1984).

Notes:
SM - Loamy Fine Sand
SP - Fine Sand
SC - Fine Sandy Loam
-- - Not Estimated
g/cc - grams per cubic centimeter

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

Rainfall that occurs 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, ground water flows in the direction of lower hydraulic head, moving through the system to discharge areas such as the New River and its tributaries or the Atlantic Ocean.

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 a or b).

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

3.6.2 Site Hydrogeology

As described in Section 3.4, the shallow subsurface portion of the site is characterized by unconsolidated deposits of silt, sand and clay, which characterize the surficial aquifer. These conditions are consistent with the regional hydrogeologic framework described in USGS publications (Harned, et al., 1989 a or b), and encountered during previous investigations conducted by Baker at MCB Camp Lejeune.

Monitoring well 2GW3D was advanced to a depth of 100 feet bgs through the surficial aquifer (approximately 0-90 feet bgs) and into the upper portion of the Castle Hayne aquifer (below 90 feet bgs). The deeper portion of the surficial aquifer is characterized by fine-grained sand with some silt and clay.

Groundwater conditions at the site were evaluated by installing six shallow (2GW6, 2GW7, 2GW8, 2GW9, 2GW10 and 2GW11; less than 15 feet bgs) and one deep monitoring well (2GW3D 100 feet bgs). During the drilling program, groundwater was encountered from approximately 3 to 5 feet bgs. Three rounds of groundwater level measurements (May 17, 1993; May 20, 1993; and June 20, 1993) were obtained during the investigation (Table 3-4).

In addition to the four shallow monitoring wells installed during this investigation, five previously installed shallow (2GW1, 2GW2, 2GW3, 2GW4 and 2GW5; 25 feet bgs) monitoring wells are present on site. These monitoring wells were installed by ESE, Inc. during the verification step of the Confirmation Study in July 1984.

Groundwater elevations measured in the previously existing monitoring wells deviate from these installed during this investigation (Table 3-4). It is not expected that this deviation is due to actual hydrogeologic conditions (the new and existing wells are screened in the same portion of the aquifer) but rather are attributable to decreased efficiency of the existing monitoring wells. This decrease in efficiency may be the result of constriction of the screen slots by compaction, siltation or bacteria buildup over time (these wells are over nine years old). Although the existing monitoring wells generally exhibited sufficient flow to allow for collection of groundwater quality samples, subsequent evaluation of groundwater flow will be limited to data collected from the newly installed monitoring wells.

Contour maps depicting groundwater flow patterns within the surficial aquifer at Site 2 are presented as Figures 3-6, 3-7, and 3-8 for May 17, May 20, and June 5, respectively. As shown on these figures, groundwater flow on-site is generally to the northeast.

The average horizontal groundwater gradient across the site was calculated based on the June 5, 1993, groundwater level data. Based on these measurements, the average horizontal groundwater gradient across the site is 0.005 feet/feet. The low gradient indicates a relatively flat water table. The water table appears to slope gradually toward the northeast.

Groundwater flow in the deeper portion of the subsurface was not evaluated (there is only one deep monitoring well - 2GW3D - on site). It is expected that deep groundwater flow at Site 2 is generally toward the New River (west). The groundwater elevation in the one deep monitoring well (2GW3D) can be compared with groundwater elevation data in the shallow monitoring wells to evaluate the general groundwater vertical gradient. The elevation of groundwater in the deep monitoring well is approximately 3 feet above msl. The elevation of

TABLE 3-4

GROUNDWATER ELEVATIONS
SITE 2 - REMEDIAL INVESTIGATION CTO-0174
MCB CAMP LEJEUNE, NORTH CAROLINA

Well Number	Top of PVC	5/17/93 Recorded Groundwater Level (SWL)	5/17/93 Groundwater Elevation, feet above msl	5/20/93 Recorded Groundwater Level (SWL)	5/20/93 Groundwater Elevation, feet above msl	6/5/93 Recorded Groundwater Level (SWL)	6/5/93 Groundwater Elevation, feet above msl
2-GW7(1)	34.03	5.85	28.18	6.02	28.01	7.18	26.85
2-GW8(1)	34.92	5.45	29.47	5.45	29.47	6.76	28.16
2-GW6(1)	34.40	5.36	29.04	5.70	28.70	7.07	27.33
2-GW9(1)	35.02	6.22	28.80	6.46	28.56	8.00	27.02
2-GW3D(1)	36.07	33.45	2.62	33.45	2.62	35.31	0.76
2-GW1(2)	34.15	9.85	24.30	9.85	24.30	19.04	15.11
2-GW2(2)	34.15	26.24	7.91	26.24	7.91	27.50	6.65
2-GW3(2)	35.40	7.30	28.10	7.30	28.10	14.00	21.40
2-GW4(2)	32.73	7.75	24.98	7.30	25.43	20.19	12.54
2-GW5(2)	33.72	13.05	20.67	12.90	20.82	16.59	17.13

Notes: (1) Monitoring well installed during this investigation.
(2) Existing monitoring well.
Monitoring well 2GW3D is a deep well (100 feet)
SWL -
msl - mean sea level

the shallow groundwater ranges from 26 to 29 feet above msl. This indicates that the hydraulic head in the deeper part of the aquifer is lower than in the shallow. It also indicates that any vertical component of groundwater flow would be in the downward direction. This pattern is typical of groundwater in recharge areas. The topography of Site 2 also supports the suggestion that it is a groundwater recharge area. Typically, groundwater recharge areas are in higher elevations than the streams and rivers (e.g., New River) that are groundwater discharge areas.

Aquifer characteristics (i.e., hydraulic conductivity, transmissivity) at Site 2 were not determined during this investigation. A recent hydrogeologic investigation was conducted by Dewberry and Davis, Inc. (September, 1992) at a proposed sanitary landfill less than 2 miles south of Site 2. In situ hydraulic conductivity tests were conducted in shallow monitoring wells as part of this investigation. The results of these tests indicate a range of hydraulic conductivity values from 2.1×10^{-3} to 3.7×10^{-4} cm/s. An aquifer test was conducted by Baker (1993) in the shallow aquifer at Hadnot Point Industrial Area (approximately 2.5 miles south of Site 2). Results of this test indicated a hydraulic conductivity of 8×10^{-4} cm/s and a transmissivity of 561 gallons per day/foot.

Aquifer characteristics for the deeper aquifer, which provides the base water supply, have been determined through long-term well performance tests (Harned, et al., 1989 a or b). For the deeper aquifer, hydraulic conductivity values ranged from 14 to 82 feet/day and transmissivity value ranged from 32,000 to 183,000 gallons per day/foot.

3.7 Land Use and Demography

MCB Camp Lejeune encompasses an area of approximately 110,000 acres and is comprised of several distinct areas of development including Hadnot Point, MCAS/Camp Geiger, French Creek, and Courthouse Bay. The installation border is approximately 70 miles in length, which includes 17 miles of ocean front and Intracoastal Waterway. According to the base Master Plan (1988), it has been recommended that an additional 52,00 acres of land west of MCB Camp Lejeune be acquired to meet range and maneuver needs.

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

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

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

There are no housing areas within the borders of Site 2. The only building on site (Building 712) is used for base administrative purposes.

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

3.8 Ecology

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

MCB Camp Lejeune is approximately 110,000 acres, with 84 percent of the area covered by forests.

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

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

The U.S. Fish and Wildlife Service (FWS) prepares National Wetland Inventory (NWI) maps. The NWI map for the Camp Lejeune, North Carolina quadrangle was prepared primarily by stereoscopic analysis of high altitude aerial photographs. The wetlands were identified on the photographs based on vegetation, visible hydrology, and geography in accordance with classification of Wetland and Deep-Water Habitats of the United States (An Operational Draft), (Cowardin, et al., 1977) (USDI, 1982). NWI maps are intended for a cursory identification of wetland areas. They cannot be substituted for an actual wetland delineation that may be required by Federal, State and Local regulatory agencies. No wetlands have been identified adjacent to Site 2 from the NWI map.

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

Many protected species have been sited near and on MCB Camp Lejeune. Table 3-5 contains a list of these protected species (either endangered, threatened, or special concern) that have been identified within the boundaries of MCB Camp Lejeune. (USMC, 1991), (LeBlond, 1991), (Fussell, 1991), and (Walters, 1991).

TABLE 3-5

PROTECTED SPECIES WITHIN MCB CAMP LEJEUNE
SITE 2 - REMEDIAL INVESTIGATION CTO - 0174
MCB CAMP LEJEUNE, NORTH CAROLINA

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

A Peregrine falcon was spotted approximately five miles southeast of Site 2 (Fussell, 1991). These birds potentially may inhabit or feed in areas surrounding Site 2 because of their large foraging range. Black skimmers and piping plovers were observed near the New River Inlet (Fussell, 1991). However, these birds primarily inhabit shore line areas and, therefore, are not expected to be found at Site 2. Bachmans sparrows and red-cockaded woodpeckers were observed at numerous locations throughout southern MCB Camp Lejeune. None of these species were observed at Site 2 during intensive investigations previously conducted for MCB Camp Lejeune, therefore, there is a low potential for them to exist at Site 2 (Fussell, 1991; Walters, 1991).

3.8.1 Other Sensitive Environments

In addition to wetlands and protected species, the presence of other sensitive environments, including those listed in 40 CFR Part 300, were evaluated. These sensitive environments are evaluated when assessing potential hazardous waste sites using the Hazard Ranking System. These sensitive environments and their presence or absence at Site 2 are discussed below.

- Marine Sanctuary - Site 2 is not located within a Marine Sanctuary (NCMFC, 1992).

- National Park - Site 2 is not located within a National Park (NPS, 1991).

- Designated Federal Wilderness Area - Site 2 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). This portion of Northeast Creek downstream of Overs Creek is designated as coastal waters by the Marine Resources Commission (NCMFC, 1992). Since Overs Creek is an unnamed tributary to Northeast Creek, it carries the same coastal waters designation as Northeast Creek. Activities in coastal waters, along with any land disturbing activities (e.g., construction, digging, etc.) within the water and within the 75 feet buffer zone will require a permit or authorization under CAMA (NC DEHNP, 1993a).

- Sensitive Areas Identified under the National Estuary Program (NEP) or Near Coastal Waters Program (NCWP) - Site 2 is not located within a Sensitive Area identified under the NEP or NCWP (USEPA, 1993).

- Critical Areas Identified under the Clean Lakes Program - Site 2 is not located within a Critical Area identified under the Clean Lakes Program (NPS, 1991).

- National Monument - Site 2 is not located within a National Monument (NPS, 1991).

- National Seashore Recreational Area - Site 2 is not located within a National Seashore Recreational Area (NPS, 1991).

- National Lakeshore Recreational Area - Site 2 is not located within a National Lakeshore Recreational Area (NPS, 1991).

- National Preserve - Site 2 is not located within a National Preserve (NPS, 1991).

- National or State Wildlife Refuge - Site 2 is not located within a National or State Wildlife Refuge (NCWRC, 1992).

- Unit of the Coastal Barrier Resource Program - Site 2 is not located within a unit of the Coastal Barrier Resource Program (USDI, 1993).

- Administratively Proposed Federal Wilderness Area - Site 2 is not located within an Administratively Proposed Federal Wilderness Area (WS, 1989, 1993).

- Spawning Areas Critical for the maintenance of fish/shellfish species within river, lake, or coastal tidal waters - There are probably spawning areas for resident fish species within the lower reacher of Overs Creek. However, specific spawning areas critical for the maintenance of fish/shellfish species in Overs Creek have not been designated by state agencies (NC DEHNR, 1993b).

- 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 - Site 2 is not a migratory pathway or feeding area critical for the maintenance of anadromous fish species because there is not a significant population of anadromous fish in Overs Creek, Northeast Creek, or the New River downstream of Northeast Creek (NC DEHNR, 1993b).

- Terrestrial areas utilized for breeding by large or dense aggregations of animals - As discussed in the Regional Ecology section of this report, several large and dense aggregations of terrestrial species inhabit MCB Camp Lejeune. Therefore, there is the potential for breeding of these animals on, or adjacent to Site 2. However, because the areas of highest contamination are in the open field and drainage ditch, the potential for breeding by terrestrial animals in contaminated areas will be limited.

- National river reach designated as Recreational - Overs Creek or Northeast Creek are not designated as National Recreational Rivers (NPS, 1990, 1993).

- Federal designated Scenic or Wild River - Overs Creek or Northeast Creek are not Federally designated Scenic or Wild Rivers (NPS, 1990, 1993).

- State land designated for wildlife or game management - Site 2 is not located within a State game land (NCWRC, 1992).

- State designated Scenic or Wild River - Overs Creek or Northeast Creek are not State designated Scenic or Wild Rivers (NCMFC, 1992).

- State designated Natural Area - Site 2 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 2 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, 1992b). However, it should be noted that the section of Northeast Creek in which Overs Creek discharges, is designated as a primary nursery area by the Marine Fisheries Commission (NC DEHNR, 1992b).

- Areas of Significant Value - Site 2 is not located within a State Area of Significant Value (LeBlond, 1991).

- State Registered Natural Resource Area - Site 2 is not located within a State Registered Natural Resource Area (LeBlond, 1991).

3.9 Identification of Water Supply Wells

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

The water supply wells are all located within the boundaries of the Base. The average water supply well at the base has a depth of 162 feet, a casing diameter of 8 inches, and yields 174 gpm (Harned, et al., 1989 a or b).

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

There are four water supply wells located in the vicinity of Site 2: 616, 645, 646, and 647. The locations of these supply wells are illustrated in Figure 3-9. Supply well construction specifications are presented on Table 3-6.

Given the distance of these wells in relationship to Site 2 (over 900 feet) and local geological/hydrogeological conditions, it is unlikely that contaminants, (if present) at Site 2 would migrate to these supply wells and impact the drinking water.

A wellhead management program engineering study was recently conducted for MCB Camp Lejeune (Geophex, 1991). Volatile organic compound contamination was detected in several water supply wells on base, particularly in developed areas (e.g., Hadnot Point). Of the four water supply wells located in the vicinity of Site 2, only supply well 645 had VOCs detected in it (low concentrations of benzene that may have resulted from leakage of the back up generators 200-gallon fuel tank located next to the well pad).

TABLE 3-6

SUPPLY WELL CONSTRUCTION SPECIFICATIONS
SITE 2 - REMEDIAL INVESTIGATION CTO-0174
MCB CAMP LEJEUNE, NORTH CAROLINA

Well #	Depth (feet)	Screened Interval(s) (feet)	Well Diameter (inches)
616	170	95-115 130-140 160-170	8
645	245	90-100 138-148 230-240	10
646	270	90-100 240-250 255-265	10
647	200	105-115 138-143 175-190	10

The wellhead management program engineering study has identified the general vicinity of Site 2 as a proposed groundwater preservation area that should be considered as a potential wellfield site (Geophex, 1991).

4.0 NATURE AND EXTENT OF CONTAMINATION

This section presents laboratory analytical results from the remedial investigation performed at Operable Unit No. 5, Site 2. The objectives of this section are to characterize the nature and delineate the extent of site contamination. The Site 2 characterization was conducted through environmental sample collection and analysis of the following media: soil, groundwater, sediment, and surface water.

Section 4.1 identifies probable source areas of site contamination and addresses potential sample interference from base operations. The analytical results, presented in Section 4.2, are grouped according to environmental investigation (e.g., soil investigation, groundwater investigation, etc.). Within each investigative subsection the analytical data from individual areas of concern are summarized (e.g., Mixing Pad Area, Former Storage Area, Overs Creek). In addition to analytical results, Section 4.2 provides a baseline reference analysis from which non-site related contaminants were identified within the sample set. Section 4.3 describes the extent to which contaminants have migrated from probable source areas and the potential for future migration. A summary of the nature and extent of site contamination is provided in Section 4.4.

Appendices H.1 through H.11 and I.1 through I.10 present analytical laboratory results, statistical data summaries, laboratory QA/QC results, and chain-of-custody forms. Figures 4-1 through 4-18 provide a graphical depiction of organic and inorganic contaminants as they occur throughout the site. Positive detections of organic compounds and inorganic constituents within individual areas of concern and according to media are presented in summary tables included at the end of this section.

Analytical results for the second round of groundwater samples, which include samples from monitoring wells 2GW10 and 2GW11, are presented in Appendix H.12. These samples were collected to provide additional confirmatory information for remedial design. The results have not been subjected to data validation and are not incorporated in the human health or ecological risk assessments.

4.1 Source Areas

Previous site operations have impacted environmental media at Site 2. This has been documented through site records, environmental investigations and historical aerial photographs. There are three general sources of contamination at Site 2:

- Lawn and Mixing Pad Areas
- Former Storage Area
- General Base-wide Spraying of Pesticides

4.1.1 Lawn and Mixing Pad Areas

The Building 712 Area has documented usage of pesticides and herbicides. The concrete pads located behind Building 712 were reportedly used for mixing pesticide and herbicide sprays, and for cleaning spraying equipment. Releases to the environment would have occurred as a result of small spills, washout and excess disposal.

In addition to pesticide/herbicide releases, petroleum hydrocarbons used at the mixing pads may also have been released to the environment. Diesel fuel was commonly used as a spraying agent for herbicides (Shaw, 1993). Diesel fuel, or some other petroleum hydrocarbon, may have been used to operate and clean the spraying equipment.

4.1.2 Former Storage Area

The Former Storage Area may be unrelated to the Building 712 Mixing Pad Area with respect to past waste handling activities. There is no information available to determine what kinds of waste handling activities occurred in this area. Historical aerial photographs included in the EPIC Study depict stained soils and the storage of bulk materials and containers at the Former Storage Area. A crane, which may have been used to unload cargo from railcars, is also shown in one of the photographs.

The results of previous investigations (ESE, 1990) indicate that shallow groundwater at the Former Storage Area is contaminated with ethylbenzene and xylenes. Possible sources of this contamination include:

- Surface Fuel Spill
- Fuel leaks from crane or other equipment stored in this area
- Herbicide spraying agent

4.1.3 General Base-wide Spraying of Pesticides and Herbicides

Historically, pesticide and herbicide spraying has been widespread at MCB Camp Lejeune. Prior to 1972, 4,4'-DDT, 4,4'-DDD, and 4,4'-DDE were used as common pesticides (their use was banned after 1972). These pesticides have been detected, in low concentrations, in soil samples collected base-wide during previous investigations (ESE, 1990; Baker, 1993).

Pesticides detected in areas not impacted by site activities (e.g., the Former Storage Area) may be attributable to general base-wide spraying and not as a result of pesticide mixing and handling on site.

4.2 Analytical Results

This section presents the results of the laboratory analysis conducted on samples collected as part of the soil, groundwater, and surface water/sediment investigations. Analytical parameters can be segregated into two broad categories: TCL organics and TAL inorganics.

The organic parameters that these samples were analyzed for are not expected to occur naturally at Site 2. The organics detected in these samples can be attributed to either contamination from site operations or to sampling/laboratory contamination. Laboratory contaminants are discussed in Section 4.2.1.1. Common laboratory contaminants include acetone, methylene, chloride and bis-d-ethylbenzene/phthalate (USEPA, 1989a). The discussion of organic parameter analytical results in this section will be limited to those parameters directly attributable to site operations.

Unlike the organics, many of the inorganic parameters that these samples were analyzed for do occur naturally. For example, lead is an element that occurs naturally in most soils (in low concentrations) but is also considered a contaminant if its concentration is well above background levels and its presence can be attributable to site operations (e.g., lead in gasoline). In order to accurately present the nature and extent of inorganic contamination at Site 2, those detected inorganic parameters that are naturally occurring on site must be segregated from those that can be attributed to site operations. Naturally occurring inorganic elements in soil, groundwater, surface water and sediments are discussed in the following subsections.

4.2.1 Non-Site Related Analytical Results

Many of the organic compounds and inorganic constituents detected in the various environmental media investigations are attributable to non-site related conditions. Two primary sources of this include laboratory (blank) contaminants and naturally occurring inorganic elements.

4.2.1.1 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 blanks were compared with concentrations of the same chemicals detected in environmental samples.

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

Acetone	29 (µg/L)
Methylene Chloride	27 (µg/L)
2-Butanone	13 (µg/L)
Di-n-butylphthalate	10J (µg/L)
bis-(2-Ethylhexyl)phthalate	52J (µg/L)

Note the "J" qualifier is a denotation of the reported sample concentration value that has been estimated. Blanks containing organic constituents that are not considered common laboratory contaminants (i.e., all other TCL compounds) were considered non-blank contaminated when observed concentrations exceeded five times the maximum concentration detected in any blank (USEPA, 1898a). All TCL compounds at less than five times the maximum level of contamination noted in any blank cannot be attributed specifically to the site. The maximum concentrations of all other detected blank contaminants are as follows:

Chloroform	5J (µg/L)
Bromodichloromethane	5J (µg/L)
Dibromodichloromethane	3J (µg/L)

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

4.2.1.2 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) are compared to information regarding background conditions at MCB Camp Lejeune and to applicable regulatory levels. The following guidelines are used for each media:

Soil:	MCB Camp Lejeune Background Samples
Groundwater:	State Groundwater and Federal Drinking Water Standards
Surface Water:	State and Federal Surface Water Quality Standards
Sediment:	EPA Region IV Sediment Screening Criteria

Soil

Typical concentration values for inorganic elements in soils at MCB Camp Lejeune are presented in Section 6. These ranges are based on analytical results of background (collected in areas not impacted by site operations) samples collected at MCB Camp Lejeune during this and previous investigations. In the subsequent sections, which discuss the analytical results of samples collected during the soil investigation, only those inorganic parameters with concentrations exceeding these ranges will be considered.

Groundwater

Unlike soil, there is no extensive data base of groundwater background samples at MCB Camp Lejeune. In the subsequent sections which discuss the analytical results of samples collected during the groundwater investigation, only those inorganic parameters with concentrations exceeding applicable State or Federal regulations will be discussed. It is understood that State and Federal regulations are health based limits and do not reflect the natural concentrations of compounds within the groundwater. This is used as a general approximation only.

Groundwater samples were analyzed for total and filtered ("dissolved") inorganic parameters. Concentrations of filtered inorganics were found to be generally lower than total inorganics for each sample. Filtering (with a 45-micron filter) in the field removes small particles of silt and clay that would otherwise be dissolved during sample preservation and generate an in ordinarily high apparent value of dissolved metals in the groundwater. The total, or unfiltered samples, thus reflect the concentrations of inorganics in the natural lithology in addition to inorganics dissolved in and transportable by groundwater.

Relatively high concentrations of metals in unfiltered groundwater are expected, the difference between the two analytical results are important in terms of understanding and separating naturally occurring elements (such as lead) from contamination by site operations (such as lead in gasoline).

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

Monitoring well 2GW9 was installed 250 feet north of Site 2. This is outside of the Site 2 operational area and is expected to represent background conditions. Inorganic parameter concentrations in 2GW9 are similar to those encountered at other Site 2 monitoring wells.

Groundwater in the MCB Camp Lejeune area is naturally rich in manganese. Manganese concentrations (total and filtered) in groundwater at MCB Camp Lejeune often exceed the

North Carolina Water Quality Standard (NCWQS) of 50 µg/L (Greenhorne and O'Mara, 1992). Manganese concentrations from several wells at Site 2 exceed the NCWQS but fall within the range of concentrations for samples collected elsewhere at MCB Camp Lejeune. There is no record of any historical use of manganese at Site 2. In light of this, it is assumed that manganese is a naturally occurring inorganic element in groundwater, and its presence is not attributable to site operations.

Sediment

There is no database of background sediment samples at MCB Camp Lejeune. In the subsequent sections which discuss the analytical results of samples collected during the sediment investigation, only those inorganic parameters with concentrations exceeding EPA Region IV Sediment Screening Criteria will be considered. As with inorganic parameters in groundwater samples, as a general approximation, inorganic parameters detected below these levels are assumed to be naturally occurring elements.

Sediment sample stations RRSD-01 and RR-SD02 are located upstream of Site 2 in the Railroad Tracks Drainage Ditches. Sediment sample station OCSD-01 is located in Overs Creek, upstream of the point where the drainage ditches empty into Overs Creek. Inorganic parameter concentrations in these samples are similar to those encountered at other Site 2 sediment sampling stations.

Surface Water

There is no database of background surface water samples at MCB Camp Lejeune. In the subsequent sections which discuss the analytical results of samples collected during the surface water investigation, only those inorganic parameters with concentrations exceeding applicable State or Federal guidelines will be considered. Inorganic parameters detected below these levels are assumed to be naturally occurring elements.

Overs Creek is subject to saltwater quality standards and the drainage ditches along the railroad tracks are subject to fresh water quality standards (see Section 3.3 for a discussion of freshwater and saltwater classifications).

Surface water sample OCSW-01 is located in Overs Creek, upstream of the point where the Railroad Tracks Drainage Ditches empty into Overs Creek. Inorganic parameter concentrations in this sample are similar to those encountered at other Site 2 surface water sampling stations. Surface water was encountered in discrete areas within the Railroad Drainage Ditches (puddles), thus no evaluation of upstream versus downstream surface water inorganic concentrations was made.

4.2.2 Soil Investigation

This section presents analytical results from the soil investigation performed at Site 2. Two areas of concern were identified, the Building 712 area, which includes the Lawn and Mixing Pad Areas and the Former Storage Area.

4.2.2.1 Lawn and Mixing Pad Areas

Soil analytical results represent samples collected within the Law and Mixing Pad Areas.

Surface Soils

Analytical results from surface soils collected within the Lawn and Mixing Pad Areas indicate the presence of organic contamination. Positive detection summaries for both organic compounds and inorganic constituents in surface soils are presented on Tables 4-1 and 4-2, provided at the end of this section. A summary of the complete Lawn and Mixing pad Areas Surface Soil analytical results, including the concentration range of contaminants, frequency of occurrence, and statistical summary is provided in Appendices H.1, H.3, I.1 and I.3. The following summarizes the range of positive detections for organic compounds detected in the Lawn and Mixing Pad Areas:

- Pesticides including heptachlor, dieldrin, 4,4'-DDE, 4,4'-DDD, 4,4'-DDT, alpha-chlordane, and gamma-chlordane were detected throughout the Mixing Pad and Lawn Areas. Forty-three of 46 soil samples contained detectable concentrations of at least one pesticide. The concentration range of detected pesticides are as follows (sample location of maximum shown in parentheses)

▸ Heptachlor	80J µg/kg	(2-MP-SB07 only)
▸ Dieldrin	1400 µg/kg	(2-MP-SB14 only)
▸ 4,4'-DDE	4.9 - 30,000 µg/kg	(2-MP-SB04 and 2-MP-SB23)
▸ 4,4'-DDD	9.8J - 1,200,000 µg/kg	(2-MP-SB14)

4,4'-DDT	5J - 3,000,000 µg/kg	(2-MP-SB04)
alpha-chlordane	4.3J - 3,900J µg/kg	(2-MP-SB07)
gamma-chlordane	5.2 - 3,400J µg/kg	(2-MP-SB07)

- Toluene was detected in soil boring 2-MP-SB28 at a concentration of 6J µg/kg. Xylenes (total) were detected in a total of 4 borings ranging from 4J - 5J µg/kg.

Twenty of 24 inorganics were detected in surface soils. Antimony, nickel, silver, and cyanide were not detected within the sample set. Aluminum, barium, calcium, copper, iron, lead, magnesium, manganese, potassium, sodium, and vanadium were detected in all of the surface soil samples. The following summarizes the concentration range of selected inorganic constituents detected above base specific reference levels within the Mixing Pad and Lawn Areas (sample location of maximum shown in parentheses):

			Reference Level (2 X Average)
Arsenic	0.52 B - 4.3J mg/kg	(2-MP-SB04)	0.8 mg/kg
Chromium	3 - 12.7 mg/kg	(2-MP-SB08)	2.0 mg/kg
Lead	5.7J - 225 mg/kg	(2-MP-SB04)	45.4 mg/kg
Magnesium	109B - 1,850J mg/kg	(2-MP-SB16)	146.3 mg/kg
Manganese	2.1 B - 63.9 mg/kg	(2-MP-SB04)	14.3 mg/kg
Mercury	0.25 - 0.69 mg/kg	(2-MP-SB04)	0.1 mg/kg

Overall, pesticides were detected in surface soils at widely varying concentrations throughout the Lawn and Mixing Pad Areas. The surface soils surrounding both mixing pads had particularly high concentrations of the pesticides including 4,4'-DDE, 4,4'-DDD, and 4,4'-DDT. As stated previously, the two mixing pads were used to mix pesticides. The remaining majority of surface soil borings within the sampling grid had substantially lower concentrations of pesticides.

Concentrations of VOCs were detected in a limited number of samples at low levels (i.e., less than 12 µg/kg) within the sampling grid.

Inorganics were detected within the Lawn and Mixing Pad Areas above reference sample ranges for surface soils at MCB Camp Lejeune. Inorganics which exhibited concentrations above reference levels include aluminum, arsenic, calcium, chromium, copper, iron, lead, magnesium, manganese, mercury, potassium, sodium, vanadium, and zinc. Although inorganic contaminant levels exceeded reference levels, the concentrations were generally within the same order of magnitude as reference samples.

Subsurface Soils

Analytical results from subsurface soils collected within the Lawn and Mixing Pad Areas sampling grids also indicate the presence of organic contamination. Positive detection summaries for both organic compounds and inorganic constituents in subsurface soils are presented on Tables 4-3 and 4-4, respectively. A summary of the complete Lawn and Mixing Pad Area subsurface soil analytical results, including the concentration range of contaminants, frequency of occurrence, and statistical summary is provided in Appendices H.2, H.4, I.2 and 2.4. The following summarizes the range of positive detections for organic compounds:

- Pesticides including heptachlor, 4,4'-DDE, 4,4'-DDD, 4,4'-DDT, alpha-chlordane, and gamma-chlordane were detected throughout the sampling grid. Thirty-seven of 46 soil borings contained detectable concentrations of at least one pesticide in subsurface soil. The range, sampling depth, and maximum concentrations of detected pesticides are as follows (sample location of maximum shown in parentheses):

▸ Heptachlor	190J µg/kg	(2-MP-SB07 only - 4'-6')
▸ 4,4'-DDE	4.6J - 6,300J µg/kg	(2-MP-SB17A - 2'-4')
▸ 4,4'-DDD	4.2J -130,000 µg/kg	(2-MP-SB17 - 4'-6')
▸ 4,4'-DDT	4J -82,000 µg/kg	(2-MP-SB18 - 4'-6')
▸ alpha-Chlordane	2.2 - 2,500 µg/kg	(2-MP-SB07 - 4'-6')
▸ gamma-Chlordane	2.4 -2,300 µg/kg	(2-MP-SB07 - 4'-6')

- SVOCs were detected in two of the 11 subsurface soil samples collected within the Lawn and Mixing Pad Areas. The associated soil borings are located adjacent to the southern mixing pad. SVOC analytical results from the two soil borings, 2-MP-SB16 and 2-MP-SB24, are summarized as follows:

	2-MP-SB16 (4'-6')	2-MP-SB24 (4'-6')
Naphthalene	4800 µg/kg	130J µg/kg
2-Methylnaphthalene	14,000 µg/kg	1,000 µg/kg
Acenaphthene	360J	ND
Fluorene	700 µg/kg	160J µg/kg
n-Nitrosodiphenylamine	1000 µg/kg	340J µg/kg
Phenanthrene	1500 µg/kg	350J µg/kg
Anthracene	150J µg/kg	ND
Fluoranthene	160J µg/kg	ND
Pyrene	160J µg/kg	ND

- 4-methyl-2-pentanone was detected in soil boring 2-LA-SB02 at a concentration of 12J µg/kg. Total xylenes were detected in 2 soil borings with a maximum concentration of 4,100 µg/kg, from sample location 2-MP-SB16 (4 to 6 feet). Acetone was detected at 1,800J µg/kg from sample location 2-MP-SB24. Sample 2-MP-SB16 also yielded 2-butanone at a concentration of 1,100J µg/kg. The volatile fractions of samples 2MP-SB16 and 2-MP-SB24 underwent a medium level sample preparation (see Section 4.2.1.1).

Seventeen of 24 inorganics were detected in subsurface soils. Antimony, cadmium, nickel, selenium, silver, thallium, and cyanide were not detected within the sample set. Aluminum, barium, calcium, iron, lead, potassium, sodium, and vanadium were detected in each of the subsurface soil samples. The following summarizes the concentration range and sampling depths of selected inorganic constituents detected above reference levels within the Lawn and Mixing Pad Areas (sample location of maximum shown in parentheses):

			Reference Level (2 X Average)
Chromium	2.4 - 15.1 mg/kg	(2-LA-SB09 - 2-4')	8.7 mg/kg
Lead	2.9J - 82.1 mg/kg	(2-LA-SB09 - 2-4')	9.1 mg/kg
Manganese	2.2 B - 12.5 mg/kg	(2-LA-SB09 - 2-4')	6.2 mg/kg
Zinc	1.9J - 29.1J mg/kg	(2-MP-SB09 - 4-6')	0.9 mg/kg

Pesticides were detected in subsurface soils at varying concentrations throughout the Lawn and Mixing Pad Areas. The subsurface soils surrounding both mixing pads had particularly elevated concentrations of the pesticides including 4,4'-DDE, 4,4'-DDD, and 4,4'-DDT. The remainder of subsurface soils collected throughout the sampling grid had substantially lower concentrations of pesticides.

SVOCs were detected in two of 11 subsurface soil sampling locations. Both borings 2-MP-SB16 and 2-MP-SB24 are located directly adjacent to the southern mixing pad. Naphthalene, 2-methylnaphthalene, n-nitrosodiphenylamine, and phenanthrene were detected at concentrations exceeding 1,000 µg/kg.

Acetone, 2-butanone, and total xylenes have also been identified at sampling locations 2-MP-SB16 and 2-MP-SB24, which are located adjacent to the southern mixing pad. Each VOC was detected at a concentration exceeding 1,000 µg/kg. Total xylenes and 4-methyl-2-pentanone were detected in a limited number of samples at low levels (i.e., less than 10 µg/kg) within the sampling grid.

Inorganics were detected within the sampling grid above reference sample ranges for surface soils at MCB Camp Lejeune. Inorganics which exhibited concentrations above reference levels include beryllium, calcium, chromium, cobalt, copper, lead, magnesium, manganese, potassium, sodium, and zinc. Although inorganic contaminant levels exceeded reference levels, the concentrations were within the same order of magnitude as reference samples.

4.2.2.2 Former Storage Area

This section presents analytical results for soil samples collected from soil borings within the Former Storage Area and from soil borings converted into groundwater monitoring wells.

Surface Soils

Analytical results from surficial soil samples collected within the Former Storage Area indicate the presence of organic contamination. Positive detection summaries for both organic compounds and inorganic constituents in surface soils are presented on Tables 4-5 and 4-6, attached to this section. A summary of the complete Former Storage Area surface soil analytical results, including the concentration range of contaminants, frequency of occurrence, and statistical summary is provided in Appendices H.5 and I.5. The following summarizes the range of positive detections for organic compounds detected in the Former Storage Area:

- Pesticides including 4,4'-DDE, 4,4'-DDD, and 4,4'-DDT were detected in surface soil samples collected within the Former Storage Area. All five of the surface soil samples contained detectable amounts of at least one pesticide. The concentration range of detected pesticides are as follows (sample location of maximum shown in parentheses).

4,4'-DDE	76 - 230J µg/kg	(2-FSA-SB06)
4,4'-DDD	30J - 1,200J µg/kg	(2-FSA-SB06)
4,4'-DDT	4.7 - 9,400 µg/kg	(2-FSA-SB06)

- Toluene was detected in boring 2-FSA-SB09 at a concentration of 5J µg/kg. Xylenes (total) were also detected in soil boring 2-FSA-SB09 at 8J µg/kg.

Eighteen of 24 inorganics were detected in surface soils. Antimony, cadmium, cobalt, nickel, thallium, and cyanide were not detected within the sample set. Aluminum, barium, calcium, chromium, copper, iron, lead, magnesium, manganese, potassium, sodium, and vanadium were detected in all of the surface soil samples. The following summarizes the concentration range of selected inorganic constituents detected above base-specific reference levels within the Former Storage Area (sample location of maximum shown in parentheses):

Chromium	6.6J - 9.8J mg/kg	(2-FSA-SB06)
Magnesium	242J - 1,830J µg/kg	(2-FSA-SB06)
Manganese	5.9J - 20.4 mg/kg	(2-FSA-SB11)
Mercury	0.34J - 0.44J mg/kg	(2-FSA-SB04)

Overall, pesticides were detected in surface soils at varying concentrations throughout the Former Storage Area. The surface soils associated with soil boring 2-FSA-SB06 had relatively elevated concentrations of the pesticides including 4,4'-DDE, 4,4'-DDD, and 4,4'-DDT. The remaining surface soil borings within the sampling grid had lower concentrations of pesticides.

Concentrations of VOCs were detected in one surface sample at low levels (i.e., less than 10 µg/kg) within the sampling grid.

Inorganics were detected within the Former Storage Area above base specific reference sample ranges for surface soils at MCB Camp Lejeune. Inorganics which exhibited concentrations above reference levels include aluminum, beryllium, calcium, chromium, copper, iron, magnesium, manganese, mercury, potassium, sodium, vanadium, and zinc. Although inorganic contaminant levels exceeded reference levels, the concentrations were generally within the same order of magnitude as reference samples.

Subsurface Soils

Analytical results from subsurface soils collected within the Former Storage Area sampling grid also indicate the presence of organic contamination. Positive detection summaries for both organic compounds and inorganic constituents in subsurface soils are presented on Tables 4-7 and 4-8, respectively. A summary of the complete Former Storage Area subsurface soil analytical results, including the concentration range of contaminants, frequency of occurrence, and statistical summary is provided in Appendices H.6 and I.6. The following summarizes the range of positive detections for organic compounds:

- Pesticides including 4,4'-DDE, 4,4'-DDD, and 4,4'-DDT were detected within the sampling grid. Six of the 11 soil borings contained detectable amounts of at least one pesticide. The range and maximum concentrations of detected pesticides are as follows (sample location of maximum shown in parentheses).

▸	4,4'-DDE	6J - 31 µg/kg	(2-GW08 - 2'-4')
▸	4,4'-DDD	11 -1,000 µg/kg	(2-GW08 - 2'-4')
▸	4,4'-DDT	6 - 1,500 µg/kg	(2-GW08 - 2'-4')

- 4-methyl-2-pentanone was detected in three of the 12 subsurface soil samples, with a maximum concentration of 8J µg/kg at 2-GW08. Total xylenes were detected in 2 soil borings with a maximum concentration of 5J µg/kg, from sample location 2-FSA-SB09. 2-butanone, with a concentration or 56J µg/kg, was identified at boring 2-FSA-SB09.

- Boring 2-FSA-SB12 yielded positive detections of o-xylenes, m/p-xylenes, ethylbenzene, and toluene at concentrations of 10.3, 14.2, 9.1, and 9.1 µg/kg, respectively.

Twenty of 24 inorganics were detected in subsurface soils. Antimony, nickel, silver, thallium, and cyanide were not detected within the sample set. Aluminum, barium, calcium, chromium, iron, lead, magnesium, manganese, potassium, sodium, and vanadium were detected in each of the subsurface soil samples. The following summarizes the concentration range and sampling depths of selected inorganic constituents detected above base-specific background levels within the Former Storage Area (sample location of maximum shown in parentheses):

Arsenic	0.52 B - 1.7J mg/kg	(2-GW07 - 2'-4')
Chromium	5.2 - 16.6 mg/kg	(2-GW03D - 46'-48')
Lead	1.2J - 8J mg/kg	(2-GW07 - 2'-4')
Manganese	2.5 B - 24.1 mg/kg	(2-GW03D - 46'-48')
Mercury	0.22 - 0.39J mg/kg	(2-FSA-SB06 - 4'-6')

Pesticides were detected in subsurface soils at varying concentrations within the Former Storage Area. Subsurface soils reflected a similar trend to that exhibited in surface soils associated with the same sampling station. In addition, the soil boring for monitoring well GW08 had positive detections of both 4,4'-DDD and 4,4'-DDT at concentrations of 1000 µg/kg and 1,500 µg/kg, respectively. With the exception of soil borings 2-FSASB06, 2-FSA-SB13, and 2-GW08 the remaining pesticide concentrations were less than 12 µg/kg.

Excluding the single occurrence of 2-butanone, concentrations of VOCs were detected in three subsurface soil stations at low levels (i.e., less than 15 µg/kg) within the sampling grid.

Inorganics were detected within the Former Storage sample grid above base-specific background levels for surface soils at MCB Camp Lejeune. Inorganics which exhibited concentrations above reference levels include aluminum, arsenic, barium, beryllium, calcium, chromium, copper, iron, lead, magnesium, manganese, mercury, potassium, sodium, vanadium and zinc. Although a limited number of inorganic contaminant levels exceeded reference levels, the concentrations were generally within the same order of magnitude as reference samples.

4.2.3 Groundwater Investigation

This section of the report discusses the Groundwater Investigation for Site 2. Five shallow monitoring wells were installed during a previous investigations. During the RI for Site 2, six shallow monitoring wells and one deep monitoring well were installed. Current Site 2 groundwater monitoring well locations have been provided in Figure 2-5.

Four of the newly installed shallow monitoring wells (2GW6, 2GW7, 2GW8, and 2GW9) were installed during the initial RI field activities in April - May, 1993. Two additional shallow monitoring wells (2GW10 and 2GW11) were installed (in response to EPA comments on the Draft Version of this RI report) in February 1994.

4.2.3.1 Round 1 Results

Ethylbenzene and total xylenes were detected in the shallow monitoring wells 2GW3 and 2GW7 (Table 4-9). Levels of ethylbenzene and total xylenes reported in 2GW3 were (190 µg/L) and (1,800J µg/L), respectively. The ethylbenzene concentration in the groundwater sample collected from monitoring well 2GW3 exceeds the North Carolina Water Quality Standards (NCWQS). The groundwater sample collected from monitoring well 2GW7 had concentrations of 2 µg/L for ethylbenzene, and 19J µg/L for total xylenes. In addition to monitoring wells 2GW3 and 2GW7, the monitoring well 2GW6 groundwater sample had a trace level of total xylenes (1 µg/L).

The groundwater sample collected from deep monitoring well 2GW3D contained low levels of TCE (5 µg/L). Also, a duplicate sample was collected from this monitoring well. Results from the duplicate also indicated a low concentration of TCE (4 µg/L).

SVOC Monitoring Wells 2GW1, 2GW3, 2GW3D, and 2GW9 had detections for analysis (Table 4-9). Wells 2GW1 and 2GW3 had low levels of naphthalene and 2-methylnaphthlene at concentrations of 2J µg/L and 3J µg/L, and 15 µg/L, and 17 µg/L, respectively. In addition to these compounds, well 2GW3 has had low levels of dimethylphenol and acenaphthene at concentrations of 6J µg/L and 2J µg/L. Although wells 2GW9 and 2GW3D had low levels of bis-(2-ethylhexyl)phthalate, Section 4.2.1.1 Laboratory Contaminants, discusses why this particular chemical is likely a laboratory contaminant and should not be used as applicable data when assessing this site. The deep monitoring well 2GW3D had low levels of phenol found in the sample at a concentration of 3J µg/L. A duplicate sample was collected from this well, which also showed a low concentration of phenol at (5J µg/L).

Only -shallow monitoring well 2GW8 had detections for pesticides (Table 4-9). The groundwater sample collected from monitoring well 2GW8 had low concentrations of 4,4'-DDD (4.0J µg/L), and 4,4'DDT (9.4 µg/L). Groundwater samples collected from the remaining wells at Site 2 exhibited nondetects for pesticides, PCBs, and herbicides. The groundwater sample collected from monitoring well 2GW8 exhibited nondetects for PCBs and HOCs.

Nineteen of the 24 total inorganics were detected in groundwater samples collected from the shallow monitoring wells (Table 4-10). Due to low sample volume, the groundwater sample collected from monitoring well 2GW2 was not analyzed for inorganics. Total inorganics were also detected in the groundwater sample collected from the deep monitoring well 2GW3D (Table 4-10).

Fifteen of the 24 dissolved (filtered) inorganics were detected in groundwater samples collected from the shallow monitoring wells (Table 4-11). Eight of the 24 dissolved inorganics were also detected in the groundwater sample collected from the deep monitoring well 2GW3D (Table 4-11).

The following summarizes inorganics (total and filtered) detected in groundwater samples that exceed the MCLs or NCWQS:

Monitoring Well	Analyte	Concentration (µg/L)	MCL (µg/L)	NCWQS (µg/L)
2GW1				
Total				
	Beryllium	1.0	1	--
	Cadmium	7.0	5	5
	Manganese	55.0	50*	50
	Lead	15.5	15	15
Filtered				
	Manganese	51.0	50*	50
2GW6				
Total				
	Manganese	79.0	50*	50
Filtered				
	Manganese	65.0	50*	50
2GW7				
Total				
	Manganese	72.0	50*	50
2GW8				
Total				
	Manganese	53.0	50*	50
2GW3D (Deep Monitoring Well)				
Total				
	Barium	1420	2,000	1,000
Filtered				
	Barium	1400	2,000	1,000

*Denotes secondary MCL.

Manganese was detected in concentrations exceeding the MCLs and/or NCWQS in several of the groundwater samples, both total and filtered. A recent study of groundwater quality at MCB Camp Lejeune (Greenhorne and O'Mara, Inc., 1992) has documented that manganese concentrations range from 50 µg/L to 120 µg/L with an average concentration of 78 µg/L. All of the above manganese concentrations fall within this range.

Groundwater Field Parameters

Field measurements including pH, temperature, and specific conductance were obtained during groundwater sampling activities. Results of the field measurements and well purging volumes are provided on Table 4-12.

Engineering Parameters

A groundwater sample was also collected from monitoring well 2GW6 and was analyzed for engineering parameters for evaluation of potential treatment options as part of the Feasibility Study. This groundwater sample was analyzed for the following parameters:

Biological Oxygen Demand
Chemical Oxygen Demand
Total Solids
Total Suspended Solids
Total Dissolved Solids
Total Volatile Solids
Total Organic Carbon

Results of the groundwater engineering parameter analysis are presented on Table 4-13.

4.2.3.2 Round 2 Results

A second round of groundwater samples was collected to provide additional information for remedial design. The results of the additional groundwater analyses have not been submitted for data validation and were not incorporated in the human health or ecological risk assessments.

Toluene (7 µg/L), chlorobenzene (2 µg/L), ethylbenzene (180 µg/L), and total xylenes (1,600 µg/L) were detected in the groundwater sample collected from monitoring well 2GW3. Chloroform (17 µg/L) was detected in the groundwater sample collected from monitoring well 2GW6.

Carbon disulfide (1 µg/L) and 2-butanone (5 µg/L) were detected in the groundwater sample collected from monitoring well 2GW3D (deep well). TCE, which was detected (5 µg/L) in this well during the initial round of sampling, was not detected in the second round.

Naphthalene (10 µg/L) and 2-methylnaphthalene (8J µg/L) were detected in the groundwater sample collected from monitoring well 2GW1. 2-methylnaphthalene (5J µg/L), was detected in the groundwater sample collected from the newly installed monitoring well 2GW11. 2,4-dimethylphenol (5J µg/L), naphthalene (4 µg/L) and 2-methylnaphthalene (8J µg/L) were detected in the groundwater sample collected from monitoring well 2GW3. No semivolatile organic compounds were detected in the deep monitoring well (2GW3D).

The distribution of semivolatiles in groundwater generally confirms the results of the first round of groundwater sampling.

4,4'-DDD (5.4 µg/L), 4,4'-DDT (1.2J µg/L) and endrin aldehyde (1.7J µg/L) were detected in the groundwater sample collected from monitoring well 2GW8. 4,4-DDT (0.1J) was detected in the groundwater sample collected from the newly installed monitoring well 2GW10. 4,4'-DDD (2.08 µg/L) was detected in the groundwater sample collected from the newly installed monitoring well 2GW11. The distribution of pesticide contaminants in groundwater do not differ significantly from the results of the first round of groundwater sampling.

The following summarize inorganics (total and filtered) detected in round two groundwater samples that exceed the MCLs or NCWQS:

Monitoring Well	Analyte	Concentration (µg/L)	MCL (µg/L)	NCWQS (µg/L)
2GW6				
Filtered				
	Manganese	156	50*	50
2GW8				
Total				
	Manganese	415	50*	50
Filtered				
	Manganese	408	50*	50
2GW9				
Total				
	Beryllium	7.0	1	--
	Chromium	83	100	50
	Lead	23.6	15	15
	Manganese	747	50*	50
Filtered				
	Beryllium	5.0	1	--
	Manganese	676	50*	50
2GW10				
Total				
	Manganese	92	50*	50
2GW11				
Total				
	Chromium	117	100	50
	Lead	44.8	15	15
	Manganese	180	50*	50
Filtered				
	Manganese	51	50*	50

*Denotes secondary MCL.

Positive detection summaries for both organic and inorganic constituents in groundwater are presented in Table 4-9, 4-10, and 4-11. Results from the second round of groundwater sampling are attached to the end of each of these tables. A summary of the complete groundwater analytical results, including the concentration range of contaminants, frequency of occurrence, and statistical summary is provided in Appendix H.7 and I.7.

4.2.4 Sediment Investigation

This section of the report discusses the Sediment Investigation at Site 2. Areas of concern for the Sediment Investigation are the Railroad Drainage Ditch Area and Overs Creek Area. This section will discuss the analytical results for sediment samples collected from the depth intervals of 0 to 6 inches and 6 to 12 inches for each analytical parameter tested.

Railroad Drainage Ditch Area

Positive detectives for both organic and inorganic constituents in sediments are presented in Tables 4-14 and 4-15. A summary of the complete sediment analytical results, including the concentration range of contaminants, frequency of occurrence, and statistical summary is provided in Appendices H-9, H-10, I-9, and I-10.

2-butanone and total xylenes were detected in (0 to 6 inch) in sediment sample 2-RRSD09-06 at concentrations of 530J µg/kg, and 1,400J µg/kg, respectively, Table 4-14. Also, shown on Table 4-14 are the detections for the sediment sample collected from 6 to 12 inches. Ethylbenzene and total xylenes were detected in subsurface sediment sample 2RRSD09-612 at concentrations of 680J µg/kg and 4,900 µg/kg, respectively.

SVOCs were detected in the sediment samples collected from the 0 to 6 inch interval Table 4-14. These include: fluoranthene (130J µg/kg), pyrene (140J µg/kg), chrysene (140J µg/kg) and benzo(b)fluoranthene (160J µg/kg). SVOCs were detected in two sediment samples, 2-RRSD09-612 and 2-RRSD02-612, from the 6 to 12 inch interval. The contaminants and corresponding concentration levels for 2-RRSD09-612 are as follows: naphthalene (700 µg/kg), 2-methylnaphthalene (860 µg/kg), acenaphthene (130J µg/kg), fluorene (140J µg/kg), and phenanthrene (130J µg/kg). The contaminants and concentrations for 2-RRSD02-612 are as follows: fluoranthene (200J µg/kg), pyrene (190J µg/kg), benzo(a)anthracene (91J µg/kg), chrysene (190J µg/kg), benzo(b)fluoranthene (200J µg/kg), benzo(k)fluoranthene (170J µg/kg), and benzo(a)pyrene (100J µg/kg).

Pesticides, including dieldrin, 4,4'-DDE, 4,4'-DDD, 4,4'-DDT, alpha-chlordane, and gamma-chlordane were detected in the sediment samples collected from the 0 to 6 inch interval along the railroad drainage ditches (Table 4-14). The ranges and maximum (sample locations shown in parentheses) concentrations of the detected pesticides are as follows:

• Dieldrin	7.5J µg/kg	(2-RRSD11-06 only)
• 4,4'-DDE	11J µg/kg to 17,000J µg/kg	(2-RRSD09-06)
• 4,4'-DDD	13J µg/kg to 710,000J µg/kg	(2-RRSD09-06)
• 4,4'-DDT	4.7J µg/kg to 38,000J µg/kg	(2-RRSD15-06)
• Alpha Chlordane	2.9J µg/kg to 2,400J µg/kg	(2-RRSD09-06)
• Gamma Chlordane	2.8J µg/kg to 47 µg/kg	(2-RRSD08-06)

Table 4-14 also shows the detections of pesticides in the sediment samples collected in the railroad drainage ditches from the 6 to 12 inch interval. These pesticides include the following: dieldrin, endosulfan II, 4,4'-DDE, 4,4'-DDD, 4,4'-DDT, alpha chlordane, and gamma chlordane. The ranges and maximum (sample locations shown in parentheses) concentrations of the detected pesticides are as follows:

Dieldrin	12J µg/kg	(2-RRSD11-612)
Endosulfan II	5.2J µg/kg	(2-RRSD15-612)
4,4'-DDE	10J µg/kg to 6,500J µg/kg	(2-RRSD09-612)
4,4'-DDD	4.2J µg/kg to 250,000J µg/kg	(2-RRSD09-612)
4,4'-DDT	6.5J µg/kg to 80,000J µg/kg	(2-RRSD09-612)
Alpha Chlordane	2.3J µg/kg to 190 µg/kg	(2-RRSD08-612)
Gamma Chlordane	2.9J µg/kg to 170 µg/kg	(2-RRSD08-612)

PCBs and herbicides were not detected in either the 0 to 6 inch or 6 to 12 inch intervals.

Inorganic sediment results from Table 4-15 were reviewed and then were compared to the National Oceanic and Atmospheric Administration (NOAA) Sediment Screening Values (SSVs) (freshwater) (USEPA, 1992b). From this comparison only two samples 2RRSD09-06 and 2-RRSD06-06 (both from the 0 to 6 inch interval) had concentrations above the NOAA SSVs. Sample 2-RRSD09-06 exceeded the SSV for lead with a concentration of (51.4 µg/kg), and sample 2-RRSD06-06 exceeded the SSV for zinc with a concentration of (120 µg/kg). No sediment samples collected from the 6 to 12 inch interval exceeded the NOAA SSVs.

<u>Overs Creek</u>

VOCs, SVOCs, PCBs and herbicides were not detected above the sample quantitation limit in any of the sediment samples collected from Overs Creek (Table 4-14).

Pesticides, including 4,4'-DDE, 4,4'-DDD, and 4,4'-DDT, were detected in the sediment samples collected from the 0 to 6 inch interval in Overs Creek (Table 4-14). The ranges and maximum (sample locations shown in parentheses) concentrations of the detected pesticides are as follows:

• 4,4'-DDE	5.7 µg/kg to 15 µg/kg	(2-OCSD01-06)
• 4,4'-DDD	7.7 µg/kg to 120 µg/kg	(2-OCSD01-06)
• 4,4'-DDT	6.5 µg/kg to 30 µg/kg	(2-OCSD01-06)

Table 4-14 also shows the detections of pesticides in the sediment samples from Overs Creek for the 6 to 12 inch interval. These pesticides include the following: 4,4'-DDE, 4,4'-DDD and 4,4'-DDT. The ranges and maximum (sample locations shown in parentheses) concentrations of the detected pesticides are as follows:

• 4,4'-DDE	29 µg/kg to 49 µg/kg	(2-OCSD01-612)
• 4,4'-DDD	14J µg/kg to 460 µg/kg	(2-OCSD01-612)
• 4,4'-DDT	11J µg/kg to 86 µg/kg	(2-OCSD01-612)

Inorganic sediment results from Table 4-15 were reviewed and then were compared to the NOAA SSVs (USEPA, 1992b).No samples exceeded any of the NOAA SSVs.

4.2.5 Surface Water Investigation

This section of the report discusses the Surface Water Investigation at Site 2. Two areas of concern have been identified, the Railroad Drainage Ditch Area and Overs Creek Area. The Surface Water Investigation for Site 2 will discuss the analytical results from the surface water for each analytical parameter tested.

Positive detection summaries for both organic and inorganic constituents in surface waters are presented in Tables 4-16 and 4-17. A summary of the complete surface water analytical results, including the concentration range of contaminants, frequency of occurrence, and statistical summary is provided in Appendices H.8 and I.8.

Railroad Drainage Ditch Area

The surface water from the railroad ditches is classified as freshwater (see Section 3.3) therefore, surface water evaluation criteria are based on freshwater values. This is not an established surface water environment; surface water flows through the ditches only during precipitation events.

VOCs, SVOCs, PCBs and herbicides were not detected in surface water samples collected from the Railroad Drainage Ditch Area (Table 4-16).

Pesticides were detected in surface water samples collected from the Railroad Drainage Ditch Area. The detected pesticides and their concentrations (maximum concentration locations included in parentheses) are as follows:

4,4'-DDD	0.33J µg/L to 2.3 µg/L	(2-RR-SW17)
4,4'-DDT	0.76 µg/L to 0.94 µg/L	(2-RR-SW06)

The following is a list of the criteria used in evaluating the inorganic contaminants and concentrations:

- Region IV - USEPA Freshwater, Water Quality Screening Values (WQSV) for Hazardous Waste Sites.
- North Carolina Water Quality Standards (NCWAS) for Freshwater Classes.
- USEPA Ambient Water Quality Criteria (AWQC).

As shown on Table 4-17, only sample 2-RRSW06 had inorganic concentrations that exceeded the evaluating criteria. Shown below are the inorganic constituents, their concentrations, and the criteria in which the concentration exceeded:

Beryllium	(1.0 B µg/L)	Region IV WQSV
Copper	(31.0 µg/L)	Region IV WQSV NCWQS AWQC
Iron	(4,410 µg/L)	NCWQS AWQC
Lead	(23.4 µg/L)	Region IV WQSV AWQC
Zinc	(418J µg/L)	Region IV WQSV NCWQS AWQC

Concentrations from sample 2-RRSW04 and 2-RRSW05 did not exceed any of the above criteria.

Overs Creek

This section of the report discusses the Surface Water Investigation for the Overs Creek Area. The Surface Water Investigation for Site 2 will discuss the analytical results from the surface water for each analytical parameter tested.

The surface water from the Overs Creek Area is classified as a saltwater water body (see Section 3.3). Therefore, this classification, all evaluating criteria for inorganics was based on saltwater values.

As shown on Table 4-16, sample 2-OCSW01 showed a trace level for carbon disulfide, at a concentration of (7.0J µg/L). A duplicate sample was taken of 2-OCSW01 results from this duplicate sample, also showed a trace level of carbon disulfide at a concentration of (9.0J µg/L). No SVOCs, pesticides, PCBs or herbicides were detected in any of the surface water samples from the Overs Creek (Table 4-16).

The following is a list of the criteria that was used when evaluating the inorganic contaminants and concentrations:

- Region IV - USEPA Saltwater, Water Quality Screening Values (WQSV) for Hazardous Waste Sites.
- North Carolina Water Quality Standards (NCWQS) for Tidal Saltwater Classes.
- USEPA Ambient Water Quality Criteria (AWQC).

As shown on Table 4-17, samples 2-OCSW01 and duplicate, and 2OCSW03 had inorganic concentrations that exceeded the evaluating criteria. Shown below are the sample numbers, inorganic elements, their concentrations, and the criteria in which the concentration exceeded:

•	2-OCSW01	Copper	(4.0 B µg/L)	Region IV SWQSV NCWQS AWQC
•	2-OCSW03	Copper	(7.0 B µg/L)	Region IV SWQSV NCWQS AWQC

4.2.6 Concrete Pad and Soil Treatment/Disposal Samples

Two concrete chip samples were collected from each concrete mixing pad. Positive detection summaries for organic and inorganic analyses of these samples are presented in Tables 4-18 and 4-19, respectively. A summary of the complete concrete chip analytical results, including the concentration range of contaminants, frequency of occurrence, and statistical summary is provided in Appendices H.11 and No. I.11.

Three soil samples were collected in the vicinity of the mixing pads, for TCLP and RCRA hazardous waste characteristic analysis. Positive detection summary of these analyses are presented on Table 4-20. None of the samples exceeded maximum concentration for characteristic of TCLP.

The results of these sample analyses will be utilized in implementing the proposed TCRA critical removal action (Section 1.4) and in the FS.

4.3 Extent of Contamination

This section describes the extent to which contamination has migrated at Site 2 and the potential for future migration of contaminants.

4.3.1 Soil

This section describes the extent of contamination in soil at Site 2. Figures 4-1 through 4-4 illustrate extent of contamination in surface soil and Figures 4-5 through 4-8 illustrate the extent of contamination in subsurface soil for the Lawn and Mixing Pad Areas, and the Former Storage Area.

4.3.1.1 Mixing Pad and Lawn Areas

Based on analytical results, organic contaminants identified within the Mixing Pad and Lawn Areas include pesticides, VOCs, and SVOCs. The pesticides identified were heptachlor, dieldrin, 4,4'-DDE, 4,4'-DDD, 4,4'-DDT, alpha-chlordane, and gamma-chlordane. Naphthalene, 2-methylnaphthalene, acenaphthene, fluorene, n-nitrosodiphenylamine, phenanthrene, anthracene, fluoranthene, and pyrene were associated with limited SVOC site contamination. The VOCs 4-methyl-2-pentanone, toluene, and total xylenes were also identified within the sampling grid.

Concentrations of inorganics in soil were for the most part within base-specific background levels for MCB Camp Lejeune. Although various inorganic contaminant concentrations did exceed base-specific background levels, they were generally less than two times the base-specific background concentration for soil samples. The analyte lead was detected above twice the base reference level in a total of 3 soil borings. Lead, however, has been identified as a common inorganic constituent found at widely varying concentrations in soils throughout MCB Camp Lejeune.

Pesticides have been detected in both surface and subsurface soils throughout Site 2, however, substantially higher concentrations have been identified in areas directly adjacent to the two mixing pads. Elevated pesticide contamination (i.e., concentrations up to six orders of magnitude greater than surrounding observations) of surface and subsurface soils is limited to the two mixing pad areas. The level of pesticide contamination decreases significantly within a few yards from the pads. The level of observed pesticide contamination is consistent with the historical use of the mixing pads and with the chemical nature of the pesticides themselves.

Pesticides, in general, are persistent and immobile in environmental media. They tend to adhere to soil particles. The compounds are not subject to aqueous transport, unlike those compounds with higher water solubilities. The rate at which pesticides are leached from soil by infiltrating precipitation is low. They are classified as immobile by Roy and Griffin (1985). The future potential for pesticide contamination to migrate from the site is negligible.

SVOCs were detected in two locations directly adjacent to the southern mixing pad, sampling stations 2MP-SB16 and 2-MP-SB24. No other significant occurrences of SVOCs were noted during the soil investigation. The impacted area appears to be centered around the southern mixing pad and is suspected to be the result of past site operations. The practice of mixing fuel and herbicides and using fuel to operate and clean spraying equipment was common in the past and may be the source, of both SVOCs and VOCs at these detected sampling stations.

VOCs were also detected at elevated concentrations (i.e., above 12 µg/kg) at sampling locations 2-MP-SB16 and 2-MP-SB24, adjacent to the southern mixing pad. The volatile fractions of these two samples underwent a medium level sample preparation (see Section 4.2.1.1). VOCs tend to be mobile in environmental media, directly relating to their ability to dissolve in water. However, without a continuing source VOCs tend not to be persistent in soil due to oxidation and biodegradation.

4.3.1.2 Former Storage Area

Analytical results confirm the presence of organic contaminants within the Former Storage Area of Site 2, including pesticides and VOCs. The pesticides identified were 4,4'-DDE, 4,4'-DDD, and 4,4'DDT. The VOCs 4-methyl-2-pentanone, toluene, 2-butanone, and total xylenes were also identified within the sampling grid.

Concentrations of inorganics in soil were for the most part within base-specific background levels for MCB Camp Lejeune. Although various inorganic contaminant concentrations did exceed base-specific background levels, they were generally less than two times the base specific concentration for soil samples. The majority of inorganics detected have been identified as common constituents found at widely varying concentrations in soils throughout MCB Camp Lejeune.

Pesticides have been detected in both surface and subsurface soils throughout the Former Storage Area; however, elevated (i.e., concentrations greater than surrounding observations) concentrations have been identified at sampling station 2FSA-SB06.

Pesticides tend to persist in environmental media, adhering to soil particles. The compounds are not subject to aqueous transport, unlike those compounds with higher water solubilities. The rate at which pesticides are leached from soil by infiltrating precipitation is low. The potential for future pesticide migration from the site is negligible.

VOCs were detected in three sampling locations (2-FSA-SB09, 2-FSASB12, and 2-GW08) in the Former Storage Area,. Excluding a single occurrence of 2-butanone, no other significant (i.e., greater than 15 µg/kg) occurrences of VOCs were noted during the soil investigation. The

VOC impacted area is believed to be limited to the southern end of the site and is most likely the result of past site operations.

4.3.2 Groundwater

This section addresses the extent of groundwater contamination at Site 2. The following discusses the extent of contamination for shallow and deep groundwater, by organic and inorganic contaminants present. Possible sources of groundwater are also evaluated.

Extent of Groundwater Contamination

VOC groundwater contamination was detected in three of the nine shallow wells at Site 2. All three monitoring wells are in the vicinity of the Former Storage Area. These wells with their corresponding analytical results are provided on Figure 4-9. As discussed in Section 4.2.3, groundwater quality has been impacted by VOCs, predominantly aromatic volatiles. ethylbenzene and total xylenes were detected in wells 2GW3, and 2GW7. Well 2GW6 only had a detection for total xylenes. Concentrations in well 2GW3 exceeds the NCWQS for ethylbenzene.

VOC groundwater contamination was detected in deep well 2GW3D, located within the Former Storage Area. TCE was detected in both the groundwater sample and a duplicate sample of 2GW3D (Figure 4-9).

SVOC groundwater contamination was detected in two of the nine shallow wells located at Site 2 (Figure 4-9). As discussed in Section 4.2.3, groundwater quality has been impacted by trace levels of SVOCs. Naphthalene and 2-methyl naphthalene were detected in well 2GW1, and dimethylphenol, naphthalene, 2-methylnaphthalene, and acenaphthene were detected in well 2GW3 (Figure 4-9).

SVOC groundwater contamination was detected in deep well 2GW3D (Figure 4-9). Both the groundwater sample and a duplicate sample of 2GW3D had 3 μg/L of phenol.

Pesticide groundwater contamination was found in only one of the nine shallow wells located at Site 2 (Figure 4-9). Pesticides 4,4'-DDD and 4,4'-DDT were detected in trace concentrations in monitoring well 2GW8.

PCBs and herbicides were not detected in any of the shallow monitoring wells. Pesticides, PCBs, and herbicides were not detected in the deep monitoring well 2GW3D.

Several inorganic constituents were detected in five of the nine shallow wells located at Site 2 in concentrations above federal and state standards (Figure 4-10). As discussed in Section 4.2.3, however, these are naturally occurring inorganics and background concentrations of these inorganics at MCB Camp Lejeune often exceed both federal and state standards. Analytical results indicated that monitoring wells 2GW1, 2GW6, 2GW7, 2GW8, and 2GW9 all had detections for manganese above state standards. Well 2GW1 also had detections for beryllium, cadmium, and lead. Well 2GW9 also had detections for chromium and lead.

Several inorganic constituents were detected in deep monitoring well 2GW3D. However, as discussed in Section 4.2.3 these are naturally occurring inorganic elements and background concentrations of these inorganics at MCB Camp Lejeune often exceed both federal and state standards. Analytical results indicated that monitoring well 2GW3D and its duplicate sample had detections for barium, above the state standard.

The highest concentration of ethylbenzene and xylenes (total) in groundwater is at monitoring well 2GW3. These compounds were detected in much lower concentrations in the downgradient monitoring well 2GW7. Trace levels of xylene were detected in monitoring well 2GW6, which is generally upgradient of monitoring well 2GW3 (Figure 4-9). VOCs were not detected in downgradient (from 2GW3) monitoring well 2GW4. The extent of ethylbenzene and xylenes (total) in groundwater at Site 2 appears to be limited to the Former Storage Area. Additionally, the results of this RI and previous investigations indicate that ethylbenzene and xylenes (total) concentrations in monitoring well 2GW3 are decreasing, possibly through natural attenuation.

Sources of Groundwater Contamination

Site 2 operational records do not provide any evidence which would identify either an activity or a source of the VOC contamination found in the monitoring wells, located around the Former Storage Area. However, the EPIC study reported linear objects and soil staining in the vicinity of these wells during a period of at least 12 years. The years in which Site 2 was photographed and that show linear objects and soil staining are as follows: 1944, 1949, 1952, and 1956. These linear objects and the soil staining are possible sources to the contaminants found in the three monitoring wells.

TCE was detected in low concentrations in deep monitoring well 2GW3D. There is no record of any operational activity at Site 2 that would serve as a source of TCE or any other related chlorinated hydrocarbon. TCE (or other related chlorinated hydrocarbons) was not detected in any other samples (surface soil, subsurface soil, shallow groundwater, sediment, surface water, concrete) collected during this RI. It is likely that Site 2 is not the source of TCE contamination in monitoring well 2GW3D. TCE and other related chlorinated hydrocarbons have been detected in deep groundwater throughout MCB Camp Lejeune (Geophex, 1991; Baker, 1993).

Site 2 operational records do not provide any evidence which would identify either an activity or a source of the SVOC groundwater contamination detected in the monitoring wells located around the Mixing Pad Area and Former Storage Area. From a 1952 aerial photograph, the EPIC Study reported four possible horizontal tanks located in the present vicinity of monitoring well 2GW1. It has been reported from the Camp Lejeune Site Summary Report that herbicides were stored at Site 2. It was a common practice for herbicides to be mixed with diesel fuel (Shaw, 1993). This was done to keep the herbicide compounds in solution, thus adding to the ease and effectiveness of application. Although there is no record of this being done at Site 2, this would explain the SVOCs that were detected in well 2GW1. Well 2GW3 located within the Former Storage Area had several trace levels of SVOCs detected. EPIC to reported linear objects and soil staining in the general vicinity of well 2GW3 from aerial photos from 1949, 1952, and 1956. These linear objects and soil stains are a possible source for the SVOC contamination. However, there are no records of what materials were stored in this area.

A geophysical investigation was conducted in the Former Storage Area. The results of this investigation are presented in Appendix A. Initial results indicated the possibility that a subsurface anomaly was present in the vicinity of well 2GW3.

This area was reinvestigated, with tighter control in the area of the potential subsurface anomaly. This reinvestigation indicated that there is no subsurface anomaly in this area.

Site 2 operational records do not show any evidence which would identify either an activity or a source of the SVOC or VOC contamination found in deep monitoring well 2GW3D.

Pesticide contamination was detected in groundwater samples collected from monitoring wells 2GW8 and 2GW9. These monitoring wells are at completely opposite ends of the site, and are not located in proximity to the mixing pads. Pesticide contamination was also detected in soil samples collected throughout Site 2. It is unlikely however, that pesticide contaminants have leached from the soil into groundwater. Pesticides do not readily leach from soil (Roy and Griffin, 1985; also see Section 5.0). It is more likely that these detected pesticides were attached to soil particles (which entered the monitoring well through the screen from the formation) entrained (suspended) in the groundwater samples.

Site 2 operational records do not show any evidence which would identify either an activity or a source of the inorganic concentrations found in monitoring wells 2GW1, 2GW6, 2GW7, 2GW8, 2GW9 and (deep) 2GW3D. These inorganic elements do not exist in any of the organic contaminant chemical structures detected at Site 2, and no documentation exists to indicate that these elements were utilized in site operations. It is likely that the detected inorganic elements, as with the pesticides discussed above, were attached to (or were naturally a part of) soil particles entrained in the groundwater samples.

4.3.3 Sediment

The sediment data presented in this section addresses the extent of sediment contamination at Site 2. The following discusses the extent of contamination for sediments located on the eastern and western sides of the Railroad Drainage Ditch Area for depths of 0 to 6 inches and 6 to 12 inches, by organic and inorganic contaminants present. Possible sources of sediment contamination are also evaluated.

Extent of Sediment Contamination - Railroad Drainage Ditch Area

VOC sediment contamination was detected in only one of the ten sediment sampling stations, located within the Railroad Drainage Ditches, that were analyzed for VOC. As discussed in Section 4.2.4, sediment quality has been impacted by VOCs. Analytical results from the 0 to 6 inch interval, indicate that 2-butanone and total xylenes were detected in sample 2RRSD09-06 (Figures 4-11 and 4-13).

VOC sediment contamination for the 6 to 12 inch interval was only detected in sediment sampling station 2RRSD09-612. Ethylbenzene and total xylenes were detected in sample 2RRSD09-612 (Figures 4-12 and 4-14).

SVOCs were not detected in sediments from the 0 to 6 inch interval within the Railroad Drainage Ditch Area. SVOCs sediment contamination for the 6 to 12 inch interval was detected in two sediment sampling stations. Fluoranthene, pyrene, benzo(a)anthracene, chrysene, benzo(b)fluoranthene, benzo(k)fluoranthene, and benzo(a)pyrene were detected in sample 2RRSD02-612. Sample 2-RRSD09-612 also had detections of SVOCs, with the following contaminants: naphthalene, methylnaphthalene, acenaphthene, fluorene, and phenanthrene. These sediment sampling stations, with corresponding SVOC concentrations are provided on Figures 4-12 and 4-14).

Pesticide sediment contamination for the 0 to 6 inch interval was detected in all fifteen sediment sampling stations. As discussed in Section 4.2.4, sediment quality has been impacted by pesticides. Dieldrin, 4,4'-DDE, 4,4'-DDD, 4,4'-DDT, alpha-chlordane, and gamma-chlordane were detected. Pesticides 4,4'-DDE, 4,4'-DDD, and 4,4'-DDT were particularly widespread. These sediment sampling stations, with corresponding pesticide concentrations are provided on Figures 4-11 and 4-13).

PCBs and herbicides were not detected in sediments from the 0 to 6 inch or 6 to 12 inch intervals within the Railroad Drainage Ditch Area.

Sediment inorganic concentrations for the 0 to 6 inch interval above NOAA SVs were detected in only two out of the fifteen sampling stations. Lead and zinc were detected in excess of the SVs in samples 2-RRSD09-06 and 2-RRSD06-06, respectively, SVs (Figures 4-17 and 4-18).

No sediment inorganic concentrations above NOAA SVs were detected in samples from the 6 to 12 inch interval within the Railroad Drainage Ditch Area.

Pesticides were detected in almost all sediment sample stations from both intervals (0 to 6 inch and 6 to 12 inch). The highest concentrations from both intervals were from a sediment sampling station that is approximately 200 feet north (downgradient) of the north mixing pad at Site 2. Also, pesticides were detected in higher concentrations within the ditch on the western side of the railroad tracks (i.e., adjacent to the Mixing Pad Area). This is the ditch that would carry any of the runoff from the Mixing Pads Areas. Following the railroad in a North direction from the Mixing Pad Area, pesticide concentrations are high then gradually decrease toward Overs Creek.

Sources of Sediment Contamination - Railroad Tracks Drainage Ditch Area

VOCs were detected in samples collected from sediment sampling stations 2-RRSD09-06 and 2-RRSD09-612, which are located directly east of the south mixing pad. VOC contamination in these samples may be attributable to former site operations activities at this mixing pad. These activities may have included small releases from: mixing fuel with herbicides and/or using fuel to operate and clean spraying equipment.

SVOCs were detected in in sediment samples 2-RRSD02-612, 2-RRSD09-612 and 2-RRSD20-06 (Figures 4-11 through 4-14). Sediment sampling station 2RRSD09 is located directly east of the south mixing pad. SVOC contamination in this sample may be attributable to former site operations activities at this mixing pad. These activities may have included small releases from: mixing fuel with herbicides and/or using fuel to operate and clean spraying equipment. SVOC contamination in samples 2-RRSD02-612 (a background/reference sample) and 2-RRSD20-06 may be attributable to railroad operation activities.

The highest cumulative pesticide detections for both the 0 to 6 inch and 6 to 12 inch intervals came from sediment samples 2RRSD09-06, 2-RRSD09-612, 2-RRSD14-06, and 2-RRSD14-612. These sediment sampling stations are the closest stations to north and south mixing pads, respectively. Elevated levels of pesticides detected in these sediment samples are likely attributable to operations that took place on the mixing pads. Also, the operation of pest and weed control spraying along the railroad lines and the areas adjacent to the railroad has been observed. This operation is another possible source of the lower levels of pesticides detected throughout both drainage ditches.

Inorganic concentrations found within the Railroad Drainage Ditch Area may be attributed to conditions which exist base wide. Section 4.2.4 of this report discusses Site 2 inorganic concentrations in more detail.

Extent of Sediment Contamination - Overs Creek

The following discussion addresses the extent of contamination for sediments in Overs Creek for depths of 0 to 6 inches and 6 to 12 inches, by organic and inorganic contaminants present.

VOCs, SVOCs, PCBs and herbicides were not detected in sediment samples from the 0 to 6 inch or 6 to 12 inch intervals within Overs Creek. Sediment sampling stations for Overs Creek are provided on Figures 4-11 through 4-14).

Pesticides were detected in two of the three sediment samples collected from the 0 to 6 inch interval. Pesticides 4,4'-DDE, 4,4'-DDD, and 4,4'-DDT, were detected. These sediment sampling stations, with corresponding pesticide concentrations are provided on Figures 4-11 through 4-14.

Pesticides were detected in all three sediment samples collected from the 6 to 12 inch interval. Pesticides 4,4'-DDE, 4,4'-DDD, and 4,4'-DDT, were detected. These sediment sampling stations, with corresponding pesticide concentrations are provided on Figures 4-11 through 4-14).

Sediment inorganic elements were not detected in concentrations above the NOAA SVs in samples collected from either the 0 to 6 inch interval or the 6 to 12 inch interval within Overs Creek.

Sources of Sediment Contamination - Overs Creek Area

General base-wide spraying of pesticides, including along railroad lines, has been well documented. This operation is one possible source for the pesticides detected in Overs Creek sediments. Migration of pesticide contaminants from the Lawn and Mixing Pad Areas to Overs Creek is another potential source of pesticides detected in Overs Creek sediments.

4.3.4 Surface Water

The surface water data presented in this section addresses the extent of contamination at Site 2. The following discusses the extent of contamination for surface water located on the eastern and western sides of the Railroad Drainage Ditch and in Overs Creek, by organic and inorganic contaminants present. Possible sources of surface water contamination are also evaluated.

Extent of Surface Water Contamination - Railroad Tracks Drainage Ditch Area

VOCs, SVOCs, PCBs and herbicides were not detected in any of the surface water samples collected from the Railroad Track Drainage Ditch Area. Surface water sampling stations and analytical results are provided on Figures 4-15 through 4-18. Pesticides were detected in trace concentrations in all surface water samples. Surface water inorganic elements in concentrations above water quality criteria were detected in only one out of the three surface water sampling stations.

Surface water is not an established environment in the Railroad Drainage Ditch Area. Surface water flows through the ditches only during precipitation events. The surface water samples were collected from discontinuous accumulations in depressed areas ("puddles"). Evaluation of the extent of pesticides in surface water is limited by the discontinuous nature of the surface water.

Sources of Surface Water Contamination - Railroad Drainage Ditch Area

Pesticides detected in the Railroad Drainage Ditch surface water may be attributable to the past practice of spraying the railroad track and the surrounding area with pesticides. Another possible source may the the migration of pesticide-contaminated sediment and/or surface water from the Lawn and Mixing Pad Areas.

Inorganic concentrations detected in the surface water of the Railroad Drainage Ditches may be attributed to conditions which exist base wide. Section 4.2.4 of this report discusses Site 2 inorganic concentrations in more detail.

Extent of Surface Water Contamination - Overs Creek Area

The surface water data presented in this section addresses the extent of contamination at Site 2. The following discusses the extent of contamination for sediments in Overs Creek by organic and inorganic contaminants present.

VOCs were detected at trace levels in one of the three surface water samples from Overs Creek. Analytical results from sample 2-OCSW01, and it's duplicate indicated that carbon disulfide was detected. This surface water sampling stations, with corresponding concentrations are provided on Figure 4-15).

SVOCs, PCBs, pesticides and herbicides were not detected in any of the surface water samples collected from Overs Creek.

Inorganics were detected in only two of the three surface water sampling stations in Overs Creek. Copper was detected in surface water samples 2-OCSW01 and 2-OCSW03, and in a duplicate sample collected with 2-OCSW03, in concentrations exceeding applicable surface water quality criteria. Sample station 2-OCSW01 is upgradient of 2-OCSW03. These surface water sampling stations, with corresponding inorganic levels are provided on Figure 4-17).

Sources of Surface Water Contamination - Overs Creek Area

The source of carbon disulfide in surface water in Overs Creek is unknown. There is no indication that this would be associated with operational activities at Site 2. It was not detected in surface water samples in the Railroad Drainage Ditches. Sampling and/or laboratory contamination are possible sources of carbon disulfide.

Pesticides in the surface water may be attributable to the past practice of spraying the railroad track and the surrounding area with pesticides. Another possible source may be the migration of pesticide-contaminated sediment and/or surface water from the Lawn and Mixing Pad Areas.

Inorganic concentrations found within the surface water of the Overs Creek Area may be attributed to conditions which exist base wide. Section 4.2.4 of this report discusses Site 2 inorganic concentrations in more detail.

4.4 Summary

This section summarizes the nature and extent of contamination at Site 2. The summary is presented by area of concern. The following environmental media at Site 2 have been impacted by former site operation activities:

- Soil in the vicinity of the former mixing pads has been impacted by pesticide contamination. This is apparently the result of releases associated with pesticide mixing and washing of pesticide and herbicide spraying equipment. The soil in this area has also been impacted by SVOC contamination. This is apparently the result of fuels (possibly diesel fuel) being used as a carrying agent for herbicide mixtures and to operate and clean spraying equipment.

- Soil throughout Site 2 has been impacted by pesticide contamination that resulted from the former practice of general base-wide spraying of pesticides. The pesticide concentrations in soil in the Lawn Area and Former Storage Area are several orders of magnitude lower than the pesticide contaminant concentrations detected in the vicinity of the former mixing pads.

- Shallow groundwater in the Former Storage Area has been impacted by VOC contamination. Ethylbenzene and xylenes (total) were detected in groundwater samples collected from shallow monitoring wells in the Former Storage Area. The area of highest VOC concentration is at monitoring well 2GW3. VOCs have been detected in this monitoring well during previous investigations. The extent of VOC contamination appears to be limited to the vicinity of the Former Storage Area.

  The source of the shallow groundwater contamination in the Former Storage Area has not been determined. Similar contaminants were detected in low levels in one soil boring in the vicinity of monitoring well 2GW3, indicating that the source may have been at or near the surface in this area (e.g., surface spill, etc.).

- TCE was detected at a low concentration (5 µg/L) in deep monitoring well 2GW3D. There is no evidence (documentation, soil samples, shallow groundwater samples) to indicate that this is related to operation activities at Site 2. TCE and other chlorinated hydrocarbons have been detected, in deep groundwater in other areas at MCB Camp Lejeune.

- Sediment in the Railroad Drainage Ditch in the vicinity of the former mixing pads has been impacted by pesticide contamination. SVOCs have also been detected in sediment samples collected in this area. This is apparently the result of releases associated with pesticide mixing and cleaning (possibly with diesel fuel) of pesticide and herbicide spraying equipment.

- Trace levels of pesticides were detected in surface water samples collected in the Railroad Drainage Ditches. This may be the result of Site 2 operations or general base-wide spraying. Copper was detected above applicable (WQSV, NCWQC, and AWQC) standards in Overs Creek.

TABLE 4 - 1
SURFACE SOIL POSITIVE DETECTION SUMMARY
ORGANIC CHEMICALS
LAWN AREA AND MIXING PAD
OPERABLE UNIT NO. 5 - SITE 2
REMEDIAL INVESTIGATION CTO - 19174
MCB CAMP LEJEUNE, NORTH CAROLINA

SAMPLE NO. DEPTH UNITS	2-LA-SB02-00 0 - 6" UG/KG	2-LA-SB04-00 0 - 6" UG/KG	2-LA-SB05-00 0 - 6" UG/KG	2-LA-SB06-00 0 - 6" UG/KG	2-LA-SB07-00 0 - 6" UG/KG	2-LA-SB08-00 0 - 6" UG/KG
<u>PESTICIDES/PCBS</u>						
HEPTACHLOR						
DIELDRIN						
4,4'-DDE	4.9	110 J	34	17	5	19
4,4'-DDD			22	26		
4,4'-DDT		59 J	11	16		8.3
ALPHA-CHLORDANE			7.7 J			
GAMMA-CHLORDANE			5.9			
<u>VOLATILES</u>						
METHYLENE CHLORIDE	7 J	7 J				
TOLUENE						
XYLENES (total)	5 J	4 J				
<u>SEMIVOLATILES</u>						
DI-N-BUTYL PHTHALATE						
BIS(2-ETHYLHEXYL)PHTHALATE					88 J	

Notes:
UG/KG - microgram per kilogram
J - value is estimated

TABLE 4 - 1
SURFACE SOIL POSITIVE DETECTION SUMMARY
ORGANIC CHEMICALS
LAWN AREA AND MIXING PAD
OPERABLE UNIT NO. 5 - SITE 2
REMEDIAL INVESTIGATION CTO - 19174
MCB CAMP LEJEUNE, NORTH CAROLINA

SAMPLE NO.	2-LA-SB09-00	2-LA-SB10-00	2-LA-SB11-00	2-LA-SB12-00	2-LA-SB13-00	2-LA-SB14-00
DEPTH	0 - 6"	0 - 6"	0 - 6"	0 - 6"	0 - 6"	0 - 6"
UNITS	UG/KG	UG/KG	UG/KG	UG/KG	UG/KG	UG/KG
PESTICIDES/PCBS						
HEPTACHLOR						
DIELDRIN						
4,4'-DDE	29		230	19		18
4,4'-DDD	40	180	84 J	9.8 J		37 J
4,4'-DDT	20		260	15	13 J	50 J
ALPHA-CHLORDANE	5.9 J			17 J		15 J
GAMMA-CHLORDANE	5.2			16		13
VOLATILES						
METHYLENE CHLORIDE	17					
TOLUENE						
XYLENES (total)	4 J					
SEMIVOLATILES						
DI-N-BUTYL PHTHALATE						
BIS(2-ETHYLHEXYL)PHTHALATE		96 J				

Notes:
UG/KG - microgram per kilogram
J - value is estimated

TABLE 4 - 1
SURFACE SOIL POSITIVE DETECTION SUMMARY
ORGANIC CHEMICALS
LAWN AREA AND MIXING PAD
OPERABLE UNIT NO. 5 - SITE 2
REMEDIAL INVESTIGATION CTO - 19174
MCB CAMP LEJEUNE, NORTH CAROLINA

SAMPLE NO.	2-LA-SB15-00	2-LA-SB16-00	2-LA-SB17-00	2-LA-SB18-00	2-LA-SB19-00	2-MP-SB01-00
DEPTH	0 - 6"	0 - 6"	0 - 6"	0 - 6"	0 - 6"	0 - 6"
UNITS	UG/KG	UG/KG	UG/KG	UG/KG	UG/KG	UG/KG
PESTICIDES/PCBS						
HEPTACHLOR						
DIELDRIN						
4,4'-DDE	5.2 J	24	55 J	5.6 J	74 J	
4,4'-DDD			60 J		12 J	15 J
4,4'-DDT	70	73	46 J		54 J	250 J
ALPHA-CHLORDANE			9.5 J			
GAMMA-CHLORDANE			7.1 J			
VOLATILES						
METHYLENE CHLORIDE						
TOLUENE						
XYLENES (total)						
SEMIVOLATILES						
DI-N-BUTYL PHTHALATE						
BIS(2-ETHYLHEXYL)PHTHALATE						

J - value is estimated

TABLE 4 - 1
SURFACE SOIL POSITIVE DETECTION SUMMARY
ORGANIC CHEMICALS
LAWN AREA AND MIXING PAD
OPERABLE UNIT NO. 5 - SITE 2
REMEDIAL INVESTIGATION CTO - 19174
MCB CAMP LEJEUNE, NORTH CAROLINA

SAMPLE NO. DEPTH UNITS	2-MP-SB02-00 0 - 6" UG/KG	2-MP-SB03-00 0 - 6" UG/KG	2-MP-SB04-00 0 - 6" UG/KG	2-MP-SB05-00 0 - 6" UG/KG	2-MP-SB06-00 0 - 6" UG/KG	2-MP-SB07-00 0 - 6" UG/KG
PESTICIDES/PCBS						
HEPTACHLOR						280 J
DIELDRIN						
4,4'-DDE			30000	25	930	3600 J
4,4'-DDD	4300		180000	20 J	36	33000 J
4,4'-DDT	69000	1700000	3000000	5 J	840	30000 J
ALPHA-CHLORDANE					4.3 J	3900 J
GAMMA-CHLORDANE						3400 J
VOLATILES						
METHYLENE CHLORIDE						
TOLUENE						
XYLENES (total)						
SEMIVOLATILES						
DI-N-BUTYL PHTHALATE			58 J			
BIS(2-ETHYLHEXYL)PHTHALATE						

Notes:
UG/KG - microgram per kilogram
J - value is estimated

TABLE 4 - 1
SURFACE SOIL POSITIVE DETECTION SUMMARY
ORGANIC CHEMICALS
LAWN AREA AND MIXING PAD
OPERABLE UNIT NO. 5 - SITE 2
REMEDIAL INVESTIGATION CTO - 19174
MCB CAMP LEJEUNE, NORTH CAROLINA

SAMPLE NO.	2-MP-SB08-00	2-MP-SB09-00	2-MP-SB10-00	2-MP-SB11-00	2-MP-SB12-00	2-MP-SB13-00
DEPTH	0 - 6"	0 - 6"	0 - 6"	0 - 6"	0 - 6"	0 - 6"
UNITS	UG/KG	UG/KG	UG/KG	UG/KG	UG/KG	UG/KG
PESTICIDES/PCBS						
HEPTACHLOR						
DIELDRIN						
4,4'-DDE	9.8	260	260	1300	460	1100
4,4'-DDD		30 J	49 J	2300	66	240
4,4'-DDT	7.9	560	1100	48000	1100	2000
ALPHA-CHLORDANE						9.4 J
GAMMA-CHLORDANE						
VOLATILES						
METHYLENE CHLORIDE						
TOLUENE						
XYLENES (total)						
SEMIVOLATILES						
DI-N-BUTYL PHTHALATE	86 J					
BIS(2-ETHYLHEXYL)PHTHALATE						

Notes:
UG/KG - microgram per kilogram
J - value is estimated

TABLE 4 - 1
SURFACE SOIL POSITIVE DETECTION SUMMARY
ORGANIC CHEMICALS
LAWN AREA AND MIXING PAD
OPERABLE UNIT NO. 5 - SITE 2
REMEDIAL INVESTIGATION CTO - 19174
MCB CAMP LEJEUNE, NORTH CAROLINA

SAMPLE NO. DEPTH UNITS	2-MP-SB14-00 0 - 6" UG/KG	2-MP-SB15-00 0 - 6" UG/KG	2-MP-SB16-00 0 - 6" UG/KG	2-MP-SB17-00 0 - 6" UG/KG	2-MP-SB17A-00 0 - 6" UG/KG	2-MP-SB18-00 0 - 6" UG/KG
PESTICIDES/PCBS						
HEPTACHLOR						
DIELDRIN	1400					
4,4'-DDE	6600 J	19000	960	7300	1100 J	1900
4,4'-DDD	1200000	130000	12000	220000	37000 J	5700 J
4,4'-DDT	3500	85000	530	5100	1500 J	29000
ALPHA-CHLORDANE						
GAMMA-CHLORDANE						
VOLATILES						
METHYLENE CHLORIDE						
TOLUENE						
XYLENES (total)			4 J			
SEMIVOLATILES						
DI-N-BUTYL PHTHALATE						
BIS(2-ETHYLHEXYL)PHTHALATE						

Notes:
UG/KG - microgram per kilogram
J - value is estimated

TABLE 4 - 1
SURFACE SOIL POSITIVE DETECTION SUMMARY
ORGANIC CHEMICALS
LAWN AREA AND MIXING PAD
OPERABLE UNIT NO. 5 - SITE 2
REMEDIAL INVESTIGATION CTO - 19174
MCB CAMP LEJEUNE, NORTH CAROLINA

SAMPLE NO. DEPTH UNITS	2-MP-SB21-00 0 - 6" UG/KG	2-MP-SB22-00 0 - 6" UG/KG	2-MP-SB23-00 0 - 6" UG/KG	2-MP-SB24-00 0 - 6" UG/KG	2-MP-SB25-00 0 - 6" UG/KG	2-MP-SB26-00 0 - 6" UG/KG
PESTICIDES/PCBS						
HEPTACHLOR						
DIELDRIN						
4,4'-DDE	4800	930	30000		2100	920
4,4'-DDD	65000	29000	450000	23000	9400 J	7000
4,4'-DDT	2100	1200	930000	46000	21000	2500
ALPHA-CHLORDANE					310	
GAMMA-CHLORDANE						
VOLATILES						
METHYLENE CHLORIDE						
TOLUENE						
XYLENES (total)						
SEMIVOLATILES						
DI-N-BUTYL PHTHALATE						
BIS(2-ETHYLHEXYL)PHTHALATE						

Notes:
UG/KG - microgram per kilogram
J - value is estimated

TABLE 4 - 1
SURFACE SOIL POSITIVE DETECTION SUMMARY
ORGANIC CHEMICALS
LAWN AREA AND MIXING PAD
OPERABLE UNIT NO. 5 - SITE 2
REMEDIAL INVESTIGATION CTO - 19174
MCB CAMP LEJEUNE, NORTH CAROLINA

SAMPLE NO.	2-MP-SB27-00	2-MP-SB28-00
DEPTH	0 - 6"	0 - 6"
UNITS	UG/KG	UG/KG
PESTICIDES/PCBS		
HEPTACHLOR		
DIELDRIN		
4,4'-DDE	37	52
4,4'-DDD	260	
4,4'-DDT	450	75
ALPHA-CHLORDANE		
GAMMA-CHLORDANE		
VOLATILES		
METHYLENE CHLORIDE		
TOLUENE		6 J
XYLENES *(total)*		
SEMIVOLATILES		
DI-N-BUTYL PHTHALATE		
BIS(2-ETHYLHEXYL)PHTHALATE		

Notes:
UG/KG - microgram per kilogram
J - value is estimated

TABLE 4 - 2
SURFACE SOIL POSITIVE DETECTION SUMMARY
TAL METALS AND CYANIDE
LAWN AREA AND MIXING PAD
OPERABLE UNIT NO. 5 - SITE 2
REMEDIAL INVESTIGATION CTO - 19174
MCB CAMP LEJEUNE, NORTH CAROLINA

SAMPLE NO.	2-LA-SB02-00	2-LA-SB04-00	2-LA-SB07-00	2-LA-SB09-00	2-LA-SB10-00	2-LA-SB19-00
DEPTH	0 - 6"	0 - 6"	0 - 6"	0 - 6"	0 - 6"	0 - 6"
UNITS	MG/KG	MG/KG	MG/KG	MG/KG	MG/KG	MG/KG
ALUMINUM	5300	4920	2700	3890	3320	7010
ARSENIC		0.52 B		0.95 B		1 B
BARIUM	5.1 B	6.4 B	6.6 B	21.4 B	7.3 B	8.8 B
BERYLLIUM						
CADMIUM				1.1	1.1	
CALCIUM	508 J	16800 J	9900 J	9300 J	667 J	7800 J
CHROMIUM	3	4		4.1	3.7	5.4
COBALT						2.8 B
COPPER	0.46 B	1.7 B	0.71 B	6.8	0.88 B	1.6 B
IRON	1500	1170	722 J	1910	862	1760 J
LEAD	11.3 J	12.4 J	8.8 J	133	6.9 J	7 J
MAGNESIUM	109 B	356 B	205 B	254 B	131 B	414 B
MANGANESE	2.1 B	6.4	5.2	11.3	7.5	6.1
MERCURY						
POTASSIUM	80 B	90.5 B	59.6 B	129 B	207 B	131 B
SELENIUM						
SODIUM	20.7 B	42.9 B	35.7 B	30.7 B	71.4 B	30.3 B
THALLIUM						0.26 B
VANADIUM	6 B	5 B	3.1 B	5.6 B	4.6 B	8.8 B
ZINC			29.3	52.8 J	10.1	11.4

Notes:
MG/KG - milligram per kilogram
B - reported value is less than Contract Required Detection Limit (CRDL), but greater than Instrument Detection Limit (IDL)
J - value is estimated

TABLE 4 - 2
SURFACE SOIL POSITIVE DETECTION SUMMARY
TAL METALS AND CYANIDE
LAWN AREA AND MIXING PAD
OPERABLE UNIT NO. 5 - SITE 2
REMEDIAL INVESTIGATION CTO - 19174
MCB CAMP LEJEUNE, NORTH CAROLINA

SAMPLE NO.	2-MP-SB04-00	2-MP-SB08-00	2-MP-SB16-00	2-MP-SB24-00	2-MP-SB28-00
DEPTH	0 - 6"	0 - 6"	0 - 6"	0 - 6"	0 - 6"
UNITS	MG/KG	MG/KG	MG/KG	MG/KG	MG/KG
ALUMINUM	4010	9650	4440 J	2310 J	5020 J
ARSENIC	4.3 J	0.6 B	0.68 J	0.66 J	1.1 J
BARIUM	25.9 B	10.2 B	25.6 J	14.9 J	9 J
BERYLLIUM	0.22 B	0.22 B			
CADMIUM					
CALCIUM	17100 J	107000 J	109000 J	77900 J	1000 J
CHROMIUM	10.8	12.7	7.3 J	7.5 J	6.2 J
COBALT					
COPPER	19.9	2.2 B	3.3 J	3.2 J	1.7 J
IRON	3880	3460	2830 J	1780 J	2390 J
LEAD	225	5.7 J	48.1 J	51.7 J	7.4 J
MAGNESIUM	600 B	1830	1850 J	1250 J	135 J
MANGANESE	63.9	18.7	24.9 J	18.6 J	5.4 J
MERCURY	0.69	0.25			
POTASSIUM	161 B	368 B	287 J	132 J	95 J
SELENIUM			0.82 J	0.66 J	
SODIUM	90.7 B	165 B	214 J	133 J	32.9 J
THALLIUM					
VANADIUM	7.3 J	14.5	8.4 J	4.7 J	7.5 J
ZINC	125		28.7 J	12.2 J	3.8 J

Notes:
MG/KG - milligram per kilogram
B - reported value is less than Contract Required Detection Limit (CRDL), but greater than Instrument Detection Limit (IDL)
J - value is estimated

TABLE 4 - 3
SUBSURFACE SOIL POSITIVE DETECTION SUMMARY
ORGANIC CHEMICALS
LAWN AREA AND MIXING PAD
OPERABLE UNIT NO. 5 - SITE 2
REMEDIAL INVESTIGATION CTO - 19174
MCB CAMP LEJEUNE, NORTH CAROLINA

SAMPLE NO.	2-LA-SB02-01	2-LA-SB04-02	2-LA-SB06-02	2-LA-SB07-01	2-LA-SB08-02	2-LA-SB09-02
DEPTH	2 - 4'	4 - 6'	4 - 6'	2 - 4'	4 - 6'	4 - 6'
UNITS	UG/KG	UG/KG	UG/KG	UG/KG	UG/KG	UG/KG
<u>PESTICIDES</u>						
HEPTACHLOR						
4,4'-DDE		9.4		4.7	24	14
4,4'-DDD			4.2 J		4.9 J	9
ENDOSULFAN SULFATE						
4,4'-DDT		4.8			11	6.8
ALPHA-CHLORDANE						2.9 J
GAMMA-CHLORDANE						2.4
<u>VOLATILES</u>						
METHYLENE CHLORIDE	10 J					28
ACETONE						
2-BUTANONE						
4-METHYL-2-PENTANONE	12 J					
XYLENES (total)	5 J					
<u>SEMIVOLATILES</u>						
NAPHTHALENE						
2-METHYLNAPHTHALENE						
ACENAPHTHENE						
FLUORENE						
N-NITROSODIPHENYLAMINE						
PHENANTHRENE						
ANTHRACENE						
DI-N-BUTYL PHTHALATE						
FLUORANTHENE						
PYRENE						
BIS(2-ETHYLHEXYL)PHTHALATE		140 J		200 J		

Notes:
UG/KG - microgram per kilogram
J - value is estimated

TABLE 4 - 3
SUBSURFACE SOIL POSITIVE DETECTION SUMMARY
ORGANIC CHEMICALS
LAWN AREA AND MIXING PAD
OPERABLE UNIT NO. 5 - SITE 2
REMEDIAL INVESTIGATION CTO - 19174
MCB CAMP LEJEUNE, NORTH CAROLINA

SAMPLE NO.	2-LA-SB10-01	2-LA-SB11-02	2-LA-SB13-02	2-LA-SB14-01	2-LA-SB15-02	2-LA-SB17-01
DEPTH	2 - 4'	4 - 6'	4 - 6'	2 - 4'	4 - 6'	2 - 4'
UNITS	UG/KG	UG/KG	UG/KG	UG/KG	UG/KG	UG/KG
PESTICIDES						
HEPTACHLOR						
4,4'-DDE		13		12		4.6 J
4,4'-DDD	12	34		40		16 J
ENDOSULFAN SULFATE						
4,4'-DDT		14	27 J	11	78	10 J
ALPHA-CHLORDANE				2.2		
GAMMA-CHLORDANE						
VOLATILES						
METHYLENE CHLORIDE						
ACETONE						
2-BUTANONE						
4-METHYL-2-PENTANONE						
XYLENES (total)						
SEMIVOLATILES						
NAPHTHALENE						
2-METHYLNAPHTHALENE						
ACENAPHTHENE						
FLUORENE						
N-NITROSODIPHENYLAMINE						
PHENANTHRENE						
ANTHRACENE						
DI-N-BUTYL PHTHALATE						
FLUORANTHENE						
PYRENE						
BIS(2-ETHYLHEXYL)PHTHALATE						

Notes:
UG/KG - microgram per kilogram
J - value is estimated

TABLE 4 - 3
SUBSURFACE SOIL POSITIVE DETECTION SUMMARY
ORGANIC CHEMICALS
LAWN AREA AND MIXING PAD
OPERABLE UNIT NO. 5 - SITE 2
REMEDIAL INVESTIGATION CTO - 19174
MCB CAMP LEJEUNE, NORTH CAROLINA

SAMPLE NO. DEPTH UNITS	2-LA-SB19-01 2 - 4' UG/KG	2-MP-SB01-01 2 - 4' UG/KG	2-MP-SB02-02 4 - 6' UG/KG	2-MP-SB03-01 2 - 4' UG/KG	2-MP-SB04-01 2 - 4' UG/KG	2-MP-SB05-01 2 - 4' UG/KG
PESTICIDES						
HEPTACHLOR						
4,4'-DDE		5.1 J	14 J		14	
4,4'-DDD	5.8 J	8.4 J	83	2800 J	31 J	5.9 J
ENDOSULFAN SULFATE						
4,4'-DDT	4 J	250 J		57000 J	520	17 J
ALPHA-CHLORDANE			5.7 J	330 J	2.5 J	
GAMMA-CHLORDANE			5.6 J	320 J		
VOLATILES						
METHYLENE CHLORIDE					5 J	
ACETONE					54 J	
2-BUTANONE						
4-METHYL-2-PENTANONE						
XYLENES (total)						
SEMIVOLATILES						
NAPHTHALENE						
2-METHYLNAPHTHALENE						
ACENAPHTHENE						
FLUORENE						
N-NITROSODIPHENYLAMINE						
PHENANTHRENE						
ANTHRACENE						
DI-N-BUTYL PHTHALATE						
FLUORANTHENE						
PYRENE						
BIS(2-ETHYLHEXYL)PHTHALATE						

Notes:
UG/KG - microgram per kilogram
J - value is estimated

TABLE 4 - 3
SUBSURFACE SOIL POSITIVE DETECTION SUMMARY
ORGANIC CHEMICALS
LAWN AREA AND MIXING PAD
OPERABLE UNIT NO. 5 - SITE 2
REMEDIAL INVESTIGATION CTO - 19174
MCB CAMP LEJEUNE, NORTH CAROLINA

SAMPLE NO.	2-MP-SB06-02	2-MP-SB07-02	2-MP-SB08-02	2-MP-SB09-01	2-MP-SB10-02	2-MP-SB11-02
DEPTH	4 - 6'	4 - 6'	4 - 6'	2 - 4'	4 - 6'	4 - 6'
UNITS	UG/KG	UG/KG	UG/KG	UG/KG	UG/KG	UG/KG
PESTICIDES						
HEPTACHLOR		190 J				
4,4'-DDE	4.8	700 J			21	110 J
4,4'-DDD		1200 J				550
ENDOSULFAN SULFATE						
4,4'-DDT	4.3	18000		19	38	1500
ALPHA-CHLORDANE		2500				
GAMMA-CHLORDANE		2300				
VOLATILES						
METHYLENE CHLORIDE						
ACETONE						
2-BUTANONE						
4-METHYL-2-PENTANONE						
XYLENES (total)						
SEMIVOLATILES						
NAPHTHALENE						
2-METHYLNAPHTHALENE						
ACENAPHTHENE						
FLUORENE						
N-NITROSODIPHENYLAMINE						
PHENANTHRENE						
ANTHRACENE						
DI-N-BUTYL PHTHALATE			140 J			
FLUORANTHENE						
PYRENE						
BIS(2-ETHYLHEXYL)PHTHALATE						

Notes:
UG/KG - microgram per kilogram
J - value is estimated

TABLE 4 - 3
SUBSURFACE SOIL POSITIVE DETECTION SUMMARY
ORGANIC CHEMICALS
LAWN AREA AND MIXING PAD
OPERABLE UNIT NO. 5 - SITE 2
REMEDIAL INVESTIGATION CTO - 19174
MCB CAMP LEJEUNE, NORTH CAROLINA

SAMPLE NO. DEPTH UNITS	2-MP-SB12-02 4 - 6' UG/KG	2-MP-SB13-02 4 - 6' UG/KG	2-MP-SB14-01 2 - 4' UG/KG	2-MP-SB15-02 4 - 6' UG/KG	2-MP-SB16-02 4 - 6' UG/KG	2-MP-SB17-02 4 - 6' UG/KG
PESTICIDES						
HEPTACHLOR						
4,4'-DDE	8.1			2200	460	
4,4'-DDD			260	89000	21000	130000
ENDOSULFAN SULFATE						
4,4'-DDT	12	11		46000	2100	17000
ALPHA-CHLORDANE						
GAMMA-CHLORDANE						
VOLATILES						
METHYLENE CHLORIDE						
ACETONE						
2-BUTANONE					1100 J	
4-METHYL-2-PENTANONE						
XYLENES (total)					4100	
SEMIVOLATILES						
NAPHTHALENE					4800	
2-METHYLNAPHTHALENE					14000	
ACENAPHTHENE					360 J	
FLUORENE					700	
N-NITROSODIPHENYLAMINE					1000	
PHENANTHRENE					1500	
ANTHRACENE					150 J	
DI-N-BUTYL PHTHALATE						
FLUORANTHENE					160 J	
PYRENE					160 J	
BIS(2-ETHYLHEXYL)PHTHALATE					180 J	

Notes:
UG/KG - microgram per kilogram
J - value is estimated

TABLE 4 - 3
SUBSURFACE SOIL POSITIVE DETECTION SUMMARY
ORGANIC CHEMICALS
LAWN AREA AND MIXING PAD
OPERABLE UNIT NO. 5 - SITE 2
REMEDIAL INVESTIGATION CTO - 19174
MCB CAMP LEJEUNE, NORTH CAROLINA

SAMPLE NO.	2-MP-SB17A-01	2-MP-SB18-02	2-MP-SB21-03	2-MP-SB22-02	2-MP-SB23-02	2-MP-SB24-02
DEPTH	2 - 4'	4 - 6'	6 - 8'	4 - 6'	4 - 6'	4 - 6'
UNITS	UG/KG	UG/KG	UG/KG	UG/KG	UG/KG	UG/KG
PESTICIDES						
HEPTACHLOR						
4,4'-DDE	6300 J	1900	3500	1871 J	560	450
4,4'-DDD	120000 J	55000	78000	66000	55000	35000
ENDOSULFAN SULFATE						
4,4'-DDT		82000	11000	71000	51000	13000
ALPHA-CHLORDANE						
GAMMA-CHLORDANE						
VOLATILES						
METHYLENE CHLORIDE						
ACETONE						1800 J
2-BUTANONE						540 J
4-METHYL-2-PENTANONE						
XYLENES (total)						
SEMIVOLATILES						
NAPHTHALENE						130 J
2-METHYLNAPHTHALENE						1000
ACENAPHTHENE						
FLUORENE						160 J
N-NITROSODIPHENYLAMINE						340 J
PHENANTHRENE						350 J
ANTHRACENE						
DI-N-BUTYL PHTHALATE						
FLUORANTHENE						
PYRENE						
BIS(2-ETHYLHEXYL)PHTHALATE						

Notes:
UG/KG - microgram per kilogram
J - value is estimated

TABLE 4 - 3
SUBSURFACE SOIL POSITIVE DETECTION SUMMARY
ORGANIC CHEMICALS
LAWN AREA AND MIXING PAD
OPERABLE UNIT NO. 5 - SITE 2
REMEDIAL INVESTIGATION CTO - 19174
MCB CAMP LEJEUNE, NORTH CAROLINA

SAMPLE NO.	2-MP-SB25-02	2-MP-SB26-02	2-MP-SB27-01	2-MP-SB28-01
DEPTH	4 - 6'	4 - 6'	2 - 4'	2 - 4'
UNITS	UG/KG	UG/KG	UG/KG	UG/KG
PESTICIDES				
HEPTACHLOR				
4,4'-DDE	4.6			
4,4'-DDD		23 J	46	
ENDOSULFAN SULFATE				
4,4'-DDT	28	15	78	4.9
ALPHA-CHLORDANE				
GAMMA-CHLORDANE				
VOLATILES				
METHYLENE CHLORIDE				
ACETONE				26 J
2-BUTANONE				
4-METHYL-2-PENTANONE				
XYLENES (total)				
SEMIVOLATILES				
NAPHTHALENE				
2-METHYLNAPHTHALENE				
ACENAPHTHENE				
FLUORENE				
N-NITROSODIPHENYLAMINE				
PHENANTHRENE				
ANTHRACENE				
DI-N-BUTYL PHTHALATE				
FLUORANTHENE				
PYRENE				
BIS(2-ETHYLHEXYL)PHTHALATE				

Notes:
UG/KG - microgram per kilogram
J - value is estimated

TABLE 4 - 4
SUBSURFACE SOIL POSITIVE DETECTION SUMMARY
TAL METALS AND CYANIDE
LAWN AREA AND MIXING PAD
OPERABLE UNIT NO. 5 - SITE 2
REMEDIAL INVESTIGATION CTO - 19174
MCB CAMP LEJEUNE, NORTH CAROLINA

SAMPLE NO.	2-LA-SB02-01	2-LA-SB04-02	2-LA-SB07-01	2-LA-SB09-02	2-LA-SB10-01	2-LA-SB19-01
DEPTH	2 - 4'	4 - 6'	2 - 4'	4 - 6'	2 - 4'	2 - 4'
UNITS	MG/KG	MG/KG	MG/KG	MG/KG	MG/KG	MG/KG
ALUMINUM	4940	3810	2840	4500	5510	8770
ARSENIC				0.62 B		
BARIUM	5.5 B	3.9 B	5.4 B	18.2 B	6 B	9.7 B
BERYLLIUM						
CALCIUM	609 J	1300 J	7020 J	5010 J	267 J	234 J
CHROMIUM	3.5	2.8		15.1	4.5	6.3
COBALT			2.4 B			3.2 B
COPPER	0.75 B			4.6 B		
IRON	729	440 J	537 J	2560	762	1170 J
LEAD	5 J	3.9 J	7.1 J	82.1	3.4 J	6.1 J
MAGNESIUM	112 B	89.6 B	154 B	180 B	176 B	155 B
MANGANESE	2.2 B	3.1 B	4.2	12.5	6.6	2.4 B
MERCURY						
POTASSIUM	148 B	87.6 B	50.5 B	135 B	178 B	136 B
SODIUM	51.6 B	15.5 B	25.4 B	25.7 B	47 B	15.8 B
VANADIUM	4.7 B	3.9 B	3.1 B	4.6 B	6 B	7 B
ZINC			18.8	29.1 J	2.1 B	

Notes:
MG/KG - milligram per kilogram
B - reported value is less than Contract Required Detection Limit (CRDL), but greater than Instrument Dectection Limit (IDL)
J - value is estimated

TABLE 4 - 4
SUBSURFACE SOIL POSITIVE DETECTION SUMMARY
TAL METALS AND CYANIDE
LAWN AREA AND MIXING PAD
OPERABLE UNIT NO. 5 - SITE 2
REMEDIAL INVESTIGATION CTO - 19174
MCB CAMP LEJEUNE, NORTH CAROLINA

SAMPLE NO.	2-MP-SB04-01	2-MP-SB08-02	2-MP-SB16-02	2-MP-SB24-02	2-MP-SB28-01
DEPTH	2 - 4'	4 - 6'	4 - 6'	4 - 6'	2 - 4'
UNITS	MG/KG	MG/KG	MG/KG	MG/KG	MG/KG
ALUMINUM	5540	2920	4130	7650 J	3760 J
ARSENIC	1.3 J				
BARIUM	7.8 B	3.7 B	4.6 B	6.6 J	5.7 J
BERYLLIUM	0.26 B			0.24 J	
CALCIUM	684 J	126 J	21700 J	1180 J	58.3 J
CHROMIUM	8.3	2.4	3.7	9.1 J	2.7 J
COBALT					
COPPER	1 B	0.73 B	0.98 B		
IRON	993	442	925 J	1220 J	324 J
LEAD	4.9	6.8 J	2.9 J	22 J	3.4 J
MAGNESIUM	108 B	81 B	484 B	183 J	
MANGANESE	2.6 B	4.9	6.6	3.7 J	
MERCURY		0.22			
POTASSIUM	190 B	122 B	194 B	288 J	104 J
SODIUM	44.9 B	27.8 B	49.6 B	29.9 J	36.1 J
VANADIUM	7.8 J	3.4 B	5.1 B	8.6 J	3 J
ZINC	6.8			2.9 J	1.9 J

Notes:
MG/KG - milligram per kilogram
B - reported value is less than Contract Required Detection Limit (CRDL), but greater than Instrument Dectection Limit (IDL)
J - value is estimated

TABLE 4 - 5
SURFACE SOIL POSITIVE DETECTION SUMMARY
ORGANIC CHEMICALS
FORMER STORAGE AREA
OPERABLE UNIT NO. 5 - SITE 2
REMEDIAL INVESTIGATION CTO - 19174
MCB CAMP LEJEUNE, NORTH CAROLINA

SAMPLE NO. DEPTH UNITS	2-FSA-SB04-00 0 - 6" UG/KG	2-FSA-SB06-00 0 - 6" UG/KG	2-FSA-SB09-00 0 - 6" UG/KG	2-FSA-SB11-00 0 - 6" UG/KG	2-FSA-SB13-00 0 - 6" UG/KG
<u>PESTICIDES/PCBS</u>					
4,4'-DDE	80	230 J		170	76
4,4'-DDD	30 J	1200 J		120 J	400
4,4'-DDT	740	9400	4.7	280	310
<u>VOLATILES</u>					
ACETONE	24 J	43 J	12 J		
2-BUTANONE		25 J	35 J		
TOLUENE			5 J		
XYLENES (total)			8 J		
<u>SEMIVOLATILES</u>					
DI-N-BUTYL PHTHALATE	68 J	120 J	100 J		
BIS(2-ETHYLHEXYL)PHTHALATE		90 J			

Notes:
MG/KG - milligram per kilogram
B - reported value is less than Contract Required Detection Limit (CRDL), but greater than Instrument Detection Limit (IDL)
J - value is estimated

TABLE 4 - 6
SURFACE SOIL POSITIVE DETECTION SUMMARY
TAL METALS AND CYANIDE
FORMER STORAGE AREA
OPERABLE UNIT NO. 5 - SITE 2
REMEDIAL INVESTIGATION CTO - 19174
MCB CAMP LEJEUNE, NORTH CAROLINA

SAMPLE NO.	2-FSA-SB04-00	2-FSA-SB06-00	2-FSA-SB09-00	2-FSA-SB11-00	2-FSA-SB13-00
DEPTH	0 - 6"	0 - 6"	0 - 6"	0 - 6"	0 - 6"
UNITS	MG/KG	MG/KG	MG/KG	MG/KG	MG/KG
ALUMINUM	4900 J	6750 J	8250 J	6030	8590
ARSENIC	0.69 J	0.86 J	0.73 J		
BARIUM	11.5 J	11.1 J	9.7 J	11 B	14 B
BERYLLIUM	0.23 J	0.23 J	0.24 J		
CALCIUM	97000 J	108000 J	551 J	94900 J	3810 J
CHROMIUM	6.6 J	9.8 J	7.1 J	9.6	7.2
COPPER	2.7 J	2.7 J	0.47 J	8.2	1.9 B
IRON	2440 J	2770 J	1760 J	2980	2600
LEAD	10.4 J	7.3 J	5.6 J	7.3 J	6.2 J
MAGNESIUM	1380 J	1830 J	242 J	1740	319 B
MANGANESE	16.5 J	18.1 J	5.9 J	20.4	6.8
MERCURY	0.44 J	0.34 J	0.39 J		
POTASSIUM	221 J	247 J	195 J	364 B	319 B
SELENIUM	0.27 J			0.46 B	0.49 J
SILVER			0.71 J		
SODIUM	149 J	238 J	38.1 J	217 B	70.6 B
VANADIUM	8.5 J	10.4 J	10.9 J	11 B	11.2 B
ZINC	12.6 J		17.7 J	51.9	7.5

Notes:
MG/KG - milligram per kilogram
B - reported value is less than Contract Required Detection Limit (CRDL), but greater than Instrument Detection Limit (IDL)
J - value is estimated

TABLE 4 - 7
SUBSURFACE SOIL POSITIVE DETECTION SUMMARY
ORGANIC CHEMICALS
FORMER STORAGE AREA
OPERABLE UNIT NO. 5 - SITE 2
REMEDIAL INVESTIGATION CTO - 19174
MCB CAMP LEJEUNE, NORTH CAROLINA

SAMPLE NO.	2-FSA-SB04-02	2-FSA-SB06-02	2-FSA-SB09-02	2-FSA-SB11-01	2-FSA-SB12-01	2-FSA-SB13-01
DEPTH	4 - 6'	4 - 6'	4 - 6'	2 - 4'	2 - 4'	2 - 4'
UNITS	UG/KG	UG/KG	UG/KG	UG/KG	UG/KG	UG/KG
PESTICIDES/PCBS						
4,4'-DDE		6 J				
4,4'-DDD		32 J		11		240 J
4,4'-DDT		230		10		120 J
VOLATILES						
ACETONE	46 J	28 J	42 J			
2-BUTANONE			56 J			
4-METHYL-2-PENTANONE			7 J			
XYLENES (total)			5 J			
SEMIVOLATILES						
DI-N-BUTYL PHTHALATE	89 J		110 J			
BIS(2-ETHYLHEXYL)PHTHALATE						
BTEX						
TOLUENE					9.1	
ETHYLBENZENE					9.1	
O-XYLENES					10.3	
M/P-XYLENES					14.2	

Notes:
UG/KG - microgram per kilogram
J - value is estimated

TABLE 4 - 7
SUBSURFACE SOIL POSITIVE DETECTION SUMMARY
ORGANIC CHEMICALS
FORMER STORAGE AREA
OPERABLE UNIT NO. 5 - SITE 2
REMEDIAL INVESTIGATION CTO - 19174
MCB CAMP LEJEUNE, NORTH CAROLINA

SAMPLE NO. DEPTH UNITS	2-GW03D-01 2 - 4' UG/KG	2-GW06-01 2 - 4' UG/KG	2-GW07-01 2 - 4' UG/KG	2-GW07-03 6 - 8' UG/KG	2-GW08-01 2 - 4' UG/KG	2-GW08-02 4 - 6' UG/KG
<u>PESTICIDES/PCBS</u>						
4,4'-DDE					31	
4,4'-DDD			12		1000	85
4,4'-DDT	6				1500	120
<u>VOLATILES</u>						
ACETONE		58 J	46 J	71 J		
2-BUTANONE						
4-METHYL-2-PENTANONE					7 J	8 J
XYLENES (total)						4 J
<u>SEMIVOLATILES</u>						
DI-N-BUTYL PHTHALATE			110 J		99 J	
BIS(2-ETHYLHEXYL)PHTHALATE			64 J			
<u>BTEX</u>						
TOLUENE						
ETHYLBENZENE						
O-XYLENES						
M/P-XYLENES						

Notes:
UG/KG - microgram per kilogram
J - value is estimated

TABLE 4 - 8
SUBSURFACE SOIL POSITIVE DETECTION SUMMARY
TAL METALS AND CYANIDE
FORMER STORAGE AREA
OPERABLE UNIT NO. 5 - SITE 2
REMEDIAL INVESTIGATION CTO - 19174
MCB CAMP LEJEUNE, NORTH CAROLINA

SAMPLE NO.	2-FSA-SB04-02	2-FSA-SB06-02	2-FSA-SB09-02	2-FSA-SB11-01	2-FSA-SB13-01	2-GW03D-01
DEPTH	4 - 6'	4 - 6'	4 - 6'	2 - 4'	2 - 4'	2 - 4'
UNITS	MG/KG	MG/KG	MG/KG	MG/KG	MG/KG	MG/KG
ALUMINUM	9230 J	11700 J	6720 J	17600	12400	6810
ARSENIC		0.81 J	0.94 J	1 B		0.52 B
BARIUM	9.7 J	17.8 J	9.4 J	15.6 B	13.3 B	5.4 B
BERYLLIUM	0.24 J	0.24 J	0.25 J			
CADMIUM						
CALCIUM	1280 J	243 J	29.7 J	1480 J	49.4 J	24.1 J
CHROMIUM	8.1 J	15.2 J	7.7 J	13.8	9.4	6.2
COBALT						2.5 B
COPPER	0.95 J	1.5 J	1.5 J			
IRON	1810 J	3130 J	1570 J	7240	1830	998 J
LEAD	4.8 J	6.3 J	5.3 J	7 J	6 J	5 J
MAGNESIUM	274 J	447 J	240 J	493 B	369 B	97 B
MANGANESE	5.5 J	8.8 J	7.2 J	8.6	9.9	2.5 B
MERCURY	0.37 J	0.39 J	0.29 J			
POTASSIUM	211 J	772 J	409 J	394 B	320 B	67.5 B
SELENIUM	0.33 J					
SODIUM	30.1 J	40.3 J	34.9 J	74.1 B	59.8 B	32.8 B
VANADIUM	10.9 J	21 J	10.2 J	25.7	12.3	6.4 B
ZINC				3.2 B	2.5 B	

Notes:
MG/KG - milligram per kilogram
B - reported value is less than Contract Required Detection Limit (CRDL), but greater than Instrument Detection Limit (IDL)
J - value is estimated

TABLE 4 - 8
SUBSURFACE SOIL POSITIVE DETECTION SUMMARY
TAL METALS AND CYANIDE
FORMER STORAGE AREA
OPERABLE UNIT NO. 5 - SITE 2
REMEDIAL INVESTIGATION CTO - 19174
MCB CAMP LEJEUNE, NORTH CAROLINA

SAMPLE NO.	2-GW03D-23	2-GW06-01	2-GW07-01	2-GW08-01	2-GW08-02
DEPTH	46 - 48'	2 - 4'	2 - 4'	2 - 4'	4 - 6'
UNITS	MG/KG	MG/KG	MG/KG	MG/KG	MG/KG
ALUMINUM	1060	15800 J	10800 J	9590	3930
ARSENIC	0.94 B		1.7 J	0.64 B	
BARIUM	7.7 B	16.4 J	12.5 J	10.4 B	5.7 B
BERYLLIUM					
CADMIUM	1.6				
CALCIUM	246000 J	56 J	186 J	32.1 J	27.8 J
CHROMIUM	16.6	9.6 J	10.9 J	7.9	5.2
COBALT					
COPPER	4.2 B	0.55 J	0.97 J	0.49 B	0.74 B
IRON	1760	3400 J	4810 J	4090	1000
LEAD	1.2 J	5.7 J	8 J	7.9 J	5.9 J
MAGNESIUM	3860	459 J	283 J	212 B	85.7 B
MANGANESE	24.1	8.7 J	4.3 J	3.7	3.4 B
MERCURY	0.33		0.3 J	0.3	0.22
POTASSIUM	308 B	342 J	350 J	136 B	124 B
SELENIUM		0.63 J	0.29 J		
SODIUM	1030 B	51.4 J	95.5 J	28.9 B	26.6 B
VANADIUM	22.5	17.2 J	13.8 J	12.6	4.2 B
ZINC	12.6 J	2.7 J			

Notes:
MG/KG - milligram per kilogram
B - reported value is less than Contract Required Detection Limit (CRDL), but greater than Instrument Detection Limit (IDL)
J - value is estimated

TABLE 4 - 9
GROUNDWATER POSITIVE DETECTION SUMMARY
ORGANIC CHEMICALS
SHALLOW AND DEEP MONITORING WELLS
OPERABLE UNIT NO. 5 - SITE 2
REMEDIAL INVESTIGATION CTO 19174
MCB CAMP LEJEUNE, NORTH CAROLINA

SAMPLE NO.	2-GW01-01	2-GW03-01	2-GW03DW-01	2-GW06-01	2-GW07-01	2-GW08-01
UNITS	UG/L	UG/L	UG/L	UG/L	UG/L	UG/L
<u>PESTICIDES/PCBS</u>						
4,4'-DDD						4 J
4,4'-DDT						9.4
<u>VOLATILES</u>						
BROMOMETHANE	1					
DICHLOROMETHANE	1					
TRICHLOROETHENE			5			
ETHHYLBENZENE		190			2	
XYLENES(total)		1800 J		1	19 J	
<u>SEMIVOLATILES</u>						
PHENOL			3 J			
2,4-DIMETHYLPHENOL		6 J				
NAPHTHALENE	2 J	15				
2-METHYLNAPHTHALENE	3 J	17				
ACENAPHTHENE		2 J				
BIS(2-ETHYLHEXYL)PHTHALATE			2 J			

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

TABLE 4 - 9
GROUNDWATER POSITIVE DETECTION SUMMARY
ORGANIC CHEMICALS
SHALLOW AND DEEP MONITORING WELLS
OPERABLE UNIT NO. 5 - SITE 2
REMEDIAL INVESTIGATION CTO 19174
MCB CAMP LEJEUNE, NORTH CAROLINA

SAMPLE NO. UNITS	2-GW09-01 UG/L
PESTICIDES/PCBS	
4,4'-DDD	0.73
4,4'-DDT	1.6
VOLATILES	
BROMOMETHANE	
DICHLOROMETHANE	
TRICHLOROETHENE	
ETHHYLBENZENE	
XYLENES(total)	
SEMIVOLATILES	
PHENOL	
2,4-DIMETHYLPHENOL	
NAPHTHALENE	
2-METHYLNAPHTHALENE	
ACENAPHTHENE	
BIS(2-ETHYLHEXYL)PHTHALATE	2 J

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

TABLE 4 - 9 (continued)
GROUNDWATER POSITIVE DETECTION SUMMARY
ORGANIC CHEMICALS - ROUND 2
SHALLOW AND DEEP MONITORING WELLS
OPERABLE UNIT NO. 5 - SITE 2
REMEDIAL INVESTIGATION CTO 19174
MCB CAMP LEJEUNE, NORTH CAROLINA

SAMPLE NO.	2-GW01-02	2-GW03-02	2-GW03DW-02	2-GW06-02	2-GW07-02	2-GW08-02
UNITS	UG/L	UG/L	UG/L	UG/L	UG/L	UG/L
PESTICIDES/PCBS						
4,4'-DDD						5.4
4,4'-DDE						
4,4'-DDT						1.2 J
ENDRIN ALDEHYDE						1.7 J
VOLATILES						
CARBON DISULFIDE			1			
2-BUTANONE			5			
CHLOROBENZENE		2				
CHLOROFORM				17		
ETHHYLBENZENE		93 E				
TOULENE		7				
XYLENES(total)		510 E				
SEMIVOLATILES						
2,4-DIMETHYLPHENOL		5 J				
NAPHTHALENE	10	11				
2-METHYLNAPHTHALENE	8 J	8 J				

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

TABLE 4 - 9 (continued)
GROUNDWATER POSITIVE DETECTION SUMMARY
ORGANIC CHEMICALS - ROUND 2
SHALLOW AND DEEP MONITORING WELLS
OPERABLE UNIT NO. 5 - SITE 2
REMEDIAL INVESTIGATION CTO 19174
MCB CAMP LEJEUNE, NORTH CAROLINA

SAMPLE NO.	2-GW09-02	2-GW10-01	2-GW11-01
UNITS	UG/L	UG/L	UG/L
PESTICIDES/PCBS			
4,4'-DDD			37 E
4,4'-DDE			0.84
4,4'-DDT		0.1	6.5
ENDRIN ALDEHYDE			
VOLATILES			
CARBON DISULFIDE			
2-BUTANONE			
CHLOROBENZENE			
CHLOROFORM			
ETHHYLBENZENE			
TOULENE			
XYLENES(total)			
SEMIVOLATILES			
2,4-DIMETHYLPHENOL			
NAPHTHALENE			
2-METHYLNAPHTHALENE			5 J

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

TABLE 4 - 10
GROUNDWATER POSITIVE DETECTION SUMMARY
TAL METALS AND CYANIDE
SHALLOW AND DEEP MONITORING WELLS
OPERABLE UNIT NO. 5 - SITE 2
REMEDIAL INVESTIGATION CTO - 19174
MCB CAMP LEJEUNE, NORTH CAROLINA

SAMPLE NO.	2-GW01-01	2-GW03-01	2-GW03DW-01	2-GW04-01	2-GW05-01	2-GW06-01
UNITS	UG/L	UG/L	UG/L	UG/L	UG/L	UG/L
ALUMINUM	36000	5200	269	16800	4050	13600
ARSENIC	21.2	2.5 B		23.6	2.2 B	5.4 B
BARIUM	52 B	46 B	1420	95 B	100 B	173 B
BERYLLIUM	1 B			2 B		
CADMIUM	7					
CALCIUM	23700	8460	450000	11100	21000	7940
CHROMIUM	18	11	16			15
COBALT	10 B					12 B
COPPER	10 B	4 B	8 B	5 B	3 B	5 B
IRON	10300	7190	127	28100	12700	11700
LEAD	15.5 J	3.5 J		2.7 J		6.7 J
MAGNESIUM	5660	1600 B	75 B	1920 B	4800 B	4120 B
MANGANESE	55	21		21	46	79
NICKEL						
POTASSIUM	2560 B	1030 B	187000	1210 B	2130 B	2570 B
SELENIUM	4.2 B					
SODIUM	4040 B	5490	103000	5560	10100	21900
VANADIUM	72	10 B		89	9 B	15 B
ZINC	146	13 B	9 B	16 B	6 B	26

Notes:
UG/L - microgram per liter
B - reported value is less than Contract Required Detection Limit (CRDL), but greater than Instrument Detection Limit (IDL)
J - value is estimated

TABLE 4 - 10
GROUNDWATER POSITIVE DETECTION SUMMARY
TAL METALS AND CYANIDE
SHALLOW AND DEEP MONIT0RING WELLS
OPERABLE UNIT NO. 5 - SITE 2
REMEDIAL INVESTIGATION CTO - 19174
MCB CAMP LEJEUNE, NORTH CAROLINA

SAMPLE NO. UNITS	2-GW07-01 UG/L	2-GW08-01 UG/L	2-GW09-01 UG/L
ALUMINUM	8550	6380	56300
ARSENIC	5.7 B	9.2 B	12.9
BARIUM	98 B	98 B	328
BERYLLIUM			3 B
CADMIUM			
CALCIUM	9350	5710	22100
CHROMIUM	15		75
COBALT			10 B
COPPER	7 B	6 B	25
IRON	12500	9150	42000
LEAD	8.3 J		27.2 J
MAGNESIUM	3620 B	2020 B	9980
MANGANESE	72	53	290
NICKEL			25 B
POTASSIUM	1940 B	1550 B	6610
SELENIUM			
SODIUM	8180	11800	18300
VANADIUM	18 B	12 B	86
ZINC	22	27	103

Notes:
UG/L - microgram per liter
B - reported value is less than Contract Required Detection Limit (CRDL), but greater than Instrument Detection Limit (IDL)
J - value is estimated

TABLE 4-10 (continued)
GROUNDWATER POSITIVE DETECTION SUMMARY
TAL METALS AND CYANIDE - ROUND 2
SHALLOW AND DEEP MONITORING WELLS
OPERABLE UNIT NO. 5 - SITE 2
REMEDIAL INVESTIGATION CTO-19174
MCB CAMP LEJEUNE, NORTH CAROLINA

SAMPLE NO. UNITS	2-GW01-02 UG/L	2-GW03-02 UG/L	2-GW03DW-02 UG/L	2-GW04-02 UG/L	2-GW05-02 UG/L	2-GW06-02 UG/L
ALUMINUM	4030	4200	346	1250	4220	15100
ARSENIC	3.5 B			3 B		
BARIUM	37 B	30 B	907	81 B	98 B	55 B
BERYLLIUM						2 B
CADMIUM						5
CALCIUM	23400	10300	321000	22600	19700	6960
CHROMIUM						
COBALT						42 B
COPPER	1 B	3 B	4 B	3 B	3 B	4 B
IRON	4460	3410	103	5660	13100	4760
LEAD	1.7 B	2.5 B	1.8 B	1.2 B	1 B	2.4 B
MAGNESIUM	4890 B	1300 B	53 B	2230 B	4360 B	5520
MANGANESE	47	10 B		18	43	140
NICKEL						40
POTASSIUM	1480 B	726 B	51500	875 B	1940 B	670 B
SELENIUM						
SILVER			3 B			4 B
SODIUM	3560 B	6000	60000	5300	8510	31100
VANADIUM	15 B	8 B	4 B	5 B	9 B	
ZINC	36				15 B	91

Notes:
UG/L - microgram per liter
B - Reported value is less than Contract Required Detection Limit (CRDL), but greater than Instrument Detection Limit (IDL).
J - Value is estimated.

TABLE 4-10 (continued)
GROUNDWATER POSITIVE DETECTION SUMMARY
TAL METALS AND CYANIDE - ROUND 2
SHALLOW AND DEEP MONITORING WELLS
OPERABLE UNIT NO. 5 - SITE 2
REMEDIAL INVESTIGATION CTO-19174
MCB CAMP LEJEUNE, NORTH CAROLINA

SAMPLE NO. UNITS	2-GW07-02 UG/L	2-GW08-02 UG/L	2-GW09-02 UG/L	2-GW10-01 UG/L	2-GW11-01 UG/L
ALUMINUM	6120	18100	71600	20600	124000
ARSENIC	2.1 B		13.8	9.7 B	16.6
BARIUM	75 B	52 B	469	127 B	309
BERYLLIUM		2 B	7		3 B
CADMIUM					
CALCIUM	23400	13800	26000	53700	37000
CHROMIUM	10		83	46	117
COBALT		78	41 B	11 B	26 B
COPPER	4 B	5 B	32	9 B	23 B
IRON	6000	3400	46600	23500	38900
LEAD	3.7	3.4	23.6	6.1	44.8
MAGNESIUM	3920 B	3200 B	14200	4360 B	8860
MANGANESE	43	415	747	92	190
NICKEL		85	69		54
POTASSIUM	1550 B	572 B	6830	2830 B	7750
SELENIUM					1.4 B
SILVER	3 B			3 B	
SODIUM	11000	28600	11800	10100	9950
VANADIUM	9 B		96	42 B	184
ZINC	9 B	232	172	38	132

Notes:
UG/L - microgram per liter
B - Reported value is less than Contract Required Detection Limit (CRDL), but greater than Instrument Detection Limit (IDL).
J - Value is estimated.

TABLE 4 - 11
GROUNDWATER POSITIVE DETECTION SUMMARY
DISSOLVED METALS
SHALLOW AND DEEP MONITORING WELLS
OPERABLE UNIT NO. 5 - SITE 2
REMEDIAL INVESTIGATION CTO - 19174
MCB CAMP LEJEUNE, NORTH CAROLINA

SAMPLE NO.	2-GW01D-01	2-GW03D-01	2-GW03DWD-01	2-GW04D-01	2-GW05D-01	2-GW06D-01
UNITS	UG/L	UG/L	UG/L	UG/L	UG/L	UG/L
ALUMINUM	1930	66 B	89 B	60 B	1990	149 B
ARSENIC	2.2 B			6.1 B		2.9 B
BARIUM	42 B	25 B	1400	64 B	98 B	126 B
BERYLLIUM	1 B				1 B	
CALCIUM	24400	7100	441000	11300	21800	8080
CHROMIUM			11			
COBALT						10 B
COPPER	4 B	2 B	6 B	9 B	4 B	2 B
IRON	2560	2170		2720	7400	7070
LEAD	2.1 J					
MAGNESIUM	5220	1030 B	26 B	1840 B	4900 B	3610 B
MANGANESE	51			17	46	65
POTASSIUM	2140 B	589 B	188000	1130 B	2170 B	1970 B
SODIUM	3590 B	5400	103000	5710	9970	22600
ZINC	28			8 B	9 B	12 B

Notes:
UG/L - microgram per liter
B - reported value is less than Contract Required Detection Limit (CRDL), but greater than Instrument Detection Limit (IDL)
J - value is estimated

TABLE 4 - 11
GROUNDWATER POSITIVE DETECTION SUMMARY
DISSOLVED METALS
SHALLOW AND DEEP MONITORING WELLS
OPERABLE UNIT NO. 5 - SITE 2
REMEDIAL INVESTIGATION CTO - 19174
MCB CAMP LEJEUNE, NORTH CAROLINA

SAMPLE NO. UNITS	2-GW07D-01 UG/L	2-GW08D-01 UG/L	2-GW09D-01 UG/L
ALUMINUM	43 B	95 B	1230
ARSENIC		7.1 B	
BARIUM	49 B	62 B	149 B
BERYLLIUM			1 B
CALCIUM	9590	5800	20800
CHROMIUM			10
COBALT	8 B		14 B
COPPER	5 B	4 B	5 B
IRON	4660	6180	7040
LEAD			
MAGNESIUM	3060 B	1730 B	6890
MANGANESE	48	40	129
POTASSIUM	1490 B	1150 B	2790 B
SODIUM	8720	12100	17200
ZINC	13 B	19 B	35

Notes:
UG/L - microgram per liter
B - reported value is less than Contract Required Detection Limit (CRDL), but greater than Instrument Detection Limit (IDL)
J - value is estimated

TABLE 4-11 (continued)
GROUNDWATER POSITIVE DETECTION SUMMARY
DISSOLVED METALS - ROUND 2
SHALLOW AND DEEP MONITORING WELLS
OPERABLE UNIT NO. 5 - SITE 2
REMEDIAL INVESTIGATION CTO-19174
MCB CAMP LEJEUNE, NORTH CAROLINA

SAMPLE NO. UNITS	2-GW01D-02 UG/L	2-GW03D-02 UG/L	2-GW03DWD-02 UG/L	2-GW04D-02 UG/L	2-GW05D-02 UG/L	2-GW06D-02 UG/L
ALUMINUM	1720	124 B	178 B	73 B	1690	15400
ANTIMONY						
ARSENIC						
BARIUM	36 B	24 B	588	82 B	98 B	57 B
BERYLLIUM						2 B
CALCIUM	23400	10700	315000	24000	20200	7860
CHROMIUM						
COBALT	11 B					43 B
COPPER	1 B	1 B	4 B		1 B	4 B
IRON	2670	2580	149	2990	7640	4580
LEAD						
MAGNESIUM	4860 B	1180 B	33 B	2290 B	4390 B	6020
MANGANESE	46 B	7 B		19	45	156
NICKEL						50
POTASSIUM	1480 B	476 B	50600	922 B	1890 B	659 B
SILVER					11	
SODIUM	3680 B	6020	60000	5430	8360	33300
VANADIUM						
ZINC	20				7 B	97

Notes:
UG/L - microgram per liter
B - Reported value is less than Contract Required Detection Limit (CRDL), but greater than Instrument Detection Limit (IDL).
J - Value is estimated.

TABLE 4-12

SUMMARY OF GROUNDWATER FIELD PARAMETERS
SITE 2
REMEDIAL INVESTIGATION CTO-0174
MCB, CAMP LEJEUNE NORTH CAROLINA

Well/No./ Date of Measurement	Depth of Well (ft)	Purge Volume (gals)	Well Volume	Specific Conductance at 25C (umhos/cm)	Temperature (C)	pH (S.U.)
2GW1 5/20/93	24.4	8.5	1	185	16.8	4.82
			2	138	17.2	4.67
			3	257	17.4	4.90
			3.5	239	17.3	5.08
2GW2 (1) 5/18/93						
2GW3 5/20/93	27.32	9.6	1	103	17.1	5.22
			2	100	16.0	5.29
			3	100	16.1	5.41
2GW3D (2) 5/20/93	102.28	135	1	7,658	20.1	12.62
2GW4 5/20/93	22.5	7.5	1	125	19.3	6.71
			2	133	18.7	6.86
			3	133	19.0	6.02
2GW5 5/20/93	27.11	7.5	1	287	17.3	5.12
			2	296	17.0	5.02
			3	289	17.2	5.08
2GW6 5/20/93	14.74	24	1	315	16.6	4.82
			2	288	18.0	5.33
			3	271	17.7	5.61
			4	260	17.5	5.58

Notes: (1) This well was purged dry and was left to recover for 24 hours, then was sampled on 5/19/93.

(2) This well was purged dry after the first volume was taken out, it was left to recover for 24 hours, then was sampled on 5/21/93.

TABLE 4-12 (Continued)

SUMMARY OF GROUNDWATER FIELD PARAMETERS
SITE 2
REMEDIAL INVESTIGATION CTO-0174
MCB, CAMP LEJEUNE NORTH CAROLINA

Well/No./ Date of Measurement	Depth of Well (ft)	Purge Volume (gals)	Well Volume	Specific Conductanc e at 25C (umhos/cm)	Temperature (C)	pH (S.U.)
2GW7 5/20/93	15.41	21	1	210	18.9	5.68
			2	171	18.6	5.96
			3	166	17.9	5.97
2GW8 5/20/93	14.67	18	1	146	17.7	5.33
			2	149	17.5	5.42
			3	154	16.8	5.63
2GW9 5/20/93	15.21	18	1	314	17.2	5.07
			2	334	16.5	4.75
			3	350	16.8	5.00

Notes: (1) This well was purged dry and was left to recover for 24 hours, then was sampled on 5/19/93.

(2) This well was purged dry after the first volume was taken out, it was left to recover for 24 hours, then was sampled on 5/21/93.

TABLE 4-13

OPERBLE UNIT NO. 5 - SITE 2
GROUNDWATER ENGINEERING PARAMETERS
MONITORING WELL 2GW6
REMEDIAL INVESTIGATION CTO-0174
MCB CAMP LEJEUNE, NORTH CAROLINA

Parameter	Result
Biological Oxygen Demand	4 mg/L
Chemical Oxygen Demand	46 mg/L
Total Solids	520 mg/L
Total Suspended Solids	280 mg/L
Total Dissolved Solids	180 mg/L
Total Volatile Solids	91 mg/L
Total Organic Carbon	5 mg/L

TABLE 4 - 14
SEDIMENT POSITIVE DETECTION SUMMARY
ORGANIC CHEMICALS
CREEK AND RAILROAD
OPERABLE UNIT NO. 5 - SITE 2
REMEDIAL INVESTIGATION CTO - 19174
MCB CAMP LEJEUNE, NORTH CAROLINA

SAMPLE NO. UNITS	2-OCSD01-06 UG/KG	2-OCSD01-612 UG/KG	2-OCSD02-06 UG/KG	2-OCSD02-612 UG/KG	2-OCSD03-06 UG/KG	2-OCSD03-612 UG/KG
PESTICIDES/PCBS						
DIELDRIN						
4,4'-DDE	15	49	5.7			29
ENDOSULFAN II						
4,4'-DDD	120	460	7.7	120		14
4,4'-DDT	30	86	6.5	11 J		
ALPHA-CHLORDANE						
GAMMA-CHLORDANE						
VOLATILES						
ACETONE					170 J	
2-BUTANONE						
ETHYLBENZENE						
XYLENES (total)						
SEMIVOLATILES						
NAPHTHALENE						
2-METHYLNAPHTHALENE						
ACENAPHTHENE						
FLUORENE						
PHENANTHRENE						
FLUORANTHENE						
PYRENE						
BENZO(A)ANTHRACENE						
CHRYSENE						
BENZO(B)FLUORANTHENE						
BENZO(K)FLUORANTHENE						
BENZO(A)PYRENE						

Notes:
UG/KG - microgram per kilogram
J - value is estimated

TABLE 4 - 14
SEDIMENT POSITIVE DETECTION SUMMARY
ORGANIC CHEMICALS
CREEK AND RAILROAD
OPERABLE UNIT NO. 5 - SITE 2
REMEDIAL INVESTIGATION CTO - 19174
MCB CAMP LEJEUNE, NORTH CAROLINA

SAMPLE NO. UNITS	2-RRSD01-06 UG/KG	2-RRSD01-612 UG/KG	2-RRSD02-06 UG/KG	2-RRSD02-612 UG/KG	2-RRSD03-06 UG/KG	2-RRSD03-612 UG/KG
<u>PESTICIDES/PCBS</u>						
DIELDRIN						
4,4'-DDE	11 J		26 J	17 J	21	
ENDOSULFAN II						
4,4'-DDD	13 J	9.8 J	17 J	15 J	16 J	4.2 J
4,4'-DDT	15 J	75 J	8.9 J	6.5 J	19	6.9 J
ALPHA-CHLORDANE						
GAMMA-CHLORDANE						
<u>VOLATILES</u>						
ACETONE						
2-BUTANONE						
ETHYLBENZENE						
XYLENES (total)						
<u>SEMIVOLATILES</u>						
NAPHTHALENE						
2-METHYLNAPHTHALENE						
ACENAPHTHENE						
FLUORENE						
PHENANTHRENE						
FLUORANTHENE				200 J		
PYRENE				190 J		
BENZO(A)ANTHRACENE				91 J		
CHRYSENE				190 J		
BENZO(B)FLUORANTHENE				200 J		
BENZO(K)FLUORANTHENE				170 J		
BENZO(A)PYRENE				100 J		

Notes:
UG/KG - microgram per kilogram
J - value is estimated

TABLE 4 - 14
SEDIMENT POSITIVE DETECTION SUMMARY
ORGANIC CHEMICALS
CREEK AND RAILROAD
OPERABLE UNIT NO. 5 - SITE 2
REMEDIAL INVESTIGATION CTO - 19174
MCB CAMP LEJEUNE, NORTH CAROLINA

SAMPLE NO.	2-RRSD04-06	2-RRSD04-612	2-RRSD05-06	2-RRSD05-612	2-RRSD06-06	2-RRSD06-612
UNITS	UG/KG	UG/KG	UG/KG	UG/KG	UG/KG	UG/KG
PESTICIDES/PCBS						
DIELDRIN						
4,4'-DDE			32	65	62	150
ENDOSULFAN II						
4,4'-DDD	13 J	32 J	50 J	150 J	700 J	2000 J
4,4'-DDT	4.7 J	58		140	260	2700
ALPHA-CHLORDANE						
GAMMA-CHLORDANE						
VOLATILES						
ACETONE					34 J	
2-BUTANONE						
ETHYLBENZENE						
XYLENES (total)						
SEMIVOLATILES						
NAPHTHALENE						
2-METHYLNAPHTHALENE						
ACENAPHTHENE						
FLUORENE						
PHENANTHRENE						
FLUORANTHENE						
PYRENE						
BENZO(A)ANTHRACENE						
CHRYSENE						
BENZO(B)FLUORANTHENE						
BENZO(K)FLUORANTHENE						
BENZO(A)PYRENE						

Notes:
UG/KG - microgram per kilogram
J - value is estimated

TABLE 4 - 14
SEDIMENT POSITIVE DETECTION SUMMARY
ORGANIC CHEMICALS
CREEK AND RAILROAD
OPERABLE UNIT NO. 5 - SITE 2
REMEDIAL INVESTIGATION CTO - 19174
MCB CAMP LEJEUNE, NORTH CAROLINA

SAMPLE NO. UNITS	2-RRSD07-06 UG/KG	2-RRSD07-612 UG/KG	2-RRSD08-06 UG/KG	2-RRSD08-612 UG/KG	2-RRSD09-06 UG/KG	2-RRSD09-612 UG/KG
PESTICIDES/PCBS						
DIELDRIN						
4,4'-DDE	230	3900	260	420	17000 J	6500 J
ENDOSULFAN II						
4,4'-DDD	1100	44000 J	3700	13000	710000 J	250000 J
4,4'-DDT	1800	6200 J	660	1900		80000 J
ALPHA-CHLORDANE	13		52 J	190	2400 J	
GAMMA-CHLORDANE			47	170		
VOLATILES						
ACETONE						
2-BUTANONE					530 J	
ETHYLBENZENE						680 J
XYLENES (total)					1400 J	4900
SEMIVOLATILES						
NAPHTHALENE						700
2-METHYLNAPHTHALENE						860
ACENAPHTHENE						130 J
FLUORENE						140 J
PHENANTHRENE						130 J
FLUORANTHENE						
PYRENE						
BENZO(A)ANTHRACENE						
CHRYSENE						
BENZO(B)FLUORANTHENE						
BENZO(K)FLUORANTHENE						
BENZO(A)PYRENE						

Notes:
UG/KG - microgram per kilogram
J - value is estimated

TABLE 4 - 14
SEDIMENT POSITIVE DETECTION SUMMARY
ORGANIC CHEMICALS
CREEK AND RAILROAD
OPERABLE UNIT NO. 5 - SITE 2
REMEDIAL INVESTIGATION CTO - 19174
MCB CAMP LEJEUNE, NORTH CAROLINA

SAMPLE NO. UNITS	2-RRSD10-06 UG/KG	2-RRSD10-612 UG/KG	2-RRSD11-06 UG/KG	2-RRSD11-612 UG/KG	2-RRSD12-06 UG/KG	2-RRSD12-612 UG/KG
PESTICIDES/PCBS						
DIELDRIN			7.5 J	12 J		
4,4'-DDE	51 J	10 J	83 J	78 J	170 J	190 J
ENDOSULFAN II						
4,4'-DDD	50 J	17 J	16 J		900 J	3600 J
4,4'-DDT	35 J	6 J	120	98 J	740 J	4500 J
ALPHA-CHLORDANE	14 J	3.5 J	3.5 J			44 J
GAMMA-CHLORDANE	15 J	2.9 J	2.8 J			49 J
VOLATILES						
ACETONE						
2-BUTANONE						
ETHYLBENZENE						
XYLENES (total)						
SEMIVOLATILES						
NAPHTHALENE						
2-METHYLNAPHTHALENE						
ACENAPHTHENE						
FLUORENE						
PHENANTHRENE						
FLUORANTHENE						
PYRENE						
BENZO(A)ANTHRACENE						
CHRYSENE						
BENZO(B)FLUORANTHENE						
BENZO(K)FLUORANTHENE						
BENZO(A)PYRENE						

Notes:
UG/KG - microgram per kilogram
J - value is estimated

TABLE 4 - 14
SEDIMENT POSITIVE DETECTION SUMMARY
ORGANIC CHEMICALS
CREEK AND RAILROAD
OPERABLE UNIT NO. 5 - SITE 2
REMEDIAL INVESTIGATION CTO - 19174
MCB CAMP LEJEUNE, NORTH CAROLINA

SAMPLE NO. UNITS	2-RRSD13-06 UG/KG	2-RRSD13-612 UG/KG	2-RRSD14-06 UG/KG	2-RRSD14-612 UG/KG	2-RRSD15-06 UG/KG	2-RRSD15-612 UG/KG
PESTICIDES/PCBS						
DIELDRIN						
4,4'-DDE	270 J			740 J	370 J	26 J
ENDOSULFAN II						5.2 J
4,4'-DDD	11000 J	4.8 J	35000 J	9600 J		350 J
4,4'-DDT	3000		13000 J	7800 J	38000 J	52 J
ALPHA-CHLORDANE						4 J
GAMMA-CHLORDANE						3.8 J
VOLATILES						
ACETONE						
2-BUTANONE						
ETHYLBENZENE						
XYLENES (total)						
SEMIVOLATILES						
NAPHTHALENE						
2-METHYLNAPHTHALENE						
ACENAPHTHENE						
FLUORENE						
PHENANTHRENE						
FLUORANTHENE						
PYRENE						
BENZO(A)ANTHRACENE						
CHRYSENE						
BENZO(B)FLUORANTHENE						
BENZO(K)FLUORANTHENE						
BENZO(A)PYRENE						

Notes:
UG/KG - microgram per kilogram
J - value is estimated

TABLE 4 - 14
SEDIMENT POSITIVE DETECTION SUMMARY
ORGANIC CHEMICALS
CREEK AND RAILROAD
OPERABLE UNIT NO. 5 - SITE 2
REMEDIAL INVESTIGATION CTO - 19174
MCB CAMP LEJEUNE, NORTH CAROLINA

SAMPLE NO.	2-RRSD16-06	2-RRSD16-612	2-RRSD17-06	2-RRSD17-612	2-RRSD18-06	2-RRSD18-612
UNITS	UG/KG	UG/KG	UG/KG	UG/KG	UG/KG	UG/KG
PESTICIDES/PCBS						
DIELDRIN						
4,4'-DDE	110		220	850	26	71
ENDOSULFAN II						
4,4'-DDD	300		1200	12000	34	1300
4,4'-DDT	210	4.9	2500	7600	78	2200
ALPHA-CHLORDANE	11		56	140	2.9	
GAMMA-CHLORDANE	6.2		40	79		
VOLATILES						
ACETONE						
2-BUTANONE						
ETHYLBENZENE						
XYLENES (total)						
SEMIVOLATILES						
NAPHTHALENE						
2-METHYLNAPHTHALENE						
ACENAPHTHENE						
FLUORENE						
PHENANTHRENE						
FLUORANTHENE						
PYRENE						
BENZO(A)ANTHRACENE						
CHRYSENE						
BENZO(B)FLUORANTHENE						
BENZO(K)FLUORANTHENE						
BENZO(A)PYRENE						

Notes:
UG/KG - microgram per kilogram
J - value is estimated

TABLE 4 - 14
SEDIMENT POSITIVE DETECTION SUMMARY
ORGANIC CHEMICALS
CREEK AND RAILROAD
OPERABLE UNIT NO. 5 - SITE 2
REMEDIAL INVESTIGATION CTO - 19174
MCB CAMP LEJEUNE, NORTH CAROLINA

SAMPLE NO. UNITS	2-RRSD19-06 UG/KG	2-RRSD19-612 UG/KG	2-RRSD20-06 UG/KG	2-RRSD20-612 UG/KG	2-RRSD21-06 UG/KG	2-RRSD21-612 UG/KG
PESTICIDES/PCBS						
DIELDRIN						
4,4'-DDE	32	35	160	10	32	22
ENDOSULFAN II						
4,4'-DDD	64 J	32 J	350	9.3 J	120 J	140
4,4'-DDT	220	74	200	18	900	41
ALPHA-CHLORDANE		2.3 J				
GAMMA-CHLORDANE						
VOLATILES						
ACETONE						
2-BUTANONE						
ETHYLBENZENE						
XYLENES (total)						
SEMIVOLATILES						
NAPHTHALENE						
2-METHYLNAPHTHALENE						
ACENAPHTHENE						
FLUORENE						
PHENANTHRENE						
FLUORANTHENE			130 J			
PYRENE			140 J			
BENZO(A)ANTHRACENE						
CHRYSENE			140 J			
BENZO(B)FLUORANTHENE			160 J			
BENZO(K)FLUORANTHENE						
BENZO(A)PYRENE						

Notes:
UG/KG - microgram per kilogram
J - value is estimated

TABLE 4 - 15
SEDIMENT POSITIVE DETECTION SUMMARY
TAL METALS AND CYANIDE
CREEK AND RAILROAD
OPERABLE UNIT NO. 5 - SITE 2
REMEDIAL INVESTIGATION CTO - 19174
MCB CAMP LEJEUNE, NORTH CAROLINA

SAMPLE NO.	2-OCSD01-06	2-OCSD01-612	2-OCSD03-06	2-OCSD03-612	2-RRSD01-06	2-RRSD01-612
UNITS	MG/KG	MG/KG	MG/KG	MG/KG	MG/KG	MG/KG
ALUMINUM	8680	9090	2560	9780	1890 J	2390 J
ANTIMONY						
ARSENIC			0.79 J			
BARIUM	30.5 B	30 B	114	32.2 B	4.9 J	3.1 J
BERYLLIUM	0.85 B	0.86 B				
CALCIUM	6320	6180	247000	10100		
CHROMIUM	9.9	10		10.1	4.4 J	3.6 J
COPPER	1.1 B	0.86 B	6.4 B	0.9 B	1 J	
IRON	842	845	14900	2680	1380 J	1540 J
LEAD	8.8	8	6.4	9.2	3 J	2.2 J
MAGNESIUM	322 B	307 B	2540	460 B		
MANGANESE	4.8	5.7	203	13.1	6.2 J	
POTASSIUM	229 B	237 B	55.4 B	284 B	29 J	22.9 J
SELENIUM	1.7 J	2.1 J				
SODIUM	86.2 B	78.9 B	171 B	80 B	41.9 J	34.8 J
THALLIUM	0.31 J	0.29 J				
VANADIUM	6.8 B	6.6 B	3.9 B	13.7 B	3.1 J	2.1 J
ZINC	18.9	18.9	68.9	7.2 J	14 J	1.4 J

Notes:
MG/KG - milligram per kilogram
B - reported value is less than Contract Required Detection Limit (CRDL), but greater than Instrument Detection Limit (IDL)
J - value is estimated

TABLE 4 - 15
SEDIMENT POSITIVE DETECTION SUMMARY
TAL METALS AND CYANIDE
CREEK AND RAILROAD
OPERABLE UNIT NO. 5 - SITE 2
REMEDIAL INVESTIGATION CTO - 19174
MCB CAMP LEJEUNE, NORTH CAROLINA

SAMPLE NO.	2-RRSD02-06	2-RRSD02-612	2-RRSD06-06	2-RRSD06-612	2-RRSD09-06	2-RRSD09-612
UNITS	MG/KG	MG/KG	MG/KG	MG/KG	MG/KG	MG/KG
ALUMINUM	2730 J	4280 J	3130 J	2200 J	3220 J	2830 J
ANTIMONY						
ARSENIC	1.1 J					
BARIUM	6.5 J	9.3 J	14.8 J	11.4 J	8.6 J	5.1 J
BERYLLIUM						
CALCIUM	854 J	868 J	25100 J	18700 J	576 J	462 J
CHROMIUM	2.5 J	2.7 J	4.6 J	2.8 J	4.4 J	3 J
COPPER	1.3 J	0.98 J	6.6 J	5.3 J	3.1 J	2.4 J
IRON	1270 J	1540 J	1950 J	1170 J	705 J	495 J
LEAD	9 J	4.6 J	6.2 J	8 J	51.4 J	30.6 J
MAGNESIUM	83.6 J	121 J	411 J	302 J	86.9 J	71 J
MANGANESE	6.3 J	7.4 J	13.1 J	9.4 J	2.3 J	2.4 J
POTASSIUM	71.3 J	87 J	155 J	103 J	77.5 J	84.6 J
SELENIUM					0.34 J	
SODIUM	43.9 J	38.2 J	103 J	64.2 J	35.5 J	33.6 J
THALLIUM						
VANADIUM	3.5 J	5.9 J	7.5 J	5 J	5.2 J	4.6 J
ZINC	7.3 J	6.1 J	120 J	75.8 J	24.8 J	20.3 J

Notes:
MG/KG - milligram per kilogram
B - reported value is less than Contract Required Detection Limit (CRDL), but greater than Instrument Detection Limit (IDL)
J - value is estimated

TABLE 4 - 15
SEDIMENT POSITIVE DETECTION SUMMARY
TAL METALS AND CYANIDE
CREEK AND RAILROAD
OPERABLE UNIT NO. 5 - SITE 2
REMEDIAL INVESTIGATION CTO - 19174
MCB CAMP LEJEUNE, NORTH CAROLINA

SAMPLE NO.	2-RRSD12-06	2-RRSD12-612	2-RRSD15-06	2-RRSD15-612	2-RRSD20-06	2-RRSD20-612
UNITS	MG/KG	MG/KG	MG/KG	MG/KG	MG/KG	MG/KG
ALUMINUM	5500 J	3990 J	5410 J	7660 J	3750	1030
ANTIMONY				1.8 J		
ARSENIC	1.4 J	0.92 J	1.3 J	1 J	0.86 J	0.5 J
BARIUM	23.8 J	12.6 J	11.6 J	10.8 J	28.5 B	6.3 B
BERYLLIUM	0.25 J					
CALCIUM	2910 J	1940 J	1040 J	318 J	6990	247 B
CHROMIUM	6.5 J	6.7 J	6.1 J	10.3 J	3.2	
COPPER	4 J	2.5 J	1.9 J	2 J	3.9 B	1.9 B
IRON	3530 J	1430 J	2270 J	1720 J	2170	453
LEAD	15.5 J	14.1 J	15.3 J	7 J	8.4	9.3
MAGNESIUM	336 J	187 J	177 J	264 J	222 B	33.9 B
MANGANESE	32.3 J	11.4 J	5.3 J	4.8 J	18.8	2.2 B
POTASSIUM	352 J	128 J	215 J	440 J	161 B	35.5 B
SELENIUM	0.38 J	0.3 J			0.27 J	
SODIUM	49.6 J	40.1 J	57.7 J	45.6 J	46.9 B	27.7 B
THALLIUM						
VANADIUM	11.5 J	6.2 J	8.5 J	14 J	7.5 B	2.2 B
ZINC	48.6 J	23 J	7.9 J	7.3 J	43	2.8 J

Notes:
MG/KG - milligram per kilogram
B - reported value is less than Contract Required Detection Limit (CRDL), but greater than Instrument Detection Limit (IDL)
J - value is estimated

TABLE 4 - 15
SEDIMENT POSITIVE DETECTION SUMMARY
TAL METALS AND CYANIDE
CREEK AND RAILROAD
OPERABLE UNIT NO. 5 - SITE 2
REMEDIAL INVESTIGATION CTO - 19174
MCB CAMP LEJEUNE, NORTH CAROLINA

SAMPLE NO.	2-RRSD21-06	2-RRSD21-612
UNITS	MG/KG	MG/KG
ALUMINUM	1480	2570
ANTIMONY		
ARSENIC	0.51 J	0.53 J
BARIUM	4.2 B	6.3 B
BERYLLIUM		
CALCIUM	340 B	530 B
CHROMIUM	2.2	3.2
COPPER	0.67 B	1.2 B
IRON	781	1350
LEAD	4.5	6.9
MAGNESIUM	56.5 B	84.9 B
MANGANESE	3.6	4.4
POTASSIUM	53.2 B	78.2 B
SELENIUM		
SODIUM	36.6 B	41.3 B
THALLIUM		
VANADIUM	3.4 B	5.3 B
ZINC	2 J	1.4 J

Notes:
MG/KG - milligram per kilogram
B - reported value is less than Contract Required Detection Limit (CRDL), but greater than Instrument Detection Limit (IDL)
J - value is estimated

TABLE 4 - 16
SURFACE WATER POSITIVE DETECTION SUMMARY
ORGANIC CHEMICALS
CREEK AND RAILROAD
OPERABLE UNIT NO. 5 - SITE 2
REMEDIAL INVESTIGATION CTO - 19174
MCB CAMP LEJEUNE, NORTH CAROLINA

SAMPLE NO. UNITS	2-OC-SW01 UG/L	2-OC-SW03 UG/L	2-RR-SW04 UG/L	2-RR-SW05 UG/L	2-RR-SW06 UG/L	2-RR-SW17 UG/L
PESTICIDES/PCBS						
4,4'-DDD			0.33 J	0.11 J	1.9 J	2.3
4,4'-DDT					0.94	0.76
VOLATILES						
ACETONE					4 J	
CARBON DISULFIDE	7 J					
CHLOROFORM	6 J	5 J				

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

TABLE 4 - 17
SURFACE WATER POSITIVE DETECTION SUMMARY
TAL METALS AND CYANIDE
CREEK AND RAILROAD
OPERABLE UNIT NO. 5 - SITE 2
REMEDIAL INVESTIGATION CTO - 19174
MCB CAMP LEJEUNE, NORTH CAROLINA

Sample No.	2-OC-SW01	2-OC-SW03	2-RRSW06
Units	UG/L	UG/L	UG/L
Aluminum	556	251	10100
Arsenic			3.3 B
Barium	18 B	25 B	85 B
Beryllium			1 B
Calcium	22900	191000	92800
Chromium			14
Copper	4 B	7 B	31
Iron	413	182	4410
Lead			23.4
Magnesium	1960 B	2660 B	2760 B
Manganese	24	4 B	58
Potassium	809 B	1630 B	2930 B
Sodium	6190	9650	7010
Vanadium			15 B
Zinc			418 J

Notes:
UG/L - microgram per liter
B - reported value is less than Contract Required Detection Limit (CRDL), but greater than Instrument Detection Limit (IDL)
J - value is estimated

TABLE 4 - 18
OPERABLE UNIT NO.5 - SITE 2
CONCRETE PAD
POSITIVE DETECTION SUMMARY
REMEDIAL INVESTIGATION CTO - 19174
MCB CAMP LEJEUNE, NORTH CAROLINA
ORGANIC CHEMICALS

SAMPLE NO. UNITS	2-CP01 UG/KG	2-CP02 UG/KG	2-CP03 UG/KG
<u>PESTICIDES</u>			
4,4'-DDE	1400	350	19000
4,4'-DDD		9.2 J	320 J
4,4'-DDT	220 J	390	
GAMMA-CHLORDANE			150 J

TABLE 4 - 19
OPERABLE UNIT NO. 5 - SITE 2
CONCRETE PAD
POSITIVE DETECTION SUMMARY
REMEDIAL INVESTIGATION CTO - 19174
MCB CAMP LEJEUNE, NORTH CAROLINA
TAL METALS AND CYANIDE

SAMPLE NO.	2-CP01	2-CP02	2-CP03	2-CP04
UNITS	MG/KG			MG/KG
ALUMINUM	5510 J			9330 J
ANTIMONY				
ARSENIC	1.6 J			0.54 J
BARIUM	46 J			53.6 J
BERYLLIUM	0.21 J			0.41 J
CADMIUM				
CALCIUM	76900 J			115000 J
CHROMIUM	7.8 J			8.9 J
COBALT				3.5 J
COPPER	5 J			5 J
IRON	4420 J			5010 J
LEAD	4.6 J			4.6 J
MAGNESIUM	3050 J			5120 J
MANGANESE	47.3 J			114 J
MERCURY				
NICKEL				
POTASSIUM	201 J			259 J
SELENIUM	0.21 J			0.21 J
SILVER				
SODIUM	88.7 J			139 J
THALLIUM				
VANADIUM	9.5 J			9.9 J
ZINC	6.5 J			9.5 J
CYANIDE				

TABLE 4-20

OPERBLE UNIT NO. 5 - SITE 2
SOIL TCLP AND RCRA HAZARDOUS ANALYSES
POSITIVE DETECTION SUMMARY
REMEDIAL INVESTIGATION CTO-0174
MCB CAMP LEJEUNE, NORTH CAROLINA

Parameter	2-MP-SB28-OU	2-MP-SB30-OU	2-MP-SB31-OU
TCLP	mg/L	mg/L	mg/L
Barium	0.34	0.22	0.38
Cadmium	0.017	0.005	--
Lead	0.13	0.006	--
RCRA HAZ			
pH (S.U.)	7.7	7.6	7.7
Sulfide, Reactive (mg/kg)	61		71
Flash Point (°F)	>200	>200	>200

5.0 CONTAMINANT FATE AND TRANSPORT

This section contains a discussion on the various physical and chemical properties, mobility and persistence of contaminants detected at Site 2 that determine the fate and transport of the contaminants in the environment. The nature and extent of contaminants is outlined in Section 4.0.

5.1 Chemical and Physical Properties

The potential for a contaminant to migrate and persist in environmental media is an important factor in evaluating risk to human health and the environment. 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 evaluates the properties of the contaminants detected at Site 2 with emphasis on potential environmental mobility and persistence.

Table 5-1 presents the physical and chemical properties associated with the organic contaminants detected at the site which determine a contaminants inherent environmental mobility and fate. These properties include specific gravity, vapor pressure, water solubility, octanol/water partition coefficient, soil/sediment adsorption coefficient, Henry's Law constant, bioconcentration factor and mobility index. A discussion of the environmental significance of each properties follows.

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

Vapor pressure 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 polycyclic aromatic hydrocarbons (PAHs). Contaminants with higher vapor pressures will enter the atmosphere at a quicker rate than the contaminants with low vapor pressures.

TABLE 5-1

ORGANIC PHYSICAL AND CHEMICAL PROPERTIES
SITE 2 - REMEDIAL INVESTIGATION CTO-0174
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 ($atm\text{-}m^3/mole$)	Mobility Index	Comments
Volatiles:								
Ethylbenzene	7	152	3.15	2.93	0.867	6.44E-03	0.1	Very mobile
Toluene	22	515	2.69	2.54	0.867	5.90E-03	1.5	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
2-Butanone	78	3.5E5/350,000	0.26	0.05/1.52	0.805	2.1 E-05	5.9/7.4	Extremely mobile
Carbon Disulfide	260	2300	1.84	2.08	1.263	1.23 E-02	3.7	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	1E-06 to 1E-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	1E-06 to 1E-11	0.006	5.61	5.44	1.274	1.1E-06	-13.7	Very immobile
Fluoranthene	1E-06 to 1E-04	0.265	5.33	4.84	NA	6.5E-06	-9.4	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 5-1 (Continued)

ORGANIC PHYSICAL AND CHEMICAL PROPERTIES
SITE 2 - REMEDIAL INVESTIGATION CTO-0174
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
Semivolatiles: (Cont)								
Pyrene	6.85	0.14	5.32	4.91	NA	5.1E-06	-11.9	Immobile
Naphthalene	1	30	3.01/3.45	1.72/3.16	1.152		-1.7/-0.24	Slightly mobile
2-Methylnaphthalene	1	26-28	4.26	2.2/3.82	0.994	--	-2.4/-0.77	Slightly mobile
Acenaphthene	1E-D3 to 1E-D2	3.42	4.33	4.22	0.899	9.20E-05	-6.7	Immobile
Fluorene	1E-D3 to 1E-D2	1.9	4.18	3.97	NA	6.42 E-05	-6.7	Immobile
Phananthrene	6.8 E-04	0.816	4.46	4.26	1.025	1.59 E-04	-7.5	Immobile
Pesticides:								
Dieldren	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
Heptachlor	3E-4	0.18	5.3	4.15	1.57	8.19 E-04	-8.4	Immobile
alpha-Chlordane	1E-5	1.85	2.78	3.19	NA	9.63 E-06	-7.9	Immobile
gamma-Chlorodane								
Endosulfan II	9E-3	0.10	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.

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, for example, that the volatile organic contaminants including monocyclic aromatics are usually several orders-of-magnitude more soluble than pesticides.

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 of organic carbon. Contaminants with high soil/sediment adsorption coefficients generally have low water solubilities and vice versa. For example, contaminants such as pesticides 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.

Both 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

Relative MI values and mobility descriptions are included on Table 5-1. Similar mobility descriptions are presented in Roy and Griffin (1985).

5.2 Contaminant Transport Pathways

Based on the evaluation of existing conditions at Site 2 the following potential contaminant transport pathways have been identified.

- On-site atmospheric deposition of windblown dust
- Surface soil runoff from the pesticide mixing/wash pads to the drainage ditches
- Surface soil runoff from the Building 712 area to the drainage ditches
- Surface soil runoff from the Former Storage Area to the drainage ditches
- Sediment migration in the Railroad Drainage Ditch and Overs Creek
- Leaching of sediment contaminants to surface water
- Migration of contaminants in surface water
- Leaching of contaminants in the concrete mixing pads to the soil
- Leaching of soil contaminants to groundwater
- Migration of groundwater contaminants off site
- Groundwater infiltration from the shallow aquifer to the deep aquifer

Contaminants released to the environment 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 behavior of relevant contaminant groups (VOCs, pesticides, etc.) in each transport pathway, under these conditions is outlined in Section 5.3. The following paragraphs describe the transport pathways listed above.

5.2.1 On-Site Deposition of Windblown Dust

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

The majority of Site 2 is covered by grass and is surrounded by tall trees. This would serve to retard airborne migration of site contaminants.

5.2.2 Surface Soil Runoff

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

The topography at Site 2 is relatively flat. This would serve to impede runoff from the Lawn and Former Storage Areas. The mixing pads, however, are located in close proximity to the western Railroad Drainage Ditch. The drainage ditch walls are steep in this area. Surface runoff of contaminated soil from the Mixing Pad Area to the drainage ditch is expected. Analytical results of sediment samples (Section 4.0) support this.

5.2.3 Sediment Migration in Railroad Drainage Ditch and Overs Creek

Sediment can be transported mechanically through the drainage ditches and Overs Creek by surface water erosion. This is influenced by: channel slope, rate of surface water flow, sediment size/density and particle cohesion and vegetative cover.

The channel slopes of the drainage ditch and Overs Creek are relatively flat. Surface water flow is intermittent in the drainage ditches and low in the upper reaches of Overs Creek. The lack of vegetative cover on the channel floors, however, exposes sediment to erosion during periods of (heavy) precipitation. Sediment sample analytical results indicate that there has not been extensive migration of sediment contaminants through the railroad tracks drainage ditches to Overs Creek (Section 4.0), based on the low levels of pesticides in the downstream sampling locations in the ditches and in Overs Creek.

5.2.4 Leaching of Sediment Contaminants to Surface Water

When in contact with surface water, contaminants attached to sediment particles can become disassociated from the sediment particle and leach into surface water. This is influenced by the physical and chemical properties of the contaminant, the physical and chemical properties of the sediment particle, and the physical and chemical properties of the surface water.

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.

5.2.5 Leaching of Contaminants in the Concrete Mixing Pads to the Soil

Contaminants, particularly pesticides, may have been released onto the cement mixing pads. Contaminants absorbed into the concrete could eventually leach into the soil below. This is influenced by the chemical and physical properties of the concrete pad and the chemical and physical properties of the contaminants.

Cracks were observed in the concrete mixing pads. These cracks would provide avenues for vertical migration to the underlying soil. Soil samples were collected from immediately below the concrete pads. Analytical results of these samples indicates that pesticides are present in elevated concentrations under the mixing pads (Section 4.0). This indicates that there has been migration of contaminants through the concrete mixing pads to the underlying soil.

5.2.6 Leaching of Soil Contaminants to Groundwater

Contaminants that have attached to soil particles or have accumulated in soil pore spaces can leach and migrate vertically to the groundwater. This is influenced by the physical and chemical properties of the soil, the physical and chemical properties of the contaminant, and the depth to the water table.

Groundwater samples were collected from shallow monitoring wells on site (less than 25 feet). The groundwater analytical results can be compared to soil sample analytical results to determine if contaminants detected in soil have migrated to groundwater.

In the mixing pad area, pesticide contamination was detected in soil and groundwater samples. Pesticides, however, are immobile (Table 5-1) in soil and the pesticides detected in groundwater are probably the result of soil particles contained in the groundwater samples, and not due to leaching of pesticides from soil to groundwater.

Ethylbenzene and xylenes (total) were detected in one soil and three groundwater samples in the Former Storage Area. The ethylbenzene and xylenes appear to have leached from a source in the soil, into the groundwater.

5.2.7 Migration of Groundwater Contaminants Off Site

Organic contaminants that reach the groundwater zone are either dissolved in water or are organic liquid phases that may be immiscible in water. The subsurface transport of the immiscible organic liquids is governed by a set of factors different from those of dissolved contaminants. In broad terms, three processes govern the migration 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.

Advection is the process which most strongly influences the migration of dissolved organic solutes. Groundwater generally flows from regions of the subsurface where the water level is high to regions of where the water level is low. Hydraulic gradient is the term used to describe the magnitude of this force or the relative slope of the water table. In general, the gradient usually follows the topography for uniform sandy aquifers (unconfined or water table aquifers) which are commonly found in coastal regions. In general, groundwater flow velocities, in sandy aquifers, under natural gradient conditions are probably between 10 m/y to 100 m/y (Lyman et al, 1968).

The average seepage velocity of groundwater flow at Site 2 can be estimated using the following equation:

$$V_x = \frac{K\,i}{N_e} \qquad \text{(Fetter, 1988)}$$

Where:
V_x = average linear velocity
K = hydraulic conductivity (cm/sec)
i = hydraulic gradient
N_e = effective porosity

For the lithology at Site 2, hydraulic conductivity (K) and effective porosity (N_e) can be estimated at 1 x 10^{-5} cm/sec and 0.4, respectively (Fetter, 1988). Hydraulic gradient for Site 2 has been calculated at 0.005 (Section 3.6.2). Average seepage velocity can thus be estimated as follows:

$$V_x = \frac{K\,i}{N_e} \qquad \text{(Fetter, 1988)}$$

$$V_x = \frac{\left(1 \times 10^{-5}\,\frac{\text{cm}}{\text{sec}}\right)(\,0.005\,)}{0.4}$$

$$= 1.25 \times 10^{-7}\,\frac{\text{cm}}{\text{sec}} = 0.04\,\frac{\text{m}}{\text{yr}}$$

Hydraulic conductivities for the surficial aquifer have also been calculated for other sites at MCB Camp Lejeune ranging from 2.1 x 10^{-3} to 8 x 10^{-4} cm/sec. The average seepage velocity, using these valves, can be estimated as follows:

for K = 8 x 10^{-4} cm/sec

$$V_x = \frac{\left(8 \times 10^{-4}\,\frac{\text{cm}}{\text{sec}}\right)(\,0.005\,)}{0.4}$$

$$= 1 \times 10^{-5}\,\frac{\text{cm}}{\text{sec}} = 3.15\,\frac{\text{m}}{\text{yr}}$$

for K = 2.1 x 10^{-3} cm/sec

$$V_x = \frac{\left(2.1 \times 10^{-3}\, \frac{cm}{sec}\right)(0.005)}{0.4}$$

$$= 2.625 \times 10^{-5}\, \frac{cm}{sec} = 8.3\, \frac{m}{yr}$$

It is thus expected that V_x at Site 2 will range from 0.04 to 8.3 m/yr.

Thus, when monitoring wells or small supply wells in sand aquifers are located hundreds of thousands of meters downgradient of a contaminant source, the average travel time for the groundwater to flow from the source to the well point typically is on the order of decades. In the zone of influence of a high capacity well or well field, however, the artificially increased gradient substantially increases the local velocity, and the average travel times for groundwater flow are reduced.

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 believed 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 2, longitudinal and transverse dispersion must be 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 contaminants distribution between the aqueous phase and the 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 are affected by hydrophobility (antipathy for dissolving in water) and the fraction of solid organic matter in the aquifer solids (organic carbon content) could potentially migrate at 10 to nearly 100 percent the velocity of groundwater in this coastal aquifer due to the low percentage of solid organic matter (Mackay, et al., 1985).

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, 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 biodegradation as vinyl chloride (Mackay, et al., 1985).

The interaction of non-ionic organic compounds with solid phases can be used to predict the fate of the contaminant. Sorptive binding is a function of 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., 1968). The uptake of neutral organics by soils results from their partitioning to the solutes aqueous solubility and to its liquid-liquid (e.g., octanol-water) partition coefficient (Chiou, 1979). Currently, literature information is available on the interrelation of soil organic properties to the binding of pesticides, herbicides, and high molecular weight pollutants such as PCBs. Organic matrices in natural systems that have varying origins, degrees of humification, and degrees of association with inorganic matrices exhibit dissimilarities in their ability to sorb non-ionic organic contaminants.

The soils and sediments formed or deposited on the land surface can act as a reservoir for contaminants. Soils contain surface-active mineral and humic constituents which are 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 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 or 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).

5.3 Fate and Transport Summary

The following paragraphs summarize the contaminant group fate and transport data for some potential COCs at Site 2.

5.3.1 Volatile Organic Compounds (VOCs)

VOCs 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.

5.3.2 Semivolatile Organic Compounds (SVOCs)

The majority of SVOCs detected at Site 2 are PAHs. Low water solubilities, high K_{ow}'s and K_{oc}'s indicate a strong tendency for PAHs to adsorb to soils. Their mobility indices indicate that they are relatively immobile from a physical-chemical standpoint. An exception is naphthalene, which is considered only slightly immobile in solution (groundwater and surface water) 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.

PAHs are not extremely persistent in the environment. 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 (Jones, et al., 1989).

5.3.3 Pesticides

Pesticides 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 (Kd) is the distribution of a pesticide between soil and water. In general, the Kd values are higher for high organic carbon soil than for low organic carbon soils. Therefore, soils with high Kd values will retain pesticides (i.e., 4,4'-DDT, 4,4'-DDE, and 4,4'-DDD).

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

TABLE 5-2

RELATIVE MOBILITIES OF INORGANICS AS A FUNCTION OF ENVIRONMENTAL CONDITIONS (Eh, pH) REMEDIAL INVESTIGATION CTO-0174 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.

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.

6.0 BASELINE HUMAN HEALTH RISK ASSESSMENT

6.1 Introduction

This section presents the baseline human health Risk Assessment (RA) for Site 2, Former Nursery/Day Care Center. The baseline RA evaluates the potential public health risks which might result, both now and in the future, under a no action remedial scenario. However, a Time-Critical Removal Action (TCRA) has been proposed for the removal of pesticide contaminated soil and sediment in the vicinity of the Mixing Pad Area (MPA), and for soil in the Former Storage Area (FSA). Engineering design activities for the TCRA have been implemented and are scheduled to be finalized in April, 1994. Therefore, the MPA was evaluated for the baseline RA by evaluating the soil and sediment both before and after the TCRA, and the FSA was evaluated before and after the TCRA for soil only. This approach to the baseline RA was discussed with the USEPA Region IV. USEPA concurred with this approach (Teleconference, August 30, 1993, see Appendix B). The soil at the FSA was evaluated separately from the Lawn Area (LA) and MPA, due to different contaminant concerns, and the groundwater was evaluated as one unit for the entire site. Sediment and surface water at Overs Creek were evaluated separately from the Railroad Track Drainage Ditches. Overs Creek was evaluated in order to determine if site contaminants were migrating off site.

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

The components of the baseline RA include:

- Identification of chemicals of potential concern
- Exposure assessment
- Toxicity assessment
- Risk characterization
- Uncertainty analysis

The human health baseline RA is divided into seven sections including this introduction. Section 6.2 identifies chemicals of potential concern, which are the chemicals detected at the site having the greatest potential to adversely affect human health. Section 6.3 presents the exposure assessment which employs a site conceptual model of potential exposure to identify current and future potential exposure pathways and receptors. Section 6.4 presents the toxicity assessment which contains the toxicological indices for chemicals of concern. Section 6.5 combines exposure pathways, receptors and toxicological indices to provide the quantitative risk characterization. Section 6.6 discusses the total site risks. Section 6.7 discusses the conclusions of the baseline human health RA, and Section 6.8 discusses the sources of uncertainty inherent to the baseline RA. The ecological risk assessment for Site 2 is included as Section 7.0 in this report.

6.2 Identification of Chemicals of Potential Concern

Chemicals of Potential Concern (COPCs) are site related chemicals used to qualitatively or quantitatively estimate potential human exposures and associated health effects. Four environmental media were investigated at Site 2 during the RI. These are groundwater, soil, surface water and sediment. In addition, surface soil and subsurface soil were evaluated separately. This section presents the rationale for the selection of COPCs for each medium investigated at Site 2.

Site history is one of the most important factors when determining the selection of COPCs. Site 2 history indicates that from 1945 to 1958, the site was used to store and dispense pesticides. Chemicals known to have been used include chlordane, 4,4'-DDT, diazinon, and 2,4-D. Chemicals known to have been stored on site include dieldrin, lindane, malathion, and silvex (ESE,1988).

In addition to site history, the prevalence of a chemical in environmental media is a primary consideration in the selection or elimination of a COPC. The Risk Assessment Guidance for Superfund Volume I, Human Health Evaluation Manual, Part A (USEPA, 1989) (RAGs) suggests that a frequency of occurrence of 5 percent (one positive detection per 20 samples) is sufficient for including a chemical as a COPC. In order for this value to be a measure of statistical significance a sample set must include at least 25 sample points. Additional selection criteria must also be considered in the selection of COPCs. Additional criteria include:

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

- Comparison of analytical results with site-specific and/or naturally occurring native background concentrations of appropriate chemicals.

- Comparison of analytical results with standards and criteria, including Maximum Contaminant Levels (MCLs), Maximum Contaminant Level Goals (MCLGs) Federal Ambient Water Quality Criteria (AWQC), Health Advisories (HA) and North Carolina State Water Quality Standards (NCWQS).

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

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

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

Secondary Maximum Contaminant Level (SMCLs) - the SMCLs control contaminants in drinking water that primarily affect the aesthetic qualities relating to the public acceptance of drinking water. At considerable higher concentrations of these contaminants health implications may also exist as well as aesthetic degradation. The regulations are not Federally enforceable but are intended as guidelines for the States.

Federal Ambient Water Quality Criteria (AWQC) - AWQC are nonenforceable regulatory guidelines and are of primary utility in assessing acute and chronic toxic effects in aquatic organisms. They may also be used for identifying the potential for human health risks. AWQCs consider acute and chronic effects in both freshwater and saltwater aquatic life, and potential carcinogenic and noncarcinogenic health effects in humans from ingestion of both water (2 liters/day) and aquatic organisms (6.5 grams/day), or from ingestion of organisms alone. The AWQCs for protection of human health for potential carcinogenic substances are based on the USEPA's incremental cancer risk range of one additional case of cancer in an exposed population of 10,000,000 to 100,000 persons (i.e., the 10^{-7} to 10^{-5} range).

Health Advisories (HAs) - HAs are guidelines developed by the USEPA Office of Drinking Water which describe nonregulatory concentrations of drinking water contaminants at which adverse health effects would not be anticipated to occur over specific exposure durations. These guidelines are designed to consider both acute and chronic toxic effects in children (assumed body weight of 10 kg) who consume 1 liter of water per day or in adults (assumed body weight of 70 kg) who consume 2 liters of water per day. Health Advisories are generally available for acute (1 day), subchronic (10 days), chronic (longer term), approximately 7 years, and lifetime exposures based on data describing noncarcinogenic endpoints of toxicity. HAs do not quantitatively incorporate any potential carcinogenic risk from such exposure. Chemical concentration values for carcinogens are correlated with a cancer potency value (unit risks) with assumptions for lifetime exposure and the consumption of drinking water.

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

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 can be used in conjunction with other information to help in the selection of chemicals of potential concern (COPCs). Selecting COPCs using RBCs is accomplished by the comparison of the maximum concentration of each chemical detected in each medium to it's corresponding RBC. The RBCs were developed using protective default exposure scenarios suggested by the USEPA, and the latest available toxicity indices for carcinogenic and systemic chemicals. The RBCs utilized correspond to a Hazard Quotient of 0.1 and a lifetime cancer risk of 1E-6. The RBCs represent protective environmental concentrations at which the USEPA would not typically take action (USEPA, Region III, 1993). The exposure scenarios under which the RBCs were developed by USEPA, Region III are presented in Appendix Q. The RBCs were utilized for the soil, groundwater, and sediment at Operable Unit No. 5.

USEPA Region IV Media Screening Method (Two-Times Rule[1]) - the USEPA Region IV has developed a screening methodology to follow for evaluating media that do not have standards. In order to aid in the selection of COPCs the Two-Times Rule can be applied. Two-times the average concentration of the background samples can be compared to the maximum concentration of the chemical detected in the media (Telecommunication, 1993). When the chemical detected in the media exceeds the twice the background concentration, the chemical may be retained as a COPC (if other selection criteria are also met). The Two-Times Rule is not a statistically defensible method for background comparison, but a "rule of thumb" method for comparing site data to a limited number of background sample results.

USEPA Interim Lead Cleanup Guidance - Interim Guidance On Establishing Soil Lead Cleanup Levels At Superfund Sites. Office of Solid Waste and Emergency Response guidance for an interim cleanup level for total lead at CERCLA sites (500-1000 parts per million). Further guidance to be developed after a verified Cancer Slope Factor and /or Reference Dose for lead is developed.

In the following subsections discussing the selection of COPCs, some detected chemicals were not retained as COPCs because of blank contamination. As stated in RAGs, common laboratory contaminants should be considered a positive result only if the concentration of the sample exceeds ten times the maximum concentration detected in any blank, and laboratory contaminants that are not common laboratory contaminants should be considered a positive result if the concentration of the sample exceeds five times the maximum contaminant in any blank. Common laboratory contaminants include acetone, 2-butanone, 2-hexanone,

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[1] The Two-Times Rule screening method has been arbitrarily named by Baker for ease of discussion in this report.

methylene chloride, and phthalate esters (i.e., bis(2-ethylhexyl) phthalate and di-n-butylphthalate). Other contaminants detected in the blanks included chloroform, bromodichloromethane, and dibromochloromethane. This guideline was followed when determining COPCs for all media. A summary table of the method blank laboratory contaminants, and contaminants detected at the site which were determined to be present due to blank contamination are presented in Appendix M.

In the following sections, the qualifier "J" will be referred to when describing certain chemical concentrations. The qualifier "J" means the associated numerical value is an estimate of the concentration present in the sample, and the actual value could be higher or lower than the reported value.

6.2.1 Soils

As discussed in Section 1.4, a TCRA has been proposed for the removal of pesticide contaminated soil in the LA and MPA. However, the selection of COPCs have been evaluated in these areas both before and after the proposed remedial action and a baseline RA has been performed for both actions. In addition, due to different contaminant concerns the LA and MPA have been evaluated separately from the FSA for the soil only.

Appendix H contains the Data Summary and Frequency Tables for Site 2.

6.2.1.1 Lawn and Mixing Pad Areas

A total of 92 surface and subsurface soil samples were collected in the LA and the MPA. Surface soil samples were collected from 0-6 inches, and subsurface soil samples were collected at various intervals from 6 inches to the top of the water table. Eleven samples were analyzed for TCL volatile organics, semivolatile organics, and TAL inorganics. Forty- six samples were analyzed for TCL pesticides, seventeen for PCBs, and the herbicides 2,4,5-TP (Silvex) and 2,4-D were analyzed for in 31 samples. Nine samples were analyzed for cyanide. One additional background sample (2GW9) was analyzed for full TCL organic and TAL inorganic parameters. In addition, base-specific soil background concentration ranges for inorganics are comprised of the one background sample taken at Site 2 and reference soil background samples that were collected during previous investigations at MCB, Camp Lejeune.

Surface Soil

The volatile organics detected in the surface soil included toluene (detected at a frequency of 1 of 11 samples), xylene (total) (detected 4 of 11 samples), and methylene chloride (detected 3 of 11 samples). Toluene was detected at a concentration of 6J µg/kg, and xylene (total) ranged between 4 and 5 µg/kg. Xylene (total) was detected four times at sampling points in close proximity to the mixing pads. In this same vicinity a fuel odor was observed during the field investigation, although the odor detected was at depth. Toluene was detected at the sampling point (2-MP-SB28-00) which is located directly adjacent to the roadway, away from the area where fuel odor was detected. Ambient concentrations of toluene and xylene have been found to range between 1,000 and 5,000 µg/kg in soils (Dragun,1988). Volatile organics such as toluene and xylene (total) are not generally expected to be persistent in surface soils due to their high vapor pressures which are indicative of rapid volatilization from soils. The RBC for toluene is 1.6E+06 µg/kg and the RBC for xylene (total) is 1.6E+07 µg/kg. In addition, none of the concentrations detected of toluene or xylene (total) approached any of the reported ambient concentrations or the RBCs. Therefore, toluene was not retained as a COPC for surface soils. However, xylene (total) was retained as a COPC because it was detected in a highly contaminated area of the site and could possibly be associated with a past fuel spill in the MPA.

Methylene chloride is known to be a common laboratory contaminant. The concentration of the positive detect of methylene chloride in soil did not exceed ten times the maximum laboratory method blank concentration. Therefore, methylene chloride was not retained as a COPC.

The only positive detects of semivolatile organics were of bis (2-ethylhexyl) phthalate and di-n-bituylphthalate, both common laboratory contaminants. The positive detections of these chemical did not exceed ten times the maximum blank concentrations. Therefore bis(2-ethylhexyl)phthalate and di-n-butylphthalate were not retained as a COPCs.

Pesticides were detected as follows; 4,4'-DDD was detected 33 of 46 samples, 4,4'-DDE was detected 38 of 46 samples, and 4,4'-DDT was detected 40 of 46 samples. Alpha- and gamma-chlordane were detected 9 of 46 and 6 of 46 samples, respectively. Heptachlor and dieldrin were detected 1 of 46 samples. Based on site history, the high frequency of detection, and the high concentrations of the positive detects, all detected pesticides were retained as COPCs.

Neither PCBs or herbicides were detected in the surficial soils in the LA and MPAs.

Table 6-1 presents a summary of Site 2 surface soil organic analytical data and frequency of detections.

Site history does not indicate that inorganic contamination of the surface soil would be attributable to past site activities. However, in order to evaluate whether or not the concentrations of the inorganics present are significantly above background soil concentrations, the Two-Times Rule was utilized, where the maximum concentration of the inorganics in surface soil samples were compared to twice the average base-specific background soil concentrations. Table 6-2 presents a summary of the LA and MPA surface soil inorganic analytical data, frequency of detections, and base-specific background concentrations. Aluminum, arsenic, barium, beryllium, cadmium, calcium, chromium, cobalt, copper, iron, lead, magnesium, manganese, mercury, potassium, sodium, vanadium, and zinc exceeded twice the base-specific average background concentrations.

As directed by RAGs chemicals that are essential human nutrients, are present at low concentrations (i.e., slightly elevated above naturally occurring levels), and are only toxic at very high doses need not be considered for evaluation in the baseline RA. Calcium, iron, magnesium, potassium, and sodium are all essential human elements, and except for calcium, were only sightly elevated above background. Calcium's presence in high concentrations in this area could be explained due to the location of the site in a coastal region. The toxicity levels of these nutrients were not evaluated since the determination of acceptable dietary levels is very difficult and literature values of acceptable levels change often. In addition, acceptable essential nutrient concentrations are often presented in the literature as concentrations within the human body (e.g., blood levels), and cannot be directly compared to concentrations detected in the media at the site. Therefore, calcium, iron, magnesium, potassium, and sodium were not retained as COPCs. Table 6-3 presents a summary of native soil concentrations.

RBCs were utilized as an additional method for selection of inorganic COPCs. In addition, the interim lead cleanup guidance level was used as a criteria for COPC selection since an RBC is not available for lead. Table 6-4 is a comparison of the maximum value of each inorganic which exceeded twice the average background concentration to the chemical's corresponding RBC. Aluminum, barium, beryllium, cadmium, chromium, copper, manganese, mercury, vanadium, and zinc did not exceed RBCs and were, therefore, not retained as COPCs. An RBC is not available for cobalt. Cobalt was detected only once in the surface soil and is a chemical of low toxicity and, therefore, was not retained as a COPC. Lead did not exceed the interim lead cleanup guidance and was not retained as a COPC. Arsenic, however, did exceed the RBC and was retained as a COPC for the surface soil in the LA and MPAs.

Subsurface Soil

The volatile organics xylene (total) and 2-butanone were detected in 2 of 11 samples, methylene chloride and acetone were detected in 3 of 11 samples, and 4-methyl-2-pentanone was detected in 1 of 11 samples. Methylene chloride and acetone are common laboratory contaminants. The detected concentrations of these chemicals did not exceed the maximum laboratory method blank concentration, therefore, methylene chloride and acetone were not retained as a COPCs. 4-Methyl-2-pentanone was not retained for further evaluation because it was detected at a low concentration (12J µg/kg) and frequency. Xylene (total) was detected at a low frequency, however, one positive detect was high (4100 µg/kg), and was located in the vicinity where a fuel odor was detected during the field activities. Therefore, xylene (total) was retained as a COPC.

Several semivolatile organics were detected in the subsurface soil. Naphthalene, 2-methylnaphthalene, fluorene, n-nitrosodiphenylamine, and phenanthrene were all detected at a frequency of 2 in 11 samples. Acenaphthene, anthracene, di-n-butylphthalate, fluoranthene, and pyrene were detected at a frequency of 1 in 11 samples and bis(2-ethylhexyl)phthalate was detected in 3 of 11 samples. Di-n-butylphthalate and bis(2-ethylhexyl)phthalate are common laboratory contaminants which did not exceed the maximum laboratory method blank concentration and were not retained as COPCs.

A common practice that was reportedly performed during the time that herbicides were being mixed at the site was to use diesel fuels to act as a carrying agent for the application of herbicides (Shaw, 1993). In addition, it is possible that fuel was used in the operation of and/or the cleaning of the spraying equipment itself. Even though there is no documentation that this practice occurred, it could possibly explain the detection of polyaromatic hydrocarbons (PAHs) at depth. Diesel fuels are comprised of the heavier PAHs, such as those detected in the subsurface soil. The PAHs detected included fluorene, phenanthrene, acenaphthene, anthracene, fluoranthene, and pyrene, and were all detected in the same soil boring, 2-MP-SB16-02. This soil boring is located adjacent to the mixing pads, and is also in the same area that a fuel odor was detected during the field investigation. It is possible that a fuel spill occurred at some point in the past while mixing pesticides. Therefore, all of the PAHs detected in the subsurface soil were retained as COPCs. N-nitrosodiphenylamine can be used to stabilize petroleum products (HSDB,1993), and since it was detected in conjunction with the PAHs, n-nitrosodiphenylamine was also retained as a COPC. In addition, naphthalene and 2-methylnaphthalene were also retained as COPCs since they are common components of diesel fuel.

Pesticides were detected in the subsurface soil. 4,4'-DDD was detected 27 of 46 samples, 4,4'-DDE was detected 24 of 46 samples, and 4,4'-DDT was detected 32 of 46 samples. Alpha- and gamma-chlordane were detected 6 of 46 and 4 of 46 samples, respectively, and heptachlor was detected 1 of 46 samples. Based on site history, the high frequency of detection, and the high concentrations of the pesticides, all pesticides were retained as COPCs.

Neither PCBs or herbicides were detected in the subsurface soil.

Table 6-5 presents a summary of Site 2 subsurface soil organic analytical data and frequency of detections.

Site history does not indicate that inorganic contamination of the subsurface soil would be attributable to site activities. However, in order to evaluate whether or not the concentrations of the inorganics present are significantly above background soil concentrations, the Two-Times Rule was utilized, where the maximum concentration of the inorganics in surface soil samples were compared to twice the average base-specific background soil concentrations. Table 6-6 presents a summary of the inorganic analytical data, frequency of detections, and base-specific background concentrations for subsurface soil in the LA and MPAs. The inorganics that exceeded twice the average background concentrations included arsenic, barium, beryllium, calcium, chromium, cobalt, copper, iron, lead, magnesium, manganese, mercury, potassium, sodium, and zinc. Calcium, iron, magnesium, potassium, and sodium are essential human elements which were detected slightly above twice the average background concentration and were were not further evaluated for subsurface soil.

RBCs were utilized as an additional method for selection of inorganic COPCs. In addition, the interim lead cleanup guidance level was used as a criteria for COPC selection since an RBC is not available for lead. Table 6-7 is a comparison of the maximum value of each inorganic which exceeded twice the average background concentration to the chemical's corresponding RBC. Barium, beryllium, chromium, copper, manganese, mercury, and zinc did not exceed

RBCs and were, therefore, not retained as COPCs. An RBC is not available for cobalt. Cobalt was detected only twice in the subsurface soil and is a chemical of low toxicity and was not retained as a COPC. Lead did not exceed the interim lead cleanup guidance level and was not retained as a COPC. Arsenic, however, did exceed the RBC and was retained as a COPC.

6.2.1.2 Lawn and Mixing Pad - Time-Critical Removal Action

The selection of COPCs for soil before the proposed TCRA have been discussed in Section 6.2.1.1. The status of the COPCs as a result of the proposed removal action, i.e., were the chemicals retained as COPCs after the proposed removal action, is discussed in this subsection. The soil samples which were removed from the data set for the proposed TCRA included samples 2-MP-SB01 to 2-MP-SB11 and 2-MP-SB14 to 2-MP-SB26.

The chemicals which were detected in the soil that were determined to be non-site related due to blank contamination were discussed in Section 6.2. These chemicals include acetone, 2-butanone, 2-hexanone, methylene chloride, toluene, bis(2-ethylhexyl)phthalate and di-n-butylphthalate, chloroform, bromodichloromethane, and dibromochloromethane.

Surface Soil

After the proposed TCRA, analytical results from 23 surface soil locations were considered in the selection of COPCs.

Xylene (total) was detected 3 of 7 samples indicating that its prevalence at the site was not restricted to the proposed TCRA area and remained a COPC.

The pesticides dieldrin and heptachlor were not detected after the elimination of the samples in the data set for the proposed TCRA and were, therefore, not further evaluated as COPCs for the surface soils. 4,4'-DDD, 4,4'-DDE, and 4,4'-DDT were still detected at high frequencies. 4,4'-DDD was detected at a frequency of 12 of 23 samples. 4,4'-DDE was detected at a frequency of 19 of 23 samples, and 4,4'-DDT was detected at a frequency of 17 of 23 samples. Alpha-chlordane was detected at a frequency of 6 of 23 samples, and gamma-chlordane was detected at a 5 of 23 samples. The frequencies of detection for the pesticides indicate that contamination due to pesticides at this site is prevalent even after the removal of the highly contaminated soils. All of the pesticides detected in the soil not affected by the proposed TCRA were retained as COPCs.

The maximum detected value of arsenic (1.1 mg/kg) still exceeded the RBC (0.97 mg/kg) and remained as a COPC.

Subsurface Soil

The volatile organic xylene (total) remained as a COPC for the subsurface soil. The frequency of detection for xylene was 1 of 7 samples.

All of the semivolatiles which were retained as COPCs before the proposed TCRA would be eliminated from the site during the removal action.

The pesticide heptachlor was not detected after the elimination of the samples in the data set for the proposed TCRA and was, therefore, not retained as a COPC for the surface soil. 4,4'-DDD, 4,4'-DDE, and 4,4'-DDT were still detected at high frequencies. 4,4'-DDD frequency of detection was 9 of 23 samples. 4,4'-DDE was detected at a frequency of 8 of 23 samples, and 4,4'-DDT was detected at a frequency of 13 of 23 samples. Alpha-chlordane was detected at a frequency of 2 of 23 samples, and gamma-chlordane was detected at a frequency of 1 of 23 samples. The frequencies of detection for the pesticides indicate that the contamination due to pesticides at this site is prevalent even after the removal of the highly contaminated soils. Therefore, all of the pesticides detected after the proposed TCRA were retained as COPCs for the subsurface soil.

The maximum detected value of arsenic (0.62 mg/kg) did not exceeded the RBC (0.97 mg/kg) and was not retained as a COPC.

6.2.1.3 Former Storage Area

Surface and subsurface soil samples were collected at the FSA. Surface soil samples were collected from 0-6 inches, and subsurface soil samples were taken from 6 inches to the water table. For the surface soil five samples were analyzed for TCL volatile organics, semivolatile organics, pesticides, and TAL inorganics. Eight samples were analyzed for BTEX (benzene, toluene, ethylbenzene and xylenes). Five samples were analyzed for cyanide. The subsurface soil was analyzed for TCL volatile organics in twelve samples. TCL semivolatile organics, pesticides, and TAL inorganics were analyzed for in eleven samples. Nine samples were analyzed for BTEX. Eleven samples were analyzed for cyanide. The base-specific background samples have been discussed in Section 6.2.1.1.

The chemicals which were detected in the soil that were determined to be non-site related due to blank contamination were discussed in Section 6.2. These chemicals include acetone, 2-butanone, 2-hexanone, methylene chloride, toluene, bis(2-ethylhexyl)phthalate, di-n-butylphthalate, chloroform, bromodichloromethane, and dibromochloromethane.

Surface Soil

The volatile organics toluene and xylene (total) were detected 1 of 5 samples. The positive detects of toluene and xylene may be from a past fuel spill at the FSA. Therefore, toluene and xylene (total) were retained as COPCs. Acetone and 2-butanone were also detected but did not exceed ten times the method blank concentration and were not retained as COPCs.

Semivolatile organics were not detected in the surface soil other than the laboratory method blank contaminants which were not retained as COPCs.

The pesticides detected in the surface soil included; 4,4'-DDD and 4,4'-DDE were detected 4 of 5 samples, and 4,4'-DDT was detected 5 of 5 samples. Based on site history, the high frequency of detection, and the high detected concentrations, all of the pesticides were retained as COPCs. Neither PCBs or BTEX were detected in the surface soil.

Table 6-8 presents a summary of Site 2 surface soil organic analytical data and frequency of detections for the FSA.

Site history does not indicate that inorganic contamination of the surface soil would be attributable to site activities. However, in order to evaluate whether or not the concentrations of the inorganics present are significantly above background soil concentrations, the Two-Times Rule was utilized, where the maximum concentration of the inorganics in surface soil samples were compared to twice the average base-specific background soil concentrations. Table 6-9 presents a summary of the FSA surface soil inorganic analytical data, frequency of detections, and base-specific background concentrations. The inorganics that exceeded twice the average background concentrations were aluminum, arsenic, barium, beryllium, calcium, chromium, copper, iron, magnesium, manganese, mercury, potassium, sodium, vanadium, and zinc. Calcium, iron, magnesium, potassium, and sodium are human essential elements, and except for calcium, were only sightly elevated above background. Calcium's presence in high concentrations in this area could be explained due to the location of the site in a coastal region. Therefore, calcium, iron, magnesium, potassium, and sodium were not retained for further evaluation for surface soil in the FSA.

RBCs were utilized as an additional method for selection of inorganic COPCs. Table 6-10 is a comparison of the maximum value of each inorganic which exceeded twice the average background concentration to the chemical's corresponding RBC. Aluminum, arsenic, barium, beryllium, chromium, copper, manganese, mercury, vanadium, and zinc did not exceed RBCs and were not retained as COPCs.

Subsurface Soil

The volatile organics detected in the subsurface soil included; xylene (total), 4-methyl-2-pentanone, acetone, methylene chloride, and 2-butanone. Acetone, methylene chloride, and 2-butanone are common laboratory contaminants which did not exceed the ten times the method blank contamination and were not retained as COPCs. Xylene (total) was detected at a frequency of 2 of 12 samples at concentrations of 4J and 5J µg/kg. 4-Methyl-2-pentanone is normally used in industry as a solvent for gums and resins. It was detected at a frequency 3 of 12 samples, but was not retained as a COPC since it was detected at low concentrations (ranging between 7J and 8J µg/kg).

BTEX was analyzed for using USEPA Method 602 in addition to the CLP analyses. Toluene, ethylbenzene, and o-xylene and m-,p-xylene were detected in 1 of 9 samples. Both toluene and ethylbenzene were detected at a concentration of 9.1 µg/kg. o-Xylene was detected at a concentration of 10.3 µg/kg, and m,p-xylene were detected at 10.3 and 14.2 µg/kg, respectively. Even though these chemicals were detected at low frequencies, toluene, ethylbenzene, and o-xylene and m-,p-xylene were retained as COPCs because fuels are suspected of being used in the FSA during past site activities.

Except for the laboratory method blank contaminants no semivolatile organics were detected in the surface soil.

The pesticides detected in the subsurface soil included; 4,4'-DDD was detected in 6 of 11 samples, 4,4'-DDE was detected in 2 of 11 samples, and 4,4'-DDT was detected in 6 of 11 samples. Based on site history and the high frequencies of detection all detected pesticides were retained as COPCs.

Neither PCBs or herbicides were detected in the subsurface soil samples.

Table 6-11 presents a summary of Site 2 subsurface soil organic analytical data and frequency of detections for the FSA.

Site history does not indicate that inorganic contamination of the subsurface soil would be attributable to site activities. However, in order to evaluate whether or not the concentrations of the inorganics present are significantly above background soil concentrations, the Two-Times Rule was utilized, where the maximum concentration of the inorganics in the subsurface soil samples were compared to twice the average base-specific background soil concentrations. Table 6-12 presents a summary of the inorganic analytical data, frequency of detections, and base-specific background concentrations for subsurface soil at the FSA. The inorganics that exceeded twice the average background concentrations were aluminum, arsenic, barium, beryllium, cadmium, calcium, chromium, cobalt, copper, iron, magnesium, manganese, mercury, potassium, sodium, vanadium, and zinc. Calcium, iron, magnesium, potassium, and sodium are essential human elements and except for calcium, were only sightly elevated above background. Calcium's presence in high concentrations in this area is likely due to the location of the site in a coastal region. Therefore, calcium, iron, magnesium, potassium, and sodium were not retained for further evaluation for subsurface soil in the FSA.

RBCs were utilized as an additional method for selection of inorganic COPCs. Table 6-13 is a comparison of the maximum value of each inorganic which exceeded twice the average background concentration to the chemical's corresponding RBC. Aluminum, barium, beryllium, cadmium, chromium, copper, manganese, mercury, vanadium, and zinc did not exceed RBCs and were not retained as COPCs. An RBC is not available for cobalt. Cobalt was detected only once in the subsurface soil and is a chemical of low toxicity, therefore, it was not retained as a COPC. Arsenic, however, did exceed the RBC and was retained as a COPC.

6.2.1.4 Former Storage Area - Time Critical Removal Action

The selection of COPCs for the soil in the FSA before the proposed TCRA have been discussed in Section 6.2.1.3. The status of the COPCs as a result of the removal action, i.e., were the chemicals retained as COPCs after the proposed removal action is discussed in this subsection.

The soil samples which were removed from the data set for the proposed TCRA included sample 2-FSA-SB06 (shallow and deep).

Surface Soil

After the proposed TCRA, analytical results from 4 surface soil locations were considered in the selection of COPCs.

The volatile organics toluene and xylenes (total) were detected at a frequency 1 of 4 samples and remained COPCs.

The pesticides 4,4'-DDD, 4,4'-DDE, and 4,4'-DDT were still detected at high frequencies. 4,4'-DDD and 4,4'-DDE were detected 3 of 4 samples. 4,4'-DDT was detected 4 of 4 samples. The frequencies of detection for the pesticides indicate that contamination at the site is widespread even in the soils not influenced by the proposed TCRA. All of the pesticides detected in the soil after the proposed TCRA were retained as COPCs.

Subsurface Soil

After the proposed TCRA, analytical results from 20 subsurface soil locations were considered in the selection of volatile organic COPCs and analytical results from 10 sample locations were evaluated for semivolatiles, pesticides, and inorganics.

The volatile organics toluene, ethylbenzene, xylenes (o-,m-,and p-) remained as COPCs for the subsurface soil. However, each xylene isomer was added together for a total xylene concentration. Each chemical was detected in 1 of 9 samples, indicating that the prevalence of volatile organics at the site was not restricted to the proposed TCRA area.

The pesticides 4,4'-DDD, 4,4'-DDE, and 4,4'-DDT were still detected in the subsurface soil. 4,4'-DDD and 4,4'-DDT were detected 5 of 10 samples. 4,4'-DDE was detected in 1 of 10 samples. The frequencies of detection for the pesticides indicate that contamination at the site is prevalent even in the soils not influenced by the proposed TCRA. All of the pesticides detected in the subsurface soil after the proposed removal action were retained as COPCs.

The maximum value of arsenic (1.7 mg/kg) still exceeded the RBC (0.97 mg/kg) and remained a COPC.

6.2.2 Groundwater

Groundwater samples were collected from ten monitoring wells (nine shallow and one deep) at Site 2 during the initial RI field activities (April - May, 1994). Well 2-GW09-01 was evaluated as the background well. All groundwater samples were analyzed for full TCL organics and TAL inorganic constituents, except for sample 2-GW02-01, which was analyzed for volatile organics and pesticides only. The groundwater has been evaluated in the baseline RA as a single unit. Table 6-14 presents the chemicals detected in the groundwater and compares them to NCWQSs, MCLs, HAs, RBCs, and background concentrations.

In response to EPA comments on the Draft RI report, two additional monitoring wells were installed on-site in February, 1994. These wells were sampled, along with the other site monitoring wells in March, 1994. The purpose of the additional sampling is to provide additional information for remedial design evaluation. Although the results of the second round of sampling generally confirm the results of the first round (Section 4.0), the second round analytical data has not been submitted for data validation and is not utilized in the baseline RA. The following discussion is limited to first round groundwater sample results.

Five volatile organics were detected in the groundwater: ethylbenzene, trichloroethene, xylene (total), bromomethane, and methylene chloride. Bromomethane and methylene chloride were detected in the groundwater at a low frequency, 1 of 8 samples, and at low concentrations (both at 1 µg/L). Methylene chloride is a common laboratory contaminant. The concentration of the positive detect of methylene chloride in groundwater did not exceed ten times the maximum laboratory method blank concentration and was not retained as a COPC. Bromomethane was detected only once and at a low concentration and, therefore, was not retained as a COPC.

Ethylbenzene was detected at a frequency of 2 of 9 samples, trichloroethene was detected at a frequency of 1 of 9 samples, and xylene (total) was detected in 3 of 9 samples. No volatile organics were detected in the background well sample. Ethylbenzene, trichloroethene, and xylene (total) exceeded State groundwater standards and the tap water RBCs, but not MCLs or HAs. However, the positive detect of trichloroethene equaled the MCL. Ethylbenzene and xylene are known fuel components and could be attributed to site related activities since it is possible that a fuel spill may have occurred in the FSA vicinity. Therefore, ethylbenzene and xylene (total) were retained as COPCs. Trichloroethene is an identified base-wide contaminant at MCB, Camp Lejeune (Geophex, 1991). Since use of trichloroethene at Site 2 has not been reported, it is likely that the trichloroethene detected is due to another source on base. However, trichloroethene was retained as a COPC because it is classified by the USEPA as a B1 - probable human carcinogen.

Six semivolatiles were detected in the groundwater. Acenaphthene, phenol, and 2,4-dimethyphenol were detected at a frequency of 1 of 8 samples. 2-Methylnaphthalene, naphthalene and bis(2-ethylhexyl)phthalate were detected at a frequency of 2 of 8 samples. Except for bis(2-ethylhexyl)phthalate, no semivolatile organics were detected in the background sample. Bis(2-ethylhexyl)phthalate is a common laboratory contaminant which did not exceed the maximum laboratory method blank concentration and was not retained as a COPC. For the remaining semivolatile organics detected, there are no State or Federal standards for any of these compounds in groundwater, and only naphthalene and phenol have HAs. However, there are tap water RBCs for all of the semivolatile organics, except for 2-methylnaphthalene (the naphthalene RBC was used as a surrogate RBC). None of the semivolatile organics exceeded the RBC. Even though none of the semivolatiles exceeded any of the standards or criteria the detected SVOCs are petroleum hydrocarbon components and could be related to past site activities involving fuels. Therefore, acenaphthene, naphthalene and 2-methylnaphthalene, 2,4-dimethyphenol, and phenol were retained as COPCs.

The pesticides 4,4'-DDD (4 µg/L) and 4,4'-DDT (10 µg/L) were detected in groundwater at a frequency of 1 of 9 samples. In addition, both of these compounds were detected in the background well, 4,4'-DDD at 0.73 µg/L, and 4,4'-DDT at 1.6 µg/L. Federal and State standards have not been set for 4,4'-DDD or 4,4'-DDT. However, both of these compounds have a RBC which was exceeded. The tap water RBC for 4,4'-DDD is 0.35 µg/L, and the RBC for 4,4'-DDT is 0.25 µg/L. Based on the historical activity of the site and the exceedances of RBCs 4,4'-DDD and 4,4'-DDT were retained as COPCs.

Total and dissolved inorganic analyses were performed for groundwater. Aluminum, arsenic, barium, beryllium, cadmium, calcium, chromium, cobalt, copper, iron, lead, magnesium, manganese, potassium, selenium, sodium, vanadium, and zinc were detected in the groundwater as total concentrations. Except for cadmium and selenium, all of these chemicals were also detected in the background well. In fact, aluminum, beryllium, chromium, copper, lead and manganese were detected in their highest concentrations in the background well. Sodium, potassium, calcium and magnesium are the principal cations detected in groundwaters (USEPA, 1986). In addition, calcium, iron, magnesium, potassium, and sodium are essential human elements and were detected in concentrations only slightly above the background concentrations (except for calcium). Therefore, calcium, magnesium, potassium, and sodium were not further evaluated for groundwater.

Total inorganic concentrations were compared to background concentrations, NCWQSs, MCLs, HAs, and RBCs. Chromium, cobalt, copper, selenium, and zinc did not exceed any of the groundwater standards or criteria were not retained as COPCs. Aluminum exceeded the SMCL. SMCLs are guidance only. In addition, aluminum is a chemical of low toxicity and was not retained as a COPC. Cadmium, lead, and manganese exceeded NCWQS for groundwater. Cadmium and lead exceeded MCLs. Arsenic, barium, beryllium, cadmium, and vanadium exceeded RBCs. Arsenic, beryllium, and cadmium exceeded HAs. Even though cadmium exceeded all standards and criteria it was detected only once and was not retained as a COPC. Barium was detected in all groundwater samples and exceeded NCWQSs and the RBC it was, therefore, retained as a COPC. Beryllium and vanadium exceeded the RBC and HAs. Vanadium was detected at a high frequency (7 of 8 samples) and was retained as a COPC. Beryllium was detected in only 2 of 8 samples but is an identified carcinogen and was, therefore, retained as a COPC. In addition, arsenic exceeded the RBC, was detected at a high frequency, is an identified pesticide component, and is a potent carcinogen. Therefore, arsenic was retained as a COPC.

Lead was detected at a frequency of 5 in 8 samples. It exceeded the Federal MCL (Action Level 15 µg/L) in one sample (2-GW01-01 at 15.5 µg/L), but did not exceed the State standard (50 µg/L). The Federal Action Level is measured at the tap (which takes into consideration the corrosivity of lead pipes) of a potable water supply. According to the federal lead standard, if 10 percent of the tap samples exceed 15 µg/L, then measures need to be taken to bring the tap samples back to or below 15 µg/L. This Action Level is not directly applicable to groundwater cleanup since the Action Level is measured at the tap and not at the source. However, the state standard for lead is also 15 µg/L. Lead was detected at its highest total concentration in the background well 2-GW09-01 (27.2 µg/L), however, it was not detected in the dissolved state in this well. Since lead was detected at a high frequency, exceeded state and federal standards, and is an identified carcinogen it was retained as a COPC.

Manganese was detected at a high frequency (7 of 7 samples) and exceeded the NCWQS for groundwater. However, manganese occurs at naturally high levels at MCB Camp Lejeune. This evaluation of manganese is based on the Wellhead Monitoring Study report performed at Camp Lejeune (Greenhorne and O'Mara, 1992). Average concentrations base-wide were reported to be 78 µg/L with a range of 50 to 120 µg/L. The highest detected value of manganese was 290 µg/L in the background well. The concentration of the highest detected value other than the background well was 79 µg/L (2-GW0601). This value fell within base-wide concentrations for manganese, and was, therefore, not retained as a COPC for groundwater.

6.2.3 Surface Water

Seven surface water samples were collected throughout the study area. Of the seven surface water samples, three were collected in Overs Creek, and four in the Railroad Track Drainage Ditches. The surface water in the drainage ditches at Site 2 are considered to be freshwater. However, according to North Carolina surface water classifications, any stream which is not named in the schedule of stream classifications carries the same classification as that assigned to the stream segment to which it is a tributary (NC DEHNR, 1993). Overs Creek is considered to be a saltwater surface water body since it is a unnamed tributary (by the state) to Northeast Creek, a state classified saltwater surface water body. Tables 6-15 and 6-16 present the surface water analytical data for the Railroad Track Drainage Ditches and Overs Creek, respectively, as well as freshwater AWQC and NCWQS for the protection of human health, and frequencies of detection.

Three surface water samples collected from the study area were analyzed for full TCL organic chemicals and TAL inorganics (one in the Railroad Track Drainage Ditches and two in Overs Creek). The volatile organics acetone, chloroform, and carbon disulfide were detected. Acetone and chloroform are laboratory contaminants which did not exceed the maximum method laboratory blank concentration and were not retained as COPCs for the surface water. Carbon disulfide was detected once (7J µg/L) in the most upgradient surface water sampling point in Overs Creek. Since it was detected at a low concentration and frequency carbon disulfide was not retained as a COPC.

Semivolatile organics were not detected in any of the surface water samples.

Seven surface water samples were analyzed for TCL pesticides and PCBs. Three in Overs Creek and four in the Railroad Track Drainage Ditches. None of the surface water samples collected in Overs Creek contained detectable levels of pesticides or PCBs. However, all four railroad drainage ditch surface water samples had positive detects of pesticides; 4,4'-DDD was detected in 4 of 7 samples, and 4,4'-DDT was detected in 2 of 7 samples. 4,4'-DDD exceeded the AWQC in all four samples, and 4,4'-DDT exceeded the AWQC and the NCWQS. Based on site history, the exceedances of standards and a high frequency of detection, 4,4'-DDD and 4,4'-DDT were retained as COPCs for surface water in the Railroad Track Drainage Ditches.

Herbicides were not detected in any of the surface water samples.

One Railroad Track Drainage Ditch and two Overs Creek surface water samples were analyzed for inorganics. Aluminum, arsenic, barium, beryllium, calcium, chromium, copper, iron, lead, magnesium, manganese, potassium, sodium, vanadium, and zinc were detected in the drainage ditch surface water. Calcium, iron, magnesium, potassium, and sodium are essential elements and were not retained as COPCs for the drainage ditches. The remaining detected inorganics were compared to AWQC and NCWQS (freshwater, human health). Human health state standards have not been set for aluminum, arsenic, chromium, copper, and lead. Aluminum is a chemical of low toxicity and, therefore, was not retained as a COPC. Barium, chromium, copper and lead did not exceed AWQC, and were not retained as COPCs. Arsenic and manganese exceeded AWQC, and beryllium exceeded AWQC and NCWQS. Beryllium was retained as a COPC since it exceeded two standards and is an identified carcinogen. Arsenic can be associated with arsenical pesticide usage, was retained as a COPC in all other media at the site, and is a potent carcinogen, therefore, arsenic was retained as a COPC. Manganese exceeded the NCWQS, however, as discussed in Section 6.2.2, manganese occurs in naturally high concentrations in this region of the country and was not retained as a COPC.

Aluminum, barium, calcium, copper, iron, magnesium, manganese, potassium, and sodium were detected in Overs Creek. Magnesium, potassium and sodium are major cations associated with saltwater; calcium and iron are essential human elements, therefore, none of these chemicals were retained as COPCs. Barium, copper, and manganese did not exceed AWQC and were not retained as COPCs for Overs Creek. Aluminum is a chemical of low toxicity and was not retained as a COPC for Overs Creek.

6.2.4 Sediment

This subsection discusses the selection of COPCs for the sediment before the proposed TCRA.

A total of 24 sediment samples were collected during the field investigation, including two background samples. Each sample was taken at two depths, 0-6 inches (shallow) and 6 to 12 inches (deep). Eighteen sediment samples were analyzed for TCL volatile organics and semivolatile organics. TAL inorganics were analyzed for in 20 samples. TCL pesticides were analyzed for in 48 samples, PCBs were analyzed for in 31 samples, and herbicides were analyzed for in 28 samples. The background samples, which were collected in the upstream portion of the railroad drainage ditch, were analyzed for full TCL organics and TAL inorganics.

Four volatile organics were detected in the sediment; acetone, 2-butanone, ethylbenzene and xylene (total). Acetone and 2-butanone were detected in the Railroad Track Drainage Ditches and in Overs Creek. Acetone and 2-butanone are common laboratory contaminants which did not exceed ten times the maximum method laboratory blank. Therefore, these contaminants were not retained as COPCs. Ethylbenzene was detected in 1 of 18 samples at a concentration of 680J µg/kg. Xylene (total) was detected in 2 of 18 samples at concentrations of 1400J and 4900 µg/kg. Both of these chemicals were detected in the Railroad Track Drainage Ditches in sample 2-RRSD09. Adjacent to the mixing pads, xylene (total) was detected in the shallow and deep sediments. The site history and the extent of contamination indicates that fuels were probably used on site near this location. Therefore, ethylbenzene and xylene (total) were retained as COPCs for the Railroad Track Drainage Ditch sediment.

The PAHs acenaphthene, fluorene, phenanthrene, fluoranthene, pyrene, benzo(a)anthracene, chrysene, benzo(b)fluoranthene, benzo(k)fluoranthene, and benzo(a)pyrene were detected in the Railroad Track Drainage Ditch samples. All of these PAHs were detected at low concentrations (estimated values below the detection limits) and frequencies (1 or 2 samples of 14). PAHs at these concentrations are ubiquitous in the environment and may occur naturally or anthropogenically by the incomplete combustion of fossil fuels (see Table 6-17). Considering that the sediment samples were taken adjacent to railroad tracks, it is probable that these PAHs detected were due to railroad operations. Therefore, the PAHs detected in the sediments were not retained as COPCs. However, naphthalene (700 µg/kg) and 2-methylnaphthalene (1,860 µg/kg) were detected in the Railroad Track Drainage Ditch sediments at a frequency of 1 of 20 samples. These chemicals were detected in sample 2-RRSD09612, the same location where ethylbenzene and xylene were detected. In addition, naphthalene and 2-methylnaphthalene were detected in other media (groundwater and soil). Since it is suspected that fuels may have been used in this area, naphthalene and 2-methylnaphthalene were retained as COPCs in the sediment. Semivolatile organics were not detected in Overs Creek.

The pesticides detected in the sediments included dieldrin, 4,4'-DDE, 4,4'-DDD, 4,4'-DDT, endosulfan II, and alpha- and gamma-chlordane. 4,4'-DDD, 4,4'-DDE, and 4,4'-DDT were detected in the sediment at Overs Creek. 4,4'-DDD, 4,4'-DDE, 4,4'-DDT, dieldrin, endosulfan II, and alpha- and gamma-chlordane were detected in the Railroad Track Drainage Ditches. Dieldrin was detected 2 of 48 samples, and endosulfan II was detected 1 of 48 samples. The remaining pesticides were detected at high concentrations (e.g., 4,4'-DDD at 710,000 µg/kg) in the area adjacent to the mixing pads. Due to the site history, the high frequency of detection, and the high concentrations of the detected samples all of the pesticides detected in the sediment were retained as COPCs.

Neither herbicides or PCBs were detected in the sediment.

The inorganic chemicals that were detected in the sediment included; aluminum, antimony, arsenic, barium, beryllium, calcium, chromium, copper, iron, lead, magnesium, manganese, potassium, selenium, sodium, thallium, vanadium, and zinc. Magnesium, potassium and sodium are major cations associated with saltwater and would be expected to be detected in sediment associated with surface water. In addition, these three cations as well as iron and calcium are essential human elements. Therefore, magnesium, potassium, sodium, iron, and calcium were not further evaluated for the baseline RA.

The Railroad Track Drainage Ditches receive surface water run-off from the railroad tracks and adjacent land areas, and only have water in them intermittently throughout the year. Because of this, the drainage ditches would tend to have characteristics of soil more than of a true sediment. Due to this similarity in media characteristics of the Railroad Track Drainage Ditch sediment to soil, a comparison to the RBCs was utilized in addition to the Two-Times Rule. The interim lead cleanup guidance level was used as a criteria for selection since an RBC is not available for lead. The maximum concentration of the inorganics detected in sediment were compared to twice the average site-specific background sediment concentrations. These same chemicals were compared to RBCs for soil. The inorganics which exceeded twice the site-specific average background concentrations in the shallow sediment of the Railroad Track Drainage Ditches included; aluminum, arsenic, barium, beryllium, chromium, copper, lead, manganese, selenium, vanadium, and zinc. Out of these chemicals only arsenic exceeded the RBC. Therefore, arsenic was retained as a COPC for the shallow sediment drainage ditches because it exceeded the RBC, was detected at a high frequency (8 of 16 samples), is an identified pesticide component, and a potent carcinogen.

Table 6-18 presents a comparison of Railroad Track Drainage Ditch shallow sediment inorganic concentrations to site-specific background concentrations and to RBCs.

Even though the characteristics of the sediment in Overs Creek would tend to be different than that of the shallow sediment of the Railroad Track Drainage Ditches due to the inherent nature of the ecosystem, the same approach that was utilized for the selection of COPCs for the shallow sediment in the Railroad Track Drainage Ditches was used for the shallow sediment in Overs Creek. Aluminum, arsenic, barium, beryllium, chromium, copper, lead, manganese, selenium, thallium, vanadium, and zinc exceeded twice the site-specific average background concentrations. Only arsenic exceeded the RBC. Therefore, arsenic was retained as a COPC for the shallow sediment in Overs Creek because it exceeded the RBC, was detected at a high frequency (8 of 16 samples), is an identified pesticide component, and a potent carcinogen.

Table 6-19 presents a comparison of Overs Creek shallow sediment inorganic concentrations to site-specific background concentrations and to RBCs.

6.2.4.1 Sediment - Time-Critical Removal Action

The selection of COPCs for the sediment before the proposed TCRA have been discussed in Section 6.2.4. The status of the COPCs as a result of the removal action, i.e., were the chemicals retained as COPCs after the proposed removal action are discussed in this section. The sediment samples which were removed from the data set include 2-RR-SD17, 2-RR-SD15, 2-RR-SD14, 2-RR-SD13, and 2-RR-SD09 (shallow and deep samples).

Volatile organics were not detected in the remaining sediment samples. Therefore, ethylbenzene and xylene (total) were not further evaluated as COPCs for the sediment.

Naphthalene and 2-methylnaphthalene were not detected in samples unaffected by the proposed removal action. Therefore, no semivolatiles were further evaluated as COPCs after the proposed TCRA.

The pesticide Endosulfan II was not detected after the proposed TCRA and, therefore, was not retained as a COPC. 4,4'-DDD, 4,4'-DDE, and 4,4'DDT were detected at high frequencies. 4,4'-DDD frequency of detection was 35 of 38 samples; 4,4'-DDE was detected 31 of 38 samples, and 4,4'-DDT was detected 35 of 38 samples. Alpha-chlordane was detected at a frequency of 10 of 38 samples, and gamma-chlordane was detected 7 of 38 samples. Dieldrin was detected at a frequency 2 of 38 samples. The frequencies of detection for the pesticides indicate that the contamination present due to pesticides is prevalent even after the removal of the highly contaminated soils. Therefore, all of the pesticides detected after the proposed TCRA were retained as COPCs for the sediment.

The maximum value of arsenic (1.4 mg/kg) fell above the RBC (0.97 mg/kg) and was retained as a COPC.

Table 6-20 presents a summary of the COPCs for all media evaluated at Site 2.

6.3 Exposure Assessment

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

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

6.3.1 Site Conceptual Model of Potential Exposure

A site conceptual model of potential exposure which includes sources, migration pathways and human receptors was developed which encompasses all potential routes of exposure both now and in the future. The site conceptual model is derived by considering current site demographic information and the future residential development of the property. Figure 6-1 presents the diagram of the conceptual site model for Site 2. Future potential exposure to contaminants is also addressed in Figure 6-1 under a no remedial action scenario.

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

- Current on-site civilian and military base personnel (adult)
- Current trespassers to Overs Creek (older child and adult)
- Future on-site residents (child and adult)
- Future on-site construction workers

Even though military base personnel have been identified as current on- site receptors, a quantitative evaluation for this group was not performed. Since the exposure frequencies and exposure durations for the current civilian base personnel far exceeded those of military personnel (e.g., an average military personnel tour would be three years, and civilian base personnel working lifetime would be 25 years), a quantitative evaluation was performed for current on-site civilian base personnel only. The scenarios evaluated for civilian base personnel would be more representative of chronic exposure to contaminants detected on site than those of military base personnel.

6.3.2 Identification of Potential Exposure Pathways

This section presents potential exposure pathways at Site 2 and the rationale for their selection. Potential exposure pathways depend on the source areas (identified by the field sampling and analytical data generated during the RI) as well as chemical fate and environmental transport potential of the selected COPCs. Tables 6-21 and 6-22 present the potential pathway summary selection and rationale for inclusion or exclusion in the baseline RA for current and future scenarios, respectively.

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

6.3.2.1 <u>Surface and Subsurface Soil</u>

Direct contact with surface and subsurface soil can result in dermal contact exposure, incidental ingestion, and particulate inhalation both now and in the future. COPCs present in on-site soils are related to on-site usage and storage of these chemicals, therefore, current civilian base personnel, future residential children and adults, and future construction workers could be exposed by dermal contact, incidental ingestion, and to particulate inhalation of COPCs in site surface soils. These pathways and receptors were, therefore, retained for quantitative evaluation.

6.3.2.2 Groundwater

All of the potable groundwater used at MCB, Camp Lejeune, is supplied by the Castle Hayne aquifer. The raw water obtained from these wells is pumped to one of six water treatment plants located on the Base. Four of the potable supply wells (wells 616, 645, 646, and 647) are located within a one-mile area of Site 2 (refer to Section 3.0). These supply wells are monitored for contamination on a regular basis by the Department of the Navy. The latest supply well sampling investigation was performed in December 1992 by Greenhorne & O'Mara. During this sampling period wells 616, 646, and 647 were found to be free of contamination. Well 645 was not operating due to contamination, and therefore was not sampled. Well 645 was determined to be contaminated by BTEX from a fuel tank, located at the pumping station (Geophex, 1991). Since the other three wells were determined to be free of contamination, it is apparent that groundwater contamination at Site 2 has not impacted the potable groundwater supply wells located near the site. Therefore, no current receptors have been identified as being exposed to groundwater in the immediate vicinity of the site.

Groundwater could be used as a potable drinking water supply if residential development of Site 2 were to occur in the future, however, this is unlikely. Future land-use plans have not proposed Site 2 for residential housing development (Base Master Plan, 1988). However, in order to conservatively address the potential risks of contaminated groundwater associated with the site, the direct ingestion of groundwater, dermal contact, and the inhalation of volatile organics while showering were retained as future potential exposure pathways despite the unlikeliness of potable groundwater usage.

6.3.2.3 Surface Water/Sediment

Direct contact with sediment can result in dermal contact exposure and incidental ingestion both now and in the future. COPCs present in on-site sediment are related to on-site usage and storage, therefore, current civilian base personnel, and future residential children and adults could be exposed by dermal contact and incidental ingestion to COPCs in on-site surface water and sediment. These pathways and receptors were, therefore, retained for quantitative evaluations. In addition, off-site COPCs were retained for the sediment at Overs Creek, and trespassing older children and adults were quantitatively evaluated.

6.3.2.4 Air

Current and future exposures to contaminants in the air could occur, both now and in the future, via fugitive dust emissions from soils. The action of the wind on fine-grained soils can generate fugitive dust, which can be carried downwind toward receptors. Lawn maintenance, such as mowing, can generate particulates; however, the vegetative covers at the site will result in minimal particulate emissions. In addition, construction activities, such as excavation of soil, can also generate particulates into the air. Therefore, this pathway was retained for current civilian base personnel, future residential children and adults, and future construction workers.

6.3.2.5 Biota

The railroad drainage ditches, that intermittently contain surface water, and Overs Creek do not support sustenance or recreational viable fish populations. Therefore, no human receptors have been identified that would be exposed to the biota in this area, and the pathway was not retained for quantitative evaluation.

6.3.3 Quantification of Exposure

6.3.3.1 Concentrations Used In The Estimation Of Potential Exposure

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

Exposure to groundwater, sediment and surface water can occur discretely or at a number of sampling locations. These media are transitory in that concentrations change frequently over time. Averaging transitory data obtained from multiple locations is difficult and requires many more data points at discrete locations than exist within Operable Unit No. 5. 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 soil exposure concentrations.

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 log-normal distribution was used to represent all facility media. This ensures conservative estimation in the calculation of chronic daily intake associated with potential exposures. Ninety-five percent upper confidence intervals derived for log-normal data sets (95 percent U.C.L.) produce concentrations in excess of the 95 percent interval derived assuming normality. As a conservative approach, the 95 percent U.C.L. for the log-normal distribution will be used for each contaminant in a given data set for quantifying potential exposure. In cases where the 95 percent U.C.L. for a contaminant exceeds the maximum detected value in a given data set, the maximum result was used in the estimate of exposure of the 95 percent U.C.L.

Maximum values, arithmetic means, normal standard deviations, and 95 percent U.C.L.s for normal and log-normal distributions are presented in Appendix I.

6.3.4 Calculation of Chronic Daily Intakes

In order to numerically estimate the risks for current and future human receptors at Site 2, a chronic daily intake (CDI) was estimated for each COPC in every retained exposure pathway.

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

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

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

Current and future exposure scenarios consider 1 to 6 year old children weighing 15 kg, and adults weighing 70 kg on average (USEPA, 1989). For the current exposure scenarios at Overs Creek older children (ages 6 to 15) weighing 37 kg were evaluated, as well as 70 kg adults (USEPA, 1989). For civilian base personnel an exposure duration of 25 years was used to estimate a working lifetime (USEPA, 1991), and for construction workers an exposure duration of 1 year was assumed (Professional Judgement).

6.3.4.1 Incidental Ingestion of Surface and Subsurface Soil

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

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

Where:

CDI = Chronic daily intake, milligrams per kilogram per day (mg/kg-d)
C = Contaminant concentration in surface or subsurface 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 COPCs associated with the potential ingestion of soils.

Civilian Base Personnel and Construction Workers

During the course of current maintenance activities at Site 2, base personnel could be exposed to COPCs by the incidental ingestion of surface soils. In addition, future construction work at the site could also expose construction workers to COPCs in the subsurface soil.

The ingestion rate for base personnel exposed to surficial soils was assumed to be 50 mg/day for a 70 kg adult. An exposure frequency of 32 days per year was used in conjunction with an exposure duration of 25 years (USEPA, 1991). The exposure frequency of 32 days per year was based on the assumption that the lawn would be mowed once per week spring through fall (8 months out of the year). Based on the site visits of this area it was apparent that the main maintenance activity of the outside would be lawn mowing. However, since the LA and MPAs are small, (area measures approximately 4236 m^2), it was assumed that all of the time would not be spent mowing the lawn, but that other lawn maintenance activities would occur, for example flower planting in the spring. Thirty-two days per year is believed to be a conservative estimate of exposure frequency for civilian base personnel. An averaging time (ATc) of or 25,550 (70 years x 365 days) days was used for exposure to potentially carcinogenic compounds, while an averaging time (ATnc) of 9,125 days (ED x 365 days) was used for noncarcinogenic exposures. An average body weight of 70 kg was used (USEPA, 1989). The fraction ingested was assumed to be 100 percent (Professional Judgement).

The ingestion rate for future construction workers exposed to subsurface soils was assumed to be 480 mg/day for a 70 kg adult. An exposure frequency of 30 days per year was assumed. This exposure frequency was chosen because the LA and MPAs, and the FSA are small (FSA is approximately 3679 m^2, and the area of the LA and MPA is approximately 4236 m^2). In addition, the depth to groundwater in this area is only 5 feet. Therefore, it would not seem likely that subsurface digging would occur for more than 30 days (Professional Judgement). An ATc of 25,550 days and an ATnc of 365 days were assumed. The fraction ingested was assumed to be 100 percent.

Future On-Site Residents

Future on-site residents could potentially be exposed to COPCs in the top 0 to 6 inch soil interval during recreational activities or landscaping activities around their homes. Children and adults could potentially be exposed to COPCs in soils by incidental ingestion.

Ingestion rates for adults and children in this scenario were assumed to be 100 mg/day and 200 mg/day, respectively. Exposure frequency for both receptor groups was assumed to be 350 days per year. Exposure duration was 30 years for a 70 kg adult, and 6 years for a 15 kg child (USEPA, 1991).

Averaging times of 25,550 days for potential carcinogens was used for both receptors, 10,950 days for noncarcinogenic constituents was used for estimating potential CDIs for adults, and an ATnc of 2,190 days was used to estimate potential CDIs for children. The fraction ingested was assumed to be 100 percent.

A summary of the exposure factors used in the estimation of soil CDIs associated with the incidental ingestion of soil is presented on Table 6-23.

6.3.4.2 Dermal Contact with Surface and Subsurface Soil

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

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

Where:

CDI = Chronic daily intake (mg/kg·d)
C = Contaminant concentration in surface or subsurface soil (mg/kg)
CF = Conversion factor (1E-6 kg/mg)
SA = Skin surface available for contact, square centimeters (cm^2)
AF = Soil to skin adherence factor (mg/cm^2)
ABS = Absorption factor (dimensionless)
EF = Exposure frequency (days/year)
ED = Exposure duration (years)
BW = Body weight (kg)
AT = Averaging time (days)

Civilian Base Personnel and Construction Workers

During current landscaping and future construction activities, there is a potential for workers to absorb COPCs by dermal contact.

It was assumed that base personnel and construction workers have approximately 5,900 cm^2 of skin surface (SA) available for dermal exposure with COPCs. The surface area was derived from USEPA's Dermal Exposure Assessment handbook (January 1992). The 95th percentile adult surface area for males is approximately 23,000 cm^2. The handbook states that about 26 percent of the total surface area exposed for adults has been estimated to occur for soil dermal contact scenarios. Therefore, 26 percent of 22,800 cm^2 equals 5,928 or 5,900 cm^2.

Exposed body parts are assumed to be the hands, neck, head, legs, and forearms. Values for exposure duration, exposure frequency, body weight, and averaging time were the same as those used for the incidental ingestion of soil scenario.

Data on soil adherence are limited. A value of 1.0 mg/cm^2 was used in this assessment. The absorption factors used were 0.01 for organics and 0.001 for inorganics (USEPA,1992).

Future On-Site Residents

Future on-site residents could be potentially exposed to COPCs in the on-site soil through dermal contact.

Skin surface areas used in the on-site resident exposure scenario were 2,600 cm^2 and 5,900 cm^2 for children and adults, respectively. The adult and child surface areas were also derived from USEPA's Dermal Exposure Assessment handbook (January 1992). The adult surface was discussed in the previous paragraphs. The child surface area was calculated by averaging the 95th percentile body surface areas for males from age 2 to 6 (less than 7) years of age and taking 30 percent of this value, 30 percent of 8,534 cm^2 equals 2,560 or 2,600 cm^2. Exposure was expected to occur at the hands, legs, forearms, neck, and head for both receptors.

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

A soil adherence value of 1.0 mg/cm^2 was used in this assessment. The absorption factors used were 0.01 for organics and 0.001 for inorganics.

A summary of the soil exposure assessment input parameters for dermal contact is presented in Table 6-23.

6.3.4.3 Inhalation of Particulates

The chronic daily intake of contaminants associated with the inhalation of soil particulates was expressed using the following general equation:

$$\text{CDI (mg/kg·day)} = \frac{(1/\text{PEF} \times \text{IR} \times \text{ET} \times \text{EF} \times \text{ED})}{\text{BW} \times \text{AT}}$$

Where:

CDI = Chronic Daily Intake (mg/kg·d)
C = Contaminant concentration in soil (mg/kg)
1/PEF = Particulate emission factor, milligrams per meter cubed (kg/m^3)
IR = Inhalation rate, meters cubed per hour (m^3/hr)
ET = Exposure time (hr/day)
EF = Exposure frequency (events/year)
ED = Exposure duration (years)
BW = Body weight (kg)
AT = Averaging time (days)

Particulate Emission Factor

The PEF relates the contaminant concentration in soil with the concentration of respirable particles (PM10) in the air due to fugitive dust emissions from contaminated surface soil.

The PEF was calculated to determine the exposure concentration of particulates in air using the following equation:

$$\text{PEF}\ (\text{m}^3/\text{kg}) = \frac{\text{LS} \times \text{V} \times \text{DH} \times 3{,}600\ \text{s/hr}}{\text{A}} \times \frac{1{,}000\ \text{g/kg}}{0.036 \times (1-\text{G}) \times (\text{U}_m/\text{U}_t)^3 \times \text{F}(x)}$$

Where:

PEF = Particulate emission factor (m^3/Kg)
LS = Width of contaminated area (m)
V = Wind speed in mixing zone (2.25 m/s)
DH = Diffusion height (2 m)
A = Area of contamination (m^2)
0.036 = Respirable fraction (g/m^2-hr)
G = Fraction of vegetative cover (unitless)
Um = Mean annual wind speed (4.5 m/s)
Ut = Equivalent threshold value of wind speed at 10 m (m/s)
F(x) = Function dependent on Um/Ut (unitless)

The width, area, and percent of vegetative cover of the LA and MPAs, and the FSA were the only site-specific input parameters used to calculate the PEF. All other parameters used in the calculation were default values (USEPA, 1991). The LA and MPA width was calculated to be approximately 18 m, the area was 2982 m^2, and the percent of vegetative cover was estimated to be 80 percent. The LA and MPA (after the TCRA) width was calculated to be approximately 18 m^2, the area was 2982 m, and the percent of vegetative cover was estimated to be 90 percent. It was assumed that the MPA would be seeded after the removal action. The FSA width was calculated to be approximately 15 m^2, the area was 3270 m^2, and the percent of vegetative cover was estimated to be 60 percent.

The PEF calculated for the LA and MPA (before and after the TCRA), and for the FSA was 8E+6 m^3/kg. The calculations of the PEF are presented in Appendix H.

Civilian Base Personnel and Construction Workers

During current maintenance activities, including lawn mowing of the LA and MPAs, and the FSA, civilian base personnel could be exposed to particulate air emissions from soils. In addition, future construction activities at the site could potentially expose construction workers to particulate emissions via building construction at the lawn and mixing pad areas and FSA.

The inhalation rate for heavy activities of 4.8 m^3/hour was used for base personnel and construction workers (USEPA, 1989). Body weight, exposure frequency, exposure duration, ATc, and ATnc were the same as those discussed for the soil ingestion scenario.

Future Residential Adults and Children

The inhalation rate for moderate activities of 2 m^3/hour was used for the child, and the adult moderate activities inhalation rate was 2.5 m^3/hour (USEPA, 1989). Body weight, exposure frequency, exposure duration, ATc, and ATnc were the same as those discussed for the future soil ingestion scenario for children and adults.

Table 6-24 presents a summary of the input parameters used in the estimation of CDIs for the inhalation of particulates for all receptors at Site 2.

6.3.4.4 Ingestion of Groundwater

Shallow groundwater is not currently being used as a potable supply at Site 2. Development of the shallow aquifer for potable use is unlikely because of the general water quality (e.g., high TSS) in the shallow zone, poor flow rates (approximately 2 to 3 gallons per minute) and the unlikely development of the site for residential housing. However, by taking the most conservative approach when evaluating the groundwater at this site, a future residential scenario was evaluated for this assessment.

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

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

Where:

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

Future On-Site Residents

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

An ingestion rate of 1 liter/day was 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) The exposure duration was 6 years.

An averaging time of 25,550 days was used for potentially carcinogenic compounds, and 6 years times 365 days/year (2,190 days) was used for noncarcinogenic compound exposure.

The exposure duration used for the estimation of adult CDIs was 30 years (USEPA, 1989), which represents the national upper-bound (90th percentile) time at one residence. The ingestion rate for a 70 kg adult was 2 liters/day (USEPA, 1989). The exposure time for noncarcinogens was 10,950 days.

Table 6-25 presents a summary of the input parameters for the ingestion of groundwater scenarios.

6.3.4.5 Dermal Contact with Groundwater

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

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

Where:

CDI = Chronic daily intake (mg/kg·d)
C = Contaminant concentration is groundwater (mg/L)
SA = Surface area available for contact (cm^2)
PC = Dermal permeability constant, centimeters per hour (cm/hr)
ET = Exposure time (hour/day)
EF = Exposure frequency (days/year)
ED = Exposure duration (years)
CF = Conversion factor, liters per cubic centimeters ($1L/1000cm^3$)
BW = Body weight (kg)
AT = Averaging time (days)

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 available for dermal absorption by children was estimated to be 8,500 cm^2 and 22,800 cm^2 for adults (USEPA, 1992). The permeability constant (PC) reflects the movement of a chemical across the skin and into the blood stream. The permeability constant of water, 1.0 x 10-3 cm/hr, was used as a default for all constituents of concern, for which literature values were not published (USEPA, 1992). This value may in fact be a realistic estimate of the absorption rate of a chemical when COPC concentrations are in the part per billion range.

Body weight, exposure frequency, exposure duration, ATc, and ATnc were the same as those discussed for the groundwater ingestion scenario for children and adults.

Table 6-25 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 asses the inhalation of contaminants volatilized from shower water, the model developed by Foster and Chrostowski (1986) was utilized. Contaminant concentrations in air, due to volatile organics while showering, were modeled by estimating the following; the rate of chemical releases into air (generation rate), the buildup of volatile organics in the shower room air while the shower was on, the decay of volatile organics in the shower room after the shower was turned off, and the quantity of airborne volatile organics inhaled while the shower was both on and off. The contaminant concentrations calculated to be in the air were then used as the concentration term of the CDI equation. A detailed discussion of this model is presented in Appendix O.3.

The CDI associated with the inhalation of airborne (vapor phase) volatile organics from groundwater while showering was estimated using the following general equation:

$$\text{Intake (mg/kg·day)} = \frac{C \times IR \times ET \times EF \times ED}{BW \times AT}$$

Where:

C = Contaminant concentration in the air (mg/m^3)
IR = Inhalation rate (m^3/hr)
ET = Exposure time (hr/day)
EF = Exposure frequency (days/year)
ED = Exposure duration (years)
BW = Body weight (kg)
ATc = Averaging time carcinogen (days)
ATnc = Averaging time noncarcinogen (days)

Future On-Site Residents

Children and adults could contact COPCs through the inhalation of vaporized organic chemicals from groundwater while showering.

It was 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, 1992). The default inhalation rate of 0.6 m^3/hr was used for both receptors (USEPA, 1989). An exposure time of 0.25 hours per day was also used for both receptors (USEPA, 1992). The exposure duration and averaging times remained the same as for groundwater ingestion.

Table 6-25 presents the exposure factors used to estimate CDIs associated with the inhalation of volatile organic chemicals from groundwater while showering.

6.3.4.7 Incidental Ingestion of Surface Water

The chronic daily intakes associated with the potential incidental ingestion of COPCs detected in surface water were calculated using the following equation:

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

Where:

CDI = Chronic daily intake (mg/kg·d)
C = Chemical concentration in water (mg/L)
CR = Contract rate (L/hour)
ET = Exposure time (hour/day)
EF = Exposure frequency (day/yr)
ED = Exposure duration (years)
BW = Body weight (kg)
AT = Averaging time (days)

Civilian Base Personnel

Civilian base personnel could be exposed to COPCs through incidental ingestion of surface water in the railroad drainage ditches during maintenance activities.

The exposure frequency for base personnel of 6 days per year was determined for this assessment by using the climatological data presented in Section 3.0 of this report. As observed on the site visits to Site 2, the drainage ditches do not have free-standing surface water in them year round. It is only in times of increased precipitation that water tends to accumulate in the ditches, i.e., in the summer which has the most rainfall, and less so in the spring and winter. The fall has the least amount of precipitation during the year in this region. For this assessment it was assumed that the ditches are dry in the fall, and have water in them for the entire summer season and for portions of the spring and winter. Since temperatures are low during the winter months along with intermittent precipitation, it was assumed that any exposures would be unlikely during this time of the year and was not included in the assessment. Therefore, only the spring and summer months were evaluated in the risk assessment for surface water exposure. An exposure frequency of six days was chosen since it was reasoned that there would only be water in the drainage ditches for five months per year. Other than cleaning out a clogged drainage pipe that runs under the access road to the wastewater treatment plant and FSA (this pipe occasionally gets clogged from sedimentation deposition), it was assumed that the employee would not have a need to be in the drainage ditches. An estimate of one exposure per month was used.

An ingestion rate of 0.01 liters per hour was used for civilian base personnel as the amount of water ingested while in contact with surface water in the Railroad Track Drainage Ditches. This incidental ingestion rate is the recommended ingestion rate used for in surface water exposure that does not involve swimming (USEPA, Region IV, 1994). An exposure time of 1.0 hours per day (hr/d) was assumed for the civilian base personnel in this scenario. This number is the recommended value used for exposure time when surface water exposure does not involve a swimming scenario (USEPA, Region IV, Personal Communication, 1994).

The averaging time for carcinogens and noncarcinogens, body weight, and exposure duration are the same as those for the groundwater ingestion scenarios.

Future On-Site Residents

Children and adults could contact COPCs through incidental ingestion of surface water in the railroad drainage ditches during recreational activities.

The exposure frequency for children was determined in a similar manner as for base personnel, except it was assumed that children would have the opportunity for exposure the entire summer, but only on the weekends in the spring. Fifty percent of the children's exposure frequency was assumed for the adult. Therefore, the exposure frequency for the ingestion of surface water by children was determined to be 46 days per year, and 23 days per year for adults. The ingestion rate of 0.01 liters per hour and the exposure time of 1.0 hours were used for both receptors, as discussed in the section for Civilian Base Personnel.

The averaging time for carcinogens and noncarcinogens, body weight, and exposure duration are the same as those for groundwater ingestion.

Table 6-26 presents the exposure factors used to estimate CDIs associated with surface water ingestion for all receptors.

6.3.4.8 Dermal Contact with Surface Water

The chronic daily intakes associated with dermal contact with COPCs in surface water were calculated using the following equation (USEPA, 1989a):

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

Where:

CDI = Chronic daily intake (mg/kg·d)
C = Chemical concentration in water (mg/L)
SA = Surface area of exposed skin (cm^2/event)
PC = Chemical specific dermal permeability constant (cm/hour)
ET = Exposure time (hour/day)
EF = Frequency of exposure (days/year)
ED = Exposure duration (years)
CF = Volumetric conversion factor (1 liter/1,000 cm^3)
BW = Body weight (kg)
AT = Averaging time (days)

Civilian Base Personnel

During current maintenance activities at Site 2, there is a potential for base personnel to absorb COPCs by dermal contact of surface water in the railroad drainage ditches. It was assumed that base personnel employees would have approximately 1,300 cm^2 of skin surface area available for dermal exposure with COPCs (USEPA, 1992). It was assumed that the exposed body parts were hands and forearms only. The exposure frequency was 6 days per year (refer to discussion of exposure frequency in Section 6.3.4.7).

Values for exposure duration, body weight, exposure time, and averaging times were the same as those used for the ingestion of surface water scenario.

Future On-Site Residents

Children and adults could contact COPCs by dermal contact of surface water in the railroad drainage ditches during recreational activities.

The surface area for children was determined to be 2,600 cm^2 and was discussed in Section 6.3.4.2 for soil dermal contact. However, it was assumed that the adult surface area, 1,800 cm^2, would include lower legs, hands, and forearms only. The averaging time for carcinogens and noncarcinogens, body weight, exposure time, and exposure duration remained the same as those for the surface water ingestion scenarios.

Table 6-26 presents the input parameters used to estimate CDIs associated with the dermal contact of surface water at Site 2.

6.3.4.9 Incidental Ingestion of Sediment

The chronic daily intake of COPCs associated with the incidental ingestion of sediment was expressed using the following general equation:

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

Where:

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

Civilian Base Personnel

Incidental ingestion of COPCs in sediments could be possible during current maintenance activities in the drainage ditches at the site.

The ingestion rate for base personnel exposed to sediments was assumed to be 50 mg/day. An exposure frequency of 9 days per year was assumed, because the chance to be exposed to sediment was also likely in the fall when surface water was not present (Professional Judgement).

The averaging time for carcinogens and noncarcinogens, body weight, and exposure duration were the same as those for surface water ingestion. The fraction ingested was assumed to be 100 percent.

Future On-Site Residents

Incidental ingestion of COPCs in sediments could be possible during future recreational activities occurring at the railroad drainage ditches.

The exposure frequency for children was increased from the surface water frequency of 46 days per year to 56 days, and the adult increased from 23 to 28 days per year. The days were added to account for the additional exposure children and adults could potentially encounter to sediment when surface water was not present in the ditches.

The input parameters for averaging times, body weight, ingestion rates, and exposure duration were the same as those for soil ingestion. The fraction ingested was assumed to be 100 percent.

Trespassers to Overs Creek

Incidental ingestion of COPCs in sediments could be possible during current trespassing activities at Overs Creek by older children (ages 6-15 years), and adults.

The ingestion rate for older children weighing 37 kg, and adults weighing 70 kg exposed to sediments was assumed to be 100 mg/day. The exposure frequencies for both receptors remained the same as for future residential children and adults exposure scenarios for sediment. The exposure duration for adults was 30 years, and 9 years for older children (USEPA, 1989 and 1992). The averaging times for adults was the same as for the future residential adults for sediment exposure scenarios. The noncarcinogenic averaging time for the older child was 3285 days, and the carcinogenic averaging time remained at 25,550 days. The fraction ingested was assumed to be 100 percent.

A summary of exposure factors for the surface water ingestion scenarios for all receptors are presented in Table 6-27.

6.3.4.10 Dermal Contact with Sediment

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

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

Where:

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

Civilian Base Personnel

Dermal contact with COPCs in sediments could occur during current maintenance activities.

Exposure of base personnel to sediments was expected to occur on the hands and forearms only, a surface area of 1,300 cm^2. The body weight, averaging times, exposure duration, and the absorption factor and adherence factor were the same as those used for soil dermal contact. The exposure frequency was the same as the sediment ingestion scenario, 9 days.

Future On-Site Child and Adult

During recreational use of the drainage ditch surface water, direct contact with sediments could occur for the future on-site child and adult.

Exposure of resident children and adults to sediments was expected to occur on the hands, forearms, lower legs and feet. The surface area of 2,600 cm^2 was assumed for children. However, it was assumed that the adult surface area, 1,800 cm^2, would include lower legs, hands, and forearms only. The body weight, averaging times, exposure duration, and the absorption and adherence factors were the same as those used for soil dermal contact. The exposure frequency of 56 days for children and 28 days for adults were chosen to account for the increased exposure frequency during the fall, this was discussed in Section 6.3.4.9.

Trespassers to Overs Creek

Dermal contact of COPCs in sediments could be possible during current trespassing activities at Overs Creek by older children (ages 6-15 years), and adults.

The body weights, exposure frequencies, exposure durations, and averaging times, were the same as those used for the sediment ingestion scenarios for Overs Creek. The absorption and adherence factors were the same as those used for the future sediment dermal contact scenarios.

Table 6-27 provides a complete summary of the input parameters used in the estimation of CDIs for dermal contact with sediment at Site 2.

6.4 Toxicity Assessment

6.4.1 Toxicological Evaluation

The purpose of this section is to identify the potential health and environmental effects with potential exposure to the potential 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 presented in contaminant of concern toxicological profiles 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 and/or reference doses have been developed for many of the COPCs. This section provides a brief description of these parameters.

6.4.2.1 Carcinogenic Slope Factor (CSF)

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

Slope factors are accompanied by Weight-of-Evidence (WOE) classifications which designate the strength of the evidence that the COPC is a human carcinogen. This system of carcinogen classifications was developed by the USEPA. When a WOE is assigned, the available data are evaluated to determine the likelihood that the agent is a human carcinogen. The evidence is characterized separately for human and animal studies as sufficient, limited, inadequate, no data, or evidence no effect. The characterizations of these two types of data are combined, and based on the extent to which the agent has been shown to be a carcinogen in experimental animals or humans, or both, the chemical is given a provisional WOE classification. The USEPA then adjusts the provisional classification upward or downward, based on other supporting evidence of carcinogenicity. The classification system is defined as:

EPA WEIGHT-OF-EVIDENCE CLASSIFICATION SYSTEM FOR CARCINOGENICITY

Group	Description
A	Human carcinogen
B1 or B2	Probable human carcinogen B1 indicates that limited human data are available. B2 indicates sufficient evidence in animals and inadequate or no evidence in humans.
C	Possible human carcinogen
D	Not classifiable as to human carcinogenicity
E	Evidence of noncarcinogenicity for humans

6.4.2.2 Reference Dose (RfD)

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

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

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

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

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

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

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

- An MF ranging from >0 to 10 is included to reflect a qualitative professional assessment of additional uncertainties in the critical study and in the entire data base for the chemical not explicitly addressed by the preceding uncertainty factors. The default for the MF is 1.

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

Toxicity factors and the USEPA Weight-of-Evidence classifications are presented in Table 6-28. The hierarchy (USEPA, 1989) for choosing these values is as follows:

- Integrated Risk Information System (IRIS)
- Health Effects Assessment Summary Table (HEAST)
- USEPA Region IV, Risk-Based Toxicity Factors

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 EPA has formed a RfD Workgroup to review existing data used to derive RfDs. Once the reference doses has been verified, they also appear in IRIS.

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

Appendix O.1 presents the toxicological profiles for the COPCs identified at Site 2.

6.5 Risk Characterization

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

The quantitative risk calculations for potentially carcinogenic compounds estimate incremental lifetime cancer risk (unit risk) levels for an individual in a specified population. This unit risk refers to the cancer risk that is over and above the background cancer risk in unexposed individuals. For example, an incremental lifetime cancer risk level (ICR) of 1E-6 indicates that, for a lifetime exposure, one additional case of cancer may occur per one million exposed individuals.

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

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

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

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

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

$$\begin{aligned} \mathrm{HI} &= \mathrm{HQ}_1 + \mathrm{HQ}_2 + \ldots \mathrm{HQ}_n \\ &= \sum_{i=1}^{n} \mathrm{HQ}_i \end{aligned}$$

where: $\mathrm{HQ}_i = \mathrm{CDI}_{i/}\mathrm{RfD}_i$

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

Estimated incremental cancer risks will be compared to the target risk range of 1E-4 to 1E-6 which the USEPA considers to be safe and protective of public health (USEPA, 1989). A value of 1.0 is used for examination of the HI. The hazard index calculated by comparing estimated chronic daily intakes with threshold levels below which, noncarcinogenic health effects are not expected to occur. Any HI equal to or exceeding 1.0 suggests that noncarcinogenic health effects are possible.

Appendix O.2 presents the derived CDI values, ICRs and HIs for each COPC by exposure pathway.

6.5.1 Human Health Effects

The following subsections present the quantitative results of the human health baseline RA performed for Site 2. The results are presented for the LA and MPA, and the FSA both before and after the TCRA. The risks associated with the sediment in Overs Creek are presented separately.

6.5.1.1 Lawn and Mixing Pad Areas

Civilian Base Personnel - Current Scenarios

Civilian base personnel could be exposed to COPCs at the LA and MPA in the surface soils, and Railroad Track Drainage Ditch surface water and sediment. The total ICR was 1E-4. This value falls within the USEPA's acceptable target risk range of 1E-4 to 1E-6 which is considered to be generally protective of human health. The HI was 1.3 which exceeded unity, or 1.0. This value suggests that adverse systemic health effects are possible. The ingestion and dermal contact of pesticides in soil were responsible for approximately 100 percent of the carcinogenic and noncarcinogenic risks. Table 6-29 presents the ICRs and HIs for Civilian Base Personnel, Current Scenarios.

Construction Worker - Future Scenarios

Construction workers could be exposed to COPCs at the LA and MPA in the subsurface soils during excavation. The total ICR was 6E-7. This value falls below the USEPA's acceptable target risk range of 1E-4 to 1E-6 which is considered to be generally protective of human health. The HI was 0.1 which fell below unity, or 1.0. This value suggests that adverse systemic health effects are not likely to occur. The ingestion and dermal contact of pesticides in soil were responsible for approximately 100 percent of the carcinogenic and noncarcinogenic risks. Table 6-30 presents the ICRs and HIs for Construction Workers, Future Scenarios.

Residential Child and Adult - Future Scenarios

Residential children and adults could be exposed to COPCs at the LA and MPA in the surface soil, groundwater, and surface water and sediment. For the child the ICR was 2E-3. This value falls above the USEPA's acceptable target risk range of 1E-4 to 1E-6. Dermal contact and the ingestion of pesticides in soil were responsible for approximately 80 percent of the carcinogenic risk for the child, while the ingestion of groundwater contaminated with arsenic and beryllium accounted for 20 percent of the carcinogenic risk. The HI was 111 which exceeded unity. This value suggests that adverse systemic health effects are possible. Dermal contact and the ingestion of pesticides in soil were responsible for approximately 90 percent of the noncarcinogenic risk for the child.

For the adult the ICR was 2E-3. This value falls above the USEPA's acceptable target risk range of 1E-4 to 1E-6. Dermal contact and the ingestion of pesticides in soil were responsible for approximately 70 percent of the carcinogenic risk for the child, while the ingestion of groundwater contaminated with arsenic and beryllium accounted for 25 percent of the carcinogenic risk. The HI was 23 which exceeded unity. This value suggests that adverse systemic health effects are possible. Dermal contact with and the ingestion of pesticides in soil were responsible for approximately 78 percent of the noncarcinogenic risk for the child.

Table 6-31 presents the ICRs and HIs for Residential Children and Adults, Future Scenarios.

6.5.1.2 Lawn and Mixing Pad Areas - Time-Critical Removal Action

Civilian Base Personnel - Current Scenarios

Civilian base personnel could be exposed to COPCs at the LA and MPA (after the proposed TCRA) in the surface soils, and the Railroad Track Drainage Ditch surface water and sediment. The ICR was 5E-7. This value falls below the USEPA's acceptable target risk range of 1E-4 to 1E-6, which is generally expected to be protective of human health. The HI was 0.008 which falls below unity. This value suggests that adverse systemic health effects are not likely to occur. Table 6-32 presents the ICRs and HIs for Civilian Base Personnel, Current Scenarios.

Construction Worker - Future Scenarios

Construction workers could be exposed to COPCs at the LA and MPA (after the proposed TCRA) in the subsurface soils during excavation. The ICR was 1E-10. This value falls below the USEPA's acceptable target risk range of 1E-4 to 1E-6, which is generally considered to protective of human health. The HI was 6E-5 which did not exceed unity. This value suggests that adverse systemic health effects are not likely to occur. Table 6-33 presents the ICRs and HIs for Construction Workers, Future Scenarios.

Residential Child and Adult - Future Scenarios

Residential children and adults could be exposed to COPCs at the LA and MPA (after the proposed TCRA) in the surface soil, groundwater, and Railroad Track Drainage Ditch surface water and sediment. For the child the ICR was 1E-4. This value falls within the USEPA's acceptable target risk range of 1E-4 to 1E-6. Arsenic and beryllium contributed approximately 92 percent of the carcinogenic risk. The HI was 11 which exceeded unity. This value suggests that adverse systemic health effects are possible. Approximately 98 percent of the noncarcinogenic risk was due to groundwater ingestion and dermal contact. Arsenic contributed 62 percent of the noncarcinogenic groundwater ingestion risk, and 4,4'-DDT contributed 26 percent of the risk due to dermal contact exposure.

For the adult the ICR was 7E-4. This value falls above the USEPA's acceptable target risk range of 1E-4 to 1E-6. Eighty-five percent of the risk was due to the ingestion of groundwater, with arsenic and beryllium contributing 92 percent of the groundwater ingestion risk. The HI was 5. This value suggests that adverse systemic health effects are possible. Approximately 90 percent of the noncarcinogenic risk was due to groundwater ingestion and dermal contact. Arsenic contributed 62 percent of the noncarcinogenic groundwater ingestion risk, and 4,4'-DDT contributed 83 percent of the risk due to dermal contact exposure.

Table 6-34 presents the ICRs and HIs for Residential Children and Adults, Future Scenarios.

6.5.1.3 Former Storage Area

Civilian Base Personnel - Current Scenarios

Civilian base personnel could be exposed to COPCs at the FSA in the surface soils. The ICR was 3E-7. This value falls below the USEPA's acceptable target risk range of 1E-4 to 1E-6, which is generally expected to be protective of human health. The HI was 0.03 which falls below unity. This value suggests that adverse systemic health effects are not likely to occur. Table 6-35 presents the ICRs and HIs for Civilian Base Personnel, Current Scenarios.

Construction Worker - Future Scenarios

Construction workers could be exposed to COPCs at the FSA in the subsurface soils during excavation. The ICR was 4E-8. This value falls below the USEPA's acceptable target risk range of 1E-4 to 1E-6, which is generally considered to protective of human health. The HI was 0.005 which did not exceed unity. This value suggests that adverse systemic health effects are not likely to occur. Table 6-36 presents the ICRs and HIs for Construction Workers, Future Scenarios.

Residential Child and Adult - Future Scenarios

Residential children and adults could be exposed to COPCs in the surface soil and groundwater at the FSA. For the child the ICR was 3E-4. This value falls above the USEPA's acceptable target risk range of 1E-4 to 1E-6. Ninety-nine percent of the risk was due to groundwater ingestion dermal contact. Ninety-two percent of the risk was due to groundwater ingestion contaminated with arsenic and beryllium. The HI was 12 which exceeded unity. This value suggests that adverse systemic health effects are possible. Groundwater ingestion was responsible for 72 percent of the noncarcinogenic risk, with 62 percent of the groundwater ingestion risk due to arsenic, and 16 percent due to 4,4'-DDT.

For the adult the ICR was 7E-4. This value falls above the USEPA's acceptable target risk range of 1E-4 to 1E-6. Approximately 85 percent of the carcinogenic risk was due to groundwater ingestion, with arsenic and beryllium contributing 92 percent of the risk. The HI was 5 which exceeded unity. This value suggests that adverse systemic health effects are likely. The ingestion of and dermal contact with groundwater contributed 99 percent noncarcinogenic risks. Eighty-three percent of the dermal contact risk was due to 4,4'-DDT, and 62 percent of the groundwater ingestion risk was due to arsenic.

Table 6-37 presents the ICRs and HIs for Residential Children and Adults, Future Scenarios.

6.5.1.4 Former Storage Area - Time Critical Removal Action

Civilian Base Personnel - Current Scenarios

Civilian base personnel could be exposed to COPCs at the FSA in the surface soils after the TCRA. The ICR was 3E-8. This value falls below the USEPA's acceptable target risk range of 1E-4 to 1E-6, which is generally expected to be protective of human health. The HI was 3E-4 which falls below unity. This value suggests that adverse systemic health effects are not likely to occur. Table 6-38 presents the ICRs and HIs for Civilian Base Personnel, Current Scenarios.

Construction Worker - Future Scenarios

Construction workers could be exposed to COPCs at the FSA in the subsurface soils during excavation. The ICR was 4E-8. This value falls below the USEPA's acceptable target risk range of 1E-4 to 1E-6, which is generally considered to protective of human health. The HI was 0.005 which did not exceed unity. This value suggests that adverse systemic health effects are not likely to occur. Table 6-39 presents the ICRs and HIs for Construction Workers, Future Scenarios.

Residential Child and Adult - Future Scenarios

Residential children and adults could be exposed to COPCs in the surface soil and groundwater at the FSA. For the child the ICR was 3E-4. This value falls above the USEPA's acceptable target risk range of 1E-4 to 1E-6. The ingestion of and dermal contact with groundwater contributed to approximately 100 percent of the risk. The HI was 22 which exceeded unity. This value suggests that adverse systemic health effects are possible. The ingestion of and dermal contact with groundwater was responsible for approximately 100 percent of the noncarcinogenic risk.

For the adult the ICR was 7E-4. This value falls above the USEPA's acceptable target risk range of 1E-4 to 1E-6. The HI was 5 which exceeded unity. This value suggests that adverse systemic health effects are likely. The ingestion of and dermal contact with groundwater was responsible for approximately 100 percent of the noncarcinogenic risk and carcinogenic risks.

Table 6-40 presents the ICRs and HIs for Residential Children and Adults, Future Scenarios.

6.5.1.5 Overs Creek

Trespassing Child and Adult - Current Scenarios

Trespassing older children (6-15 years) and adults could be exposed to COPCs at Overs Creek in the sediment. No COPCs were retained for the surface water at Overs Creek. For the child the ICR was 1E-7. This value falls below the USEPA's acceptable target risk range of 1E-4 to 1E-6, which is generally considered to be protective of human health. The HI was 0.001 which did not exceed unity. This value suggests that adverse systemic health effects are not likely.

For the adult the ICR was 9E-8. This value fell below the USEPA's acceptable target risk range of 1E-4 to 1E-6, which is generally considered to be protective of human health. The HI was 3E-4 which did not exceed unity. This value suggests that adverse systemic health effects are not likely.

Table 6-41 presents the ICRs and HIs for Trespassing Older Children and Adults, Current Scenarios.

6.6 Total Site Risks

A quantitative evaluation of current and future human exposure to COPCs detected in environmental media, investigated at Site 2, resulted in total site ICRs in excess of the USEPA's target risk range for some receptors. The target risk range (1E-6 to 1E-4) is generally expected to be protective of human health. In addition, the HIs for some receptors exceeded unity, 1.0, indicating that noncarcinogenic adverse human health effects could occur.

Table 6-42 presents a summary of Total Site Incremental Lifetime Cancer Risks and Hazard Indices for the following areas of concern within Operable Unit No.5: Lawn (LA) and Mixing

Pad Areas (MPA); Lawn and Mixing Pad Areas - TCRA; Former Storage Area (FSA); Former Storage Area - TCRA; and Overs Creek.

Current property usage at Site 2 will remain unchanged in the foreseeable future (Base Master Plan 1988). For the LA and MPAs, civilian base employees were evaluated since this area is currently used as an administration office. As a conservative estimation of risk, the potential future development of the site for residential housing was also evaluated. The potential receptors for exposure in the future scenarios include construction workers, and resident children and adults. The total site risk in the LA and MPA exceeded the ICR range of 1E-6 to 1E-4 for the future residential child and adult, i.e., 2E-3 for both receptors. The civilian base personnel fell within the acceptable range (1E-4) while the ICR for the construction worker fell below the acceptable target range (6E-7). The HI exceeded unity (1.0) for the future residential child and adult, i.e., 111 and 23 for the child and adult, respectively. The civilian base personnel also fell above unity (1.3), while the HI for the construction worker fell below unity (0.1). The majority of the carcinogenic and noncarcinogenic risks for current adult base personnel (approximately 100 percent) were due to the ingestion of and dermal contact with pesticide contaminated soil. For the future residential child and adult, exposure to groundwater contaminated with inorganics, mainly arsenic and beryllium, contributed approximately 20-25 percent of the carcinogenic risks with pesticide contaminated soil contributing the remaining (75-80 percent) risks. For the noncarcinogenic risks pesticide contaminated soil contributed to the majority of the risks for the resident child and adult.

The risks calculated for the LA and MPAs, after the proposed TCRA of pesticide contaminated soil and sediment, greatly reduced the risk to all receptors. All of the individual ICRs and HQs for these two media fell within acceptable levels. The total site HIs, however, exceeded unity for the future residential child (HI = 11) and adult (HI = 5), and the total site ICR for the resident adult (7E-4) and the resident child (3E-4) fell above the acceptable cancer risk range of 1E-6 to 1E-4. Arsenic and beryllium accounted for the increase of carcinogenic risks due to groundwater ingestion. The elevated HIs (i.e., greater than unity) were due to exposure to contaminated shallow groundwater, with arsenic, barium, and 4,4'-DDT, driving the noncarcinogenic ingestion risks and 4,4'-DDT and ethylbenzene driving the groundwater noncarcinogenic dermal contact risks. Exposure to the shallow groundwater accounted for the elevated ICRs. The ingestion of arsenic and beryllium, and the dermal contact of pesticide contaminated groundwater drive the carcinogenic risk.

The FSA was evaluated separately from the LA and MPA due to different contaminant concerns and land usage. However, the same receptors were evaluated in both areas. The total site risks for this area included the risks from the soil and groundwater only (before and after the proposed TCRA). Before the proposed TCRA, the civilian base personnel (3E-7) and construction worker (4E-8) risks fell below the acceptable target risk range (1E-6 to 1E-4), and the HIs for these receptors fell below unity. The total ICR for the resident child (3E-4) and adult (7E-4) fell above the acceptable target risk range (1E-6 to 1E-4). The HIs exceeded unity, 12 and 5 for children and adults, respectively. The elevated HIs (i.e, greater than 1.0) were mainly due to the dermal contact of and the direct ingestion of groundwater contaminated with inorganics and pesticides. After the proposed TCRA in the FSA, the risks (ICRs and HIs) remained unchanged for these two receptors, since the majority of the risks in the FSA were due to the groundwater both before and after the proposed TCRA. The HIs for both receptors still exceeded unity, 7 for the child and 3 for the adult. The elevated HIs and ICR were mainly due to the direct ingestion of arsenic, beryllium, and 4,4'-DDT in the groundwater.

Currently there are no receptors who are exposed to the shallow groundwater in this area. All groundwater used at MCB, Camp Lejeune is supplied by the deeper Castle Hayne aquifer from uncontaminated supply wells. Future development of the shallow aquifer for potable use is unlikely because of the general poor water quality in the shallow zone, poor flow rates, and the unlikely future development of the site for residential housing. The potential risk, that could be due to groundwater exposure at this site, was evaluated as a conservative estimation of exposure.

Overs Creek is not located within the boundary of Operable Unit No.5. However, it was evaluated separately from the site to determine if contamination from Site 2 was migrating to the creek. COPCs were selected for the sediment only. Trespassing older children and adults were the receptors evaluated. The total site risk for Overs Creek did not exceed the acceptable target risk range (1E-6 to 1E-4), and the HIs did not exceed unity for either receptor.

6.7 Conclusion

The pesticide contaminated surface soil and sediment at the LA and MPAs (before the proposed TCRA), have the potential to present the greatest adverse human health risks from all media evaluated at Site 2. The risks calculated for this area, after the proposed TCRA, were greatly reduced into acceptable ranges for soil and sediment, for all receptors.

The risks calculated for soil in the FSA area fell within acceptable risk levels both before and after the proposed TCRA.

Future potential use of shallow groundwater exhibited noncarcinogenic and carcinogenic risks to future resident children and adults due mainly to arsenic, beryllium, and pesticide contamination. However, shallow groundwater is not utilized for potable supply or other uses.

The total site risk at Overs Creek indicates that contamination from Site 2 is not appreciably migrating to the creek, and that adverse human health risks are not expected to occur due to contamination at Overs Creek.

6.8 Sources of Uncertainty

Uncertainties are encountered throughout the process of performing a risk assessment. This section discusses the sources of uncertainty inherent in the following elements of the public health and environmental evaluation performed for Site 2:

- Analytical data
- Exposure assessment
- Toxicity assessment
- Risk characterization
- Chemicals not quantitatively evaluated

Uncertainties associated with this risk assessment are discussed in the following paragraphs. Table 6-43 summarizes the potential effects of certain uncertainties on the estimation of human health risks.

6.8.1 Sampling and Analysis

The development of a risk 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 methods of analysis. For example, contract laboratory program (CLP) methods of analysis have, in general, a precision of approximately plus or minus 50 percent depending upon 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 concentrations, detection frequencies) are subject to the overall uncertainty in data measurement. Furthermore, chemical concentrations in environmental media fluctuate over time and with respect to sampling location. Analytical data must be sufficient to consider the temporal and spatial characteristics of contamination at the site with respect to exposure.

Analytical data must also be comprehensive in order to address the COPCs associated with the site. Types of COPCs encountered at Site 2 included pesticides, volatile, and semivolatile organic constituents.

To minimize the uncertainties associated with sampling and analysis at Site 2, USEPA approved sampling and analytical methods were employed. Data was generated in most cases using USEPA's Statement of Work for CLP. Samples were analyzed for target compound list (TCL) organics, target analyte list (TAL) inorganics and cyanide. Samples were taken from locations specified in the approved Work Plan along with the necessary QA/QC samples.

For the groundwater sampling procedures, there is some uncertainty associated with the results of total concentration analyses of chemicals. In most instances of groundwater sampling methods, entrained silt is associated with the groundwater sample. These groundwater samples are unlike treated tap water samples where extreme turbidity is not expected, such as the water at MCB, Camp Lejeune. Chemical adsorbed particles can inadvertently increase the concentration of a chemical in groundwater.

6.8.2 Exposure Assessment

In performing exposure assessments, uncertainties arise from two main sources. First, uncertainties arise in estimating the fate of a compound in the environment, including estimating release and transport in a particular environmental medium. Second, uncertainties arise in the estimation of chemical intakes resulting from contact by a receptor with a particular medium.

To estimate an intake, certain assumptions must be made about exposure events, exposure durations, and the corresponding assimilation of constituents by the receptor. Exposure factors have been generated by the scientific community and have undergone review by the USEPA. The USEPA has published an Exposure Factors Handbook and Dermal Exposure Handbook, which contain the latest exposure factor values. Regardless of the validity of these exposure factors, they have been derived from a range of values generated by studies of limited numbers of individuals. In all instances, values used in this risk assessment, scientific judgments, and conservative assumptions agree with those of the USEPA.

The use of a Reasonable Maximum Exposure (RME) approach, designed as not to underestimate daily intakes, was employed throughout this risk assessment. The use of 95th percent upper confidence estimates of the arithmetic mean or maximum values as the concentration term in estimating the CDI reduces the potential for underestimating exposure at Site 2. Recent research using Monte-Carlo estimation techniques indicate that USEPA's RME represents the 98 to 99.99 percent upper limit of the estimated risk distribution.

The use of total pesticide analytical results in groundwater to represent conditions "at the tap," result in an overestimation of potential risks for these COPCs. The presence of fine particulates in unfiltered groundwater samples contribute greatly to the concentration of insoluble constituents such as 4,4'-DDT and other pesticides. The presence of fine particulates in groundwater samples can be attributed to the design of monitoring wells which is different than potable well design.

6.8.3 Toxicological Assessment

In making quantitative estimates of the toxicity of varying dosages of compounds to human receptors, uncertainties arise from two sources. First, data on human exposure and the subsequent effects are usually insufficient, if they are at all available. Human exposure data usually lack adequate concentration estimations and suffer from inherent temporal variability. Therefore, animal studies are often used and new uncertainties arise from the process of extrapolating animal results to humans. Second, to obtain observable effects with a manageable number of experimental subjects, high doses of a compound are often used. In this situation, a high dose means that high exposures are used in the experiment with respect to most 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 high doses in animals to low doses in people, 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 doses to low doses. In deriving carcinogenic potency factors, the 95th percent upper confidence value is promulgated by the agency to prevent underestimation of potential risk.

As instructed by RAGS, the toxicity factors used for dermal contact exposure pathways were adjusted CSFs and RfDs, so that the chemicals evaluated would be expressed as an absorbed dose and not as an administered dose. As directed by USEPA, Region IV, the adjusted fraction for volatile organics was 0.8, for semivolatile organics the adjusted fraction was 0.5, and for inorganics the adjusted fraction was 0.2. CSFs and RfDs are developed based on the oral ingestion exposure route. Adjusting oral toxicity values for the dermal contact exposure route may not accurately describe the potential risk from dermal exposure since the same systemic toxic effects may not occur from the oral and dermal exposure routes.

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.

6.8.4 Human Risk Characterization

The risk characterization bridges the gap between risk assessment and risk management, ultimately providing impetus for the remediation of the site.

Uncertainties associated with risk characterization include the assumption of chemical additivity and the inability to predict synergistic or antagonistic interactions between COPCs. These uncertainties are inherent in any inferential risk assessment. USEPA promulgated inputs to the quantitative risk assessment and toxicological indices are calculated to be protective of the human receptor and to err conservatively, so as to not underestimate the potential human health risks.

6.8.5 Compounds Not Quantitatively Evaluated

Semivolatile organic tentatively identified compounds (TICs) were not quantitatively evaluated in the baseline RA for soils and sediment. The procedures used to identify and estimate concentrations for TICs is uncertain. Rather than identifying each constituent individually, TICs are compared to "fingerprints" of mass spectra and are matched to the chemical that most closely resembles the compound to be identified from a computerized library of mass spectra. Estimates of the concentrations of the TICs (which are obtained through procedures outlined in the USEPA's CLP Scope of Work) is also an uncertain process, where the concentrations of the chemicals could be orders of magnitude higher or lower than the reported value (USEPA, 1989c). The lack of promulgated toxicological indices for TICs does not have significant effects on the underestimation of risk due to the presence of other COPCs such as 4,4'-DDD, 4,4'-DDE, and 4,4'-DDT which were detected in environmental media at relatively high concentrations.

Although these constituents were not quantitatively evaluated, this risk assessment has been performed using conservative concentration estimates (RMEs), exposure scenarios (use of the groundwater as a drinking water source), and available toxicological information.

TABLE 6-1

SUMMARY OF SITE 2 ORGANIC ANALYTICAL DATA LAWN AND MIXING PAD AREAS - SURFACE SOIL REMEDIAL INVESTIGATION CTO-0174 MCB CAMP LEJEUNE, NORTH CAROLINA

Organic Chemical	Range of Positive Detections (µg/kg)	No. of Positive Detects/ No. of Samples
Volatiles		
Toluene	ND - 6	1/11
Xylene (total)	4 - 5	4/11
Pesticides		
alpha-Chlordane	4.3 - 3,900	9/46
gamma-Chlordane	5.2 - 3,400	6/46
4,4'-DDD	9.8 - 1,200,000	33/46
4,4'-DDE	4.9 - 30,000	38/46
4,4'-DDT	5 - 3,000,000	40/46
Dieldrin	ND - 1,400	1/46
Heptachlor	ND - 280	1/46

Notes: Concentrations expressed in microgram per kilogram (µg/kg).
ND - Not Detected

TABLE 6-2

SUMMARY OF SITE 2 INORGANIC ANALYTICAL DATA
LAWN AND MIXING PAD AREAS - SURFACE SOIL
REMEDIAL INVESTIGATION CTO-0174
MCB CAMP LEJEUNE, NORTH CAROLINA

Inorganic	Surface Soil (0-6 inches)				
	Base-Specific Background Concentration Range[1]	Twice the Base-Specific Average Concentration	Range of Positive Detections	No. of Positive Detects/ No. of Samples	No. of Times Exceeded Background/ No. of Times Detected
Aluminum	<90.5 - 1,490	1,459	2,310 - 9,650	11/11	11/11
Arsenic	<0.44 - 0.91	0.8	0.52 - 4.3	8/11	4/8
Barium	3.5 - 16.5	13	5.1 - 25.9	11/11	4/11
Beryllium	<0.06 - <0.22	0.1	0.22 - 0.22	2/11	2/2
Cadmium	<0.35 - <1.1	0.8	1.1 - 1.1	2/11	2/2
Calcium	108 - 10,700	4,932	508 - 109,000	11/11	8/11
Chromium	<0.06 - <3.2	2	3 - 12.7	10/11	10/10
Cobalt	<0.37 - <1.8	1.6	ND - 2.8	1/11	1/1
Copper	<1.1 - 3.1	2.8	0.46 - 19.9	11/11	4/11
Iron	160 - 1,020	1,051	722 - 3,880	11/11	9/11
Lead	2.0 - 20.4	45	5.7 - 225	11/11	4/11
Magnesium	<20.2 - 200	146	109 - 1,850	11/11	8/11
Manganese	<2.0 - 11.1	14	2.1 - 63.9	11/11	4/11
Mercury	<0.02 - <0.12	0.1	0.25 - 0.69	2/11	2/2
Potassium	54.5 - 102	104	59.6 - 368	11/11	7/11
Selenium	<0.31 - <1.0	0.9	0.66 - 0.82	2/11	0/2
Sodium	<9.4 - 67.5	49	20.7 - 214	11/11	5/11
Thallium	<0.22 - <0.41	0.4	ND - 0.26	1/11	0/1
Vanadium	<2.1 - 5.3	4.6	3.1 - 14.5	11/11	7/11
Zinc	<1.1 - 28.3	23	3.8 - 125	8/11	4/8

Notes: Concentrations expressed in milligram per kilogram (mg/kg).
ND - Not Detected
(1) Soil background concentrations are based on reference background soil samples from samples taken for Site 2 and previous investigations at Camp Lejeune.

TA. 6-3
NATIVE CONCENTRATION RANGES FOR SELECT INORGANICS IN SOILS FROM LITERATURE
REMEDIAL INVESTIGATION CTO-0174
MCB CAMP LEJEUNE, NORTH CAROLINA

Inorganic	Lindsay, 1979(1)	Tox. Profiles(2)	Tox. of Metals, 1986(3)	Dragun, 1988(4)	Modern Env. Tox. XI, 1987(5)	U.S. Geological Survey (Eastern Portion of U.S.)(6)
Aluminum	NA	NA	NA	10,000 - 300,000	NA	7,000 - >10,000
Arsenic	1.0 - 80	0.1 - 80	40	1 - 40	Trace - 40	<0.1 - 73
Beryllium	NA	0.01 - 40	NA	0.1 - 40	NA	<1.0 - 7.0
Cadmium	0.01 - 0.7	0.6 - 6.0	<1.0	0.01 - 7.0	<1.0 - 30	NA
Calcium	NA	NA	NA	100 - 400,000	NA	100 - 320,000
Chromium	1 - 100	NA	Trace - 250	5.0 - 3,000	Trace - 250	1.0 - 1,000
Copper	NA	NA	NA	2-100	NA	<1 - 300
Lead	2 - 200	10 - 30	2 - 200	2.0 - 200	10 - 700	<10 - 300
Magnesium	NA	NA	NA	600 - 6,000	NA	50 - >100,000
Manganese	NA	NA	NA	100 - 4000	NA	<1 - 7000
Mercury	0.01 - 0.3	NA	NA	0.01 - 0.08	0.01 - 0.3	<0.01 - 3.4
Nickel	NA	5.0 - 1,000	NA	5.0 - 1,000	NA	<5.0 - 700
Potassium	NA	NA	NA	50 - 5,000	NA	<20 - 6,800
Selenium	0.1 - 2.0	4.0 - 8.0	NA	0.1 - 2.0	0.1 - 10.0	<0.01 - 3.9
Sodium	NA	NA	NA	750 - 7,500	NA	<500 - 100,000
Vanadium	NA	NA	NA	20 - 500	NA	<7 - 500
Zinc	NA	10 - 300	NA	<10 - 2,000	NA	<5.0 - 2,900

Notes: NA - Not available

All values reported in milligram per kilogram (mg/kg).

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

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

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

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

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

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

TABLE 6-4

COMPARISON OF INORGANIC SOIL CONCENTRATIONS TO RISK-BASED CONCENTRATIONS
LAWN AND MIXING PAD AREAS - SURFACE SOIL
REMEDIAL INVESTIGATION CTO-0174
MCB CAMP LEJEUNE, NORTH CAROLINA

Inorganic	Maximum Detected Concentrations (mg/kg)	Risk-Based Concentration[1] (mg/kg)	Maximum Detected[2] Value Exceeded Risk-Based Concentration
Aluminum	9,650	23,000	N
Arsenic	4.3	0.97	Y
Barium	25.9	550	N
Beryllium	0.22	0.4	N
Cadmium	1.1	3.9	N
Chromium	12.7	39[3]	N
Cobalt	2.8	--[4]	--
Copper	19.97	290	N
Lead	225	500[5]	N
Manganese	63.9	780	N
Mercury	0.69	2.3	N
Vanadium	14.5	55	N
Zinc	125	2,300	N

Notes: Concentrations expressed in milligram per kilogram (mg/kg).

[1] USEPA, 1993. Selecting Exposure Routes and Contaminants of Concern by Risk-Based Screening.

[2] Y/N (yes/no), denotes maximum detected value exceeded risk-based concentration.

[3] Chromium $^{+6}$

[4] (--) Value not available

[5] USEPA, 1990. "Interim Guidance on Establishing Soil Lead Cleanup Levels at Superfund Sites."

TABLE 6-5

SUMMARY OF SITE 2 ORGANIC ANALYTICAL DATA
LAWN AND MIXING PAD AREAS - SUBSURFACE SOIL
REMEDIAL INVESTIGATION CTO-0174
MCB CAMP LEJEUNE, NORTH CAROLINA

Organic Chemical	Range of Positive Detections (µg/kg)	No. of Positive Detects/ No. of Samples
Volatiles		
Xylene (total)	5 - 4,100	2/11
Semivolatiles		
Acenaphthene	ND - 360	1/11
Anthracene	ND - 150	1/11
Fluoranthene	ND - 160	1/11
Fluorene	160 - 700	2/11
2-Methylnaphthalene	1,000 - 14,000	2/11
Naphthalene	130 - 4,800	2/11
n-Nitrosodiphenylamine	340 - 1,000	2/11
Phenanthrene	350 - 1,500	2/11
Pyrene	ND - 160	1/11
Pesticides		
alpha-Chlordane	2.2 - 2,500	6/46
gamma-Chlordane	2.4 - 2,300	4/46
4,4'-DDD	4.2 - 130,000	27/46
4,4'-DDE	4.6 - 6,300	24/46
4,4'-DDT	4 - 82,000	32/46
Heptachlor	ND - 190	1/46

Notes: Concentrations expressed in microgram per kilogram (µg/kg).
ND - Not Detected

TABLE 6-6

SUMMARY OF SITE 2 INORGANIC ANALYTICAL DATA
LAWN AND MIXING PAD AREAS - SUBSURFACE SOIL
REMEDIAL INVESTIGATION CTO-0174
MCB CAMP LEJEUNE, NORTH CAROLINA

Inorganic	Subsurface Soil (6 inches to the water table)				
	Base-Specific Background Concentration Range(1)	Twice the Base-Specific Average Concentration	Range of Positive Detections	No. of Positive Detects/ No. of Samples	No. of Times Exceeded Background/ No. of Times Detected
Aluminum	672 - 10,200	8,946	2,840 - 8,770	11/11	0/11
Arsenic	<0.47 - <0.65	0.6	0.62 - 1.3	2/11	2/2
Barium	<4.0 - 10.9	12	3.7 - 18.2	11/11	1/11
Beryllium	<0.05 - <0.23	0.2	0.24 - 0.26	2/11	2/2
Calcium	<10.7 - 81.3	1,508	58.3 - 21,700	11/11	3/11
Chromium	<3.2 - 8.7	8.7	2.4 - 15.1	10/11	2/10
Cobalt	<0.35 - <1.9	1.6	2.4 - 3.2	2/11	2/2
Copper	<0.47 - 1.2	1.6	0.73 - 4.6	5/11	1/5
Iron	126 - 2,840	1,778	324 - 2,560	11/11	1/11
Lead	1.2 - 6.1	9.1	2.9 - 82.1	11/11	2/11
Magnesium	<25.4 - 260	231	81 - 484	10/11	1/10
Manganese	1.2 - 5.2	6.2	2.2 - 12.5	10/11	3/10
Mercury	<0.02 - <0.11	0.1	ND - 0.22	1/11	1/1
Potassium	<81.6 - 187	223	50.5 - 288	11/11	1/11
Sodium	<14.5 - <44.9	41	15.5 - 51.6	11/11	4/11
Vanadium	<1.5 - 13.4	10	3 - 8.6	11/11	0/11
Zinc	<0.19 - 11.6	5.6	1.9 - 29.1	6/11	3/6

Notes: Concentrations expressed in milligram per kilogram (mg/kg).
ND - Not Detected
(1) Soil background concentrations are based on reference background soil samples from samples taken for Site 2 previous investigations at Camp Lejeune.

TABLE 6-7

COMPARISON OF INORGANIC SOIL CONCENTRATIONS TO RISK-BASED CONCENTRATIONS
LAWN AND MIXING PAD AREAS - SUBSURFACE SOIL
REMEDIAL INVESTIGATION CTO-0174
MCB CAMP LEJEUNE, NORTH CAROLINA

Inorganic	Maximum Detected Concentration (mg/kg)	Risk-Based Concentration(1) (mg/kg)	Maximum Detected(2) Value Exceeded Risk-Based Concentration
Arsenic	1.3	0.97	Y
Barium	18.2	550	N
Beryllium	0.26	0.4	N
Chromium	15.1	39(3)	N
Cobalt	3.2	--(4)	--
Copper	4.6	290	N
Lead	82.1	500 - 1,000(5)	N
Manganese	12.5	780	N
Mercury	0.22	2.3	N
Zinc	29.1	2,300	N

Notes: Concentrations expressed in milligram per kilogram (mg/kg).

(1) USEPA, 1993. Selecting Exposure Routes and Contaminants of Concern by Risk-Based Screening.

(2) Y/N (yes/no), denotes maximum detected value exceeded risk-based concentration.

(3) Chromium $+6$

(4) (--) Value not available.

(5) USEPA, 1990. "Interim Guidance on Establishing Soil Lead Cleanup Levels at Superfund Sites."

TABLE 6-8

SUMMARY OF SITE 2 ORGANIC ANALYTICAL DATA
FORMER STORAGE AREA - SURFACE SOIL
REMEDIAL INVESTIGATION CTO-0174
MCB CAMP LEJEUNE, NORTH CAROLINA

Organic Chemical	Range of Positive Detections (µg/kg)	No. of Positive Detects/ No. of Samples
Volatiles		
Toluene	ND - 5	1/5
Xylene (total)	ND - 8	1/5
Pesticides		
4,4'-DDD	30 - 1,200	4/5
4,4'-DDE	76 - 230	4/5
4,4'-DDT	4.7 - 9,400	5/5

Notes: Concentrations expressed in microgram per kilogram (µg/kg).
ND - Not Detected

TABLE 6-9

SUMMARY OF SITE 2 INORGANIC ANALYTICAL DATA
FORMER STORAGE AREA - SURFACE SOIL
REMEDIAL INVESTIGATION CTO-0174
MCB CAMP LEJEUNE, NORTH CAROLINA

Inorganic	Surface Soil (0-6 inches)				
	Base-Specific Background Concentration Range(1)	Twice the Base-Specific Average Concentration	Range of Positive Detections	No. of Positive Detects/ No. of Samples	No. of Times Exceeded Background/ No. of Times Detected
Aluminum	<90.5 - 1,490	1,459	4,900 - 8,590	5/5	5/5
Arsenic	<0.44 - 0.91	0.8	0.69 - 0.86	3/5	1/3
Barium	3.5 - 16.5	13	9.7 - 14	5/5	1/5
Beryllium	<0.06 - <0.22	0.1	0.23 - 0.24	3/5	3/3
Calcium	108 - 10,700	4,932	551 - 108,000	5/5	3/5
Chromium	<0.06 - <3.2	2	6.6 - 9.8	5/5	5/5
Copper	<1.1 - 3.1	2.8	0.47 - 8.2	5/5	1/5
Iron	160 - 1,020	1,051	1,760 - 2,980	5/5	5/5
Lead	2.0 - 20.4	45	5.6 - 10.4	5/5	0/5
Magnesium	<20.2 - 200	146	242 - 1,830	5/5	5/5
Manganese	<2.0 - 11.1	14	5.9 - 20.4	5/5	3/5
Mercury	<0.02 - <0.12	0.1	0.34 - 0.44	3/5	3/3
Potassium	54.5 - 102	104	195 - 364	5/5	5/5
Selenium	<0.31 - <1.0	0.9	0.27 - 0.49	3/5	0/3
Silver	<0.37 - 62	1.1	0.71	1/5	0/1
Sodium	<9.4 - 67.5	49	38.1 - 238	5/5	4/5
Vanadium	<2.1 - 5.3	4.6	8.5 - 11.2	5/5	5/5
Zinc	<1.1 - 28.3	23	7.5 - 51.9	4/5	1/4

Notes: Concentrations expressed in milligram per kilogram (mg/kg).

(1) Soil background concentrations are based on reference background soil samples from samples taken for Site 2 and previous investigations at Camp Lejeune.

TABLE 6-10

COMPARISON OF INORGANIC SOIL CONCENTRATIONS TO RISK-BASED CONCENTRATIONS
FORMER STORAGE AREA - SURFACE SOIL
REMEDIAL INVESTIGATION CTO-0174
MCB CAMP LEJEUNE, NORTH CAROLINA

Inorganic	Maximum Detected Concentration (mg/kg)	Risk-Based Concentration(1) (mg/kg)	Maximum Detected(2) Value Exceeded Risk-Based Concentration
Aluminum	8,590	23,000	N
Arsenic	0.86	0.97	N
Barium	14	550	N
Beryllium	0.24	0.4	N
Chromium	9.8	39(3)	N
Copper	8.2	290	N
Manganese	20.4	780	N
Mercury	0.44	2.3	N
Vanadium	11.2	55	N
Zinc	51.9	2,300	N

Notes: Concentrations expressed in milligram per kilogram (mg/kg).

(1) USEPA, 1993. Selecting Exposure Routes and Contaminants of Concern by Risk-Based Screening.

(2) Y/N (yes/no), denotes maximum detected value exceeded risk-based concentration.

(3) Chromium $^{+6}$

TABLE 6-11

SUMMARY OF SITE 2 ORGANIC ANALYTICAL DATA FORMER STORAGE AREA - SUBSURFACE SOIL REMEDIAL INVESTIGATION CTO-0174 MCB CAMP LEJEUNE, NORTH CAROLINA

Organic Chemical	Range of Positive Detections (µg/kg)	No. of Positive Detects/ No. of Samples
Volatiles		
Xylene (total)*	4 - 5	2/12
Pesticides		
4,4'-DDD	11 - 1,000	6/11
4,4'-DDE	6 - 31	2/11
4,4'-DDT	6 - 1,500	6/11
BTEX		
Toluene	ND - 9.1	1/9
Ethylbenzene	ND - 9.1	1/9
o-Xylene*	ND - 10.3	1/9
m- and p-Xylene*	ND - 14.2	1/9

Notes: Concentrations expressed in microgram per kilogram (µg/kg).
ND - Not Detected

* Xylene was analyzed for by the Contract Laboratory Program for organics and by USEPA Method 602. o-Xylene and m- and p-xylene were combined to get a total xylene concentration of 24.5 mg/kg.

TABLE 6-12

SUMMARY OF SITE 2 INORGANIC ANALYTICAL DATA
FORMER STORAGE AREA - SUBSURFACE SOIL
REMEDIAL INVESTIGATION CTO-0174
MCB CAMP LEJEUNE, NORTH CAROLINA

Inorganic	Subsurface Soil (6 inches and below)				
	Base-Specific Background Concentration Range(1)	Twice the Base-Specific Maximum Concentration	Range of Positive Detections	No. of Positive Detects/ No. of Samples	No. of Times Exceeded Background/ No. of Times Detected
Aluminum	672 - 10,200	8,946	1,060 - 17,600	11/11	7/11
Arsenic	<0.47 - <0.65	0.6	0.52 - 1.7	7/11	6/7
Barium	<4.0 - 10.9	12	5.4 - 17.8	11/11	5/11
Beryllium	<0.05 - <0.23	0.2	0.24 - 0.25	3/11	3/3
Cadmium	<0.34 - <1.2	1	1.6	1/11	1/1
Calcium	<10.7 - 81.3	1,508	24.1 - 246,000	11/11	1/11
Chromium	<3.2 - 8.7	8.7	5.2 - 16.6	11/11	2/11
Cobalt	<0.35 - <1.9	1.6	2.5	1/11	1/1
Copper	<0.47 - 1.2	1.6	0.49 - 4.2	8/11	5/8
Iron	126 - 2,840	1,778	998 - 7,240	11/11	7/11
Lead	1.2 - 6.1	9.1	1.2 - 8	11/11	0/11
Magnesium	<25.4 - 260	231	85.7 - 3,860	11/11	8/11
Manganese	1.2 - 5.2	6.2	2.5 - 24.1	11/11	6/11
Mercury	<0.02 - <0.11	0.1	0.22 - 0.39	7/11	7/7
Potassium	<81.6 - 187	223	67.5 - 772	11/11	7/11
Selenium	0.23 - <1.0	0.8	0.29 - 0.63	3/11	0/3
Sodium	<14.5 - <44.9	41	26.6 - 1,030	11/11	5/11
Vanadium	<1.5 - 13.4	10	4.2 - 25.7	11/11	9/11
Zinc	<0.19 - 11.6	5.6	2.5 - 12.6	4/11	1/4

Notes: Concentrations expressed in milligram per kilogram (mg/kg).

(1) Soil background concentrations are based on reference background soil samples from samples taken for Site 2 and previous investigations at Camp Lejeune.

TABLE 6-13

COMPARISON OF INORGANIC SOIL CONCENTRATIONS TO RISK-BASED CONCENTRATIONS
FORMER STORAGE AREA - SUBSURFACE SOIL
REMEDIAL INVESTIGATION CTO-0174
MCB CAMP LEJEUNE, NORTH CAROLINA

Inorganic	Maximum Detected Concentration (mg/kg)	Risk-Based Concentration(1) (mg/kg)	Maximum Detected(2) Value Exceeded Risk-Based Concentration
Aluminum	17,600	23,000	N
Arsenic	1.7	0.97	Y
Barium	17.8	550	N
Beryllium	0.25	0.4	N
Cadmium	1.6	3.9	N
Chromium	16.6	39(3)	N
Cobalt	2.5	--	--
Copper	4.2	290	N
Manganese	24.1	780	N
Mercury	0.39	2.3	N
Vanadium	25.7	55	N
Zinc	12.6	2,300	N

Notes: Concentrations expressed in milligram per kilogram (mg/kg).
(1) USEPA, 1993. Selecting Exposure Routes and Contaminants of Concern by Risk-Based Screening.
(2) Y/N (yes/no), denotes maximum detected value exceeded risk-based concentration.
(3) Chromium $^{+6}$

TABLE 6-14

COMPARISON OF SITE 2 GROUNDWATER ANALYTICAL RESULTS TO STANDARDS AND CRITERIA
REMEDIAL INVESTIGATION CTO-0174
MCB CAMP LEJEUNE, NORTH CAROLINA

Chemical	Contaminant Frequency/Range			Groundwater Standards and Criteria				Comparison to Standards and Criteria			
	No. of Positive Detects/ No. of Samples	Range of Positive Detections	Background 2-GW09-01	NCWQS (1) (µg/L)	MCLs/ MCLGs (2) (µg/L)	HAs (3) (µg/L)	RBCs (4) (µg/L)	No. of Positive Detects Above NCWQS	No. of Positive Detects Above MCLs/ MCLGs	No. of Positive Detects Above HAs	No. of Positive Detects Above RBCs
Volatile Organics											
Ethylbenzene	2/9	2-190	ND	29	700	700	130	1/2	0/2	0/2	1/2
Trichloroethene	1/9	ND-5	ND	2.8	5/0	300	2.1	1/1	0/1 (6)	0/1	1/1
Xylene (total)	3/9	1-1800	ND	530	10,000	10,000	1,200	1/3	0/3	0/3	1/3
Semivolatile Organics											
Acenaphthene	1/8	ND-2	ND	--	--	--	220	--	--	--	0/1
2,4-Dimethylphenol	1/8	ND-6	ND	--	--	--	73	--	--	--	0/1
2-Methylnaphthalene	2/8	3-17	ND	--	--	--	150 (5)	--	--	--	0/2
Naphthalene	2/8	2-15	ND	--	--	20	150	--	--	0/2	0/2
Phenol	1/8	ND-3	ND	--	--	400	2,200	--	--	0/2	0/1
Pesticides											
4,4'-DDD	1/9	ND-4	0.73	--	--	--	0.35	--	--	--	1/1
4,4'-DDT	1/9	ND-10	1.6	--	--	--	0.25	--	--	--	1/1

Notes: All concentrations expressed in microgram per liter (µg/L).
-- = Not Available or Not Applicable
(1) NCWQS - North Carolina Water Quality Standards for Groundwater
(2) MCL - Maximum Contaminant Level. Lead and copper standards are an action level.
(3) HA - Lifetime health advisories for 70 kg adult (value for trichloroethene, arsenic, and beryllium is for the 10^{-4} cancer risk).
(4) USEPA, Region III, October 1993.
(5) Value is the value for naphthalene.
(6) Trichloroethene equaled the MCL.
(7) Value is for chromium $^{+6}$.
(8) Secondary MCL.
(9) Chromium $^{+6}$ value equaled the RBC.

TABLE 6- ontinued)

COMPARISON OF SITE 2 GROUNDWATER ANALYTICAL RESULTS TO STANDARDS AND CRITERIA
REMEDIAL INVESTIGATION CTO-0174
MCB CAMP LEJEUNE, NORTH CAROLINA

Chemical	Contaminant Frequency/Range			Groundwater Standards and Criteria				Comparison to Standards and Criteria			
	No. of Positive Detects/ No. of Samples	Range of Positive Detections	Background 2-GW09-01	NCWQS (1) (µg/L)	MCLs/ MCLGs (2) (µg/L)	HAs (3) (µg/L)	RBCs (4) (µg/L)	No. of Positive Detects Above NCWQS	No. of Positive Detects Above MCLs/ MCLGs	No. of Positive Detects Above HAs	No. of Positive Detects Above RBCs
Inorganics											
Aluminum	8/8	269-36,000	56,300	--	50-200 (8)	--	11,000	--	8/8(8)	--	8
Arsenic	7/8	2.2-23.6	12.9	50	50	2	0.049	0/7	0/7	7/7	7/7
Barium	8/8	46-1,420	328	2,000	2,000	2,000	260	0/8	0/8	0/8	1/8
Beryllium	2/8	1-2	3	--	4	0.8	0.02	--	0/2	2/2	2/2
Cadmium	1/8	7	ND	5	5	5	1.8	1/1	1/1	1/1	1/1
Chromium	5/8	11-18	75	50	100	100	18 (7)	0/5	0/5	0/5	0/5 (9)
Cobalt	2/8	10-12	10	--	--	--	1	--	--	--	0/2
Copper	8/8	3-10	25	1,000	1,300	--	140	0/8	0/8	--	0/8
Lead	5/8	2.7-15.5	27.2	15	15	--	--	1/5	1/5	--	--
Manganese	7/8	21-79	290	50	50 (8)	--	370	4/7	--	--	0/7
Selenium	1/8	4.2	ND	50	50	--	18	0/1	0/1	--	0/1
Vanadium	7/8	9-89	86	--	--	--	26	--	--	--	2/7
Zinc	8/8	6-146	103	2,100	--	200	1,100	0/8	--	0/8	0/8

Notes: All concentrations expressed in microgram per liter (µg/L).

-- = Not Available or Not Applicable

(1) NCWQS - North Carolina Water Quality Standards for Groundwater

(2) MCL - Maximum Contaminant Level. Lead and copper standards are an action level.

(3) HA - Lifetime health advisories for 70 kg adult (value for trichloroethene, arsenic, and beryllium is for the 10^{-4} cancer risk).

(4) USEPA, Region III, October 1993.

(5) Value is the value for naphthalene.

(6) Trichloroethene equaled the MCL.

(7) Value is for chromium $^{+6}$.

(8) Secondary MCL.

(9) Chromium $^{+6}$ value equaled the RBC.

TABLE 6-15

COMPARISON OF RAILROAD TRACK DRAINAGE DITCH SURFACE WATER ANALYTICAL DATA TO STATE STANDARDS AND FEDERAL CRITERIA
REMEDIAL INVESTIGATION CTO-0174
MCB CAMP LEJEUNE, NORTH CAROLINA

Parameter	Contaminant Frequency/Range		Comparison to Standards and Criteria			
	No. of Positive Detects/ No. of Samples	Range of Positive Detections (µg/L)	NCWQS(1) (µg/L)	AWQCs(2) (µg/L)	No. of Positive Detects above NCWQS	No. of Positive Detects above AWQCs
Pesticides						
4,4'-DDD	4/7	0.11 - 1.9	NA	8.3×10^{-4}(3)	--	4/4
4,4'-DDT	2/7	0.74 - 0.94	5.88E-4	2.4E-5	2/2	2/2
Inorganics						
Arsenic	1/1	3.3	NA	2.2E-3	--	1/1
Barium	1/1	85	100	1,000	0/1	0/1
Beryllium	1/1	1.0	6.8E-3	3.7×10^{-2}(4)	1/1	1/1
Chromium	1/1	14	NA	1.7×10^{5}(4)	--	0/1
Copper	1/1	31	NA	1,300(4)	--	0/1
Lead	1/1	23.4	NA	50(4)	--	0/1
Manganese	1/1	58	200	50	0/1	1/1
Vanadium	1/1	15	NA	NA	--	--
Zinc	1/1	418	NA	NA	--	--

Notes: Concentrations expressed in microgram per liter (µg/L).
NA - Not Available
(1) NCWQS - North Carolina Water Quality Standard for Freshwater (human health)
(2) AWQCs - Federal Ambient Water Quality Standards (human health, water and organisms)
(3) Recalculated using IRIS, 1990.
(4) Value withdrawn (Federal Register, December 1992).

TABLE 6-16

COMPARISON OF OVERS CREEK SURFACE WATER ANALYTICAL DATA TO STATE STANDARDS AND FEDERAL CRITERIA REMEDIAL INVESTIGATION CTO-0174 MCB CAMP LEJEUNE, NORTH CAROLINA

Parameter	Contaminant Frequency/Range		Comparison to Criteria			
	No. of Positive Detects/ No. of Samples	Maximum Positive Detection (µg/L)	NCWQS (1) (µg/L)	AWQCs (2) (µg/L)	No. of Positive Detects above NCWQS	No. of Positive Detects above AWQCs
Inorganics						
Barium	2/2	25	NA	1,000	--	0/2
Copper	2/2	7	NA	1,300(3)	--	0/2
Manganese	2/2	24	NA	50	--	0/2

Notes: Concentrations expressed in microgram per liter (µg/L).
NA - Not Applicable, no standard promulgated
(1) NCWQS - North Carolina Water Quality Standard for Tidal Saltwaters (human health)
(2) AWQCs - Federal Ambient Water Quality Standards (human health, water and organisms)
(3) Value is calculated using IRIS (USEPA, 1990).

TABLE 6-17

BACKGROUND SOIL CONCENTRATIONS OF POLYCYCLIC AROMATIC HYDROCARBONS (PAHs)
REMEDIAL INVESTIGATION CTO-0174
MCB CAMP LEJEUNE, NORTH CAROLINA

Chemical	Rural Soil Range (µg/kg)	Urban Soil Range (µg/kg)
Anthracene	11 - 13(1)	NA
Benzo(a)anthracene	5 - 20	169 - 59,000
Benzo(b)fluoranthene	20 - 30	15,000 - 62,000
Benzo(a)pyrene	2 - 1,300	165 - 220
Benzo(k)fluoranthene	10 - 110	300 - 26,000
Chrysene	38.3	251 - 640
Fluoranthene	0.3 - 40	200 - 166,000
Fluorene	9.7(1)	NA
Phenanthrene	30	NA
Pyrene	1 - 19.7	145 - 147,000

Notes: Concentrations expressed in microgram per kilogram (µg/kg).
(1) Value is for agricultural soil.
NA = Not Available

Reference: Agency for Toxic Substances and Disease Registry Toxicological Profile for Polynuclear Aromatic Hydrocarbons, Draft, 1990.

TABLE 6-18

SUMMARY OF SITE 2 SHALLOW SEDIMENT INORGANIC ANALYTICAL DATA
RAILROAD TRACK DRAINAGE DITCHES
REMEDIAL INVESTIGATION CTO-0174
MCB CAMP LEJEUNE, NORTH CAROLINA

Parameter	Maximum Detected Concentration (mg/kg)	Twice the Average Background Concentration (mg/kg)	RBC(1) (mg/kg)	Exceeded Background(2)	Exceeded RBC(2)
Aluminum	5,500	4,620	23,000	Y	N
Arsenic	1.4	1.36	0.97	Y	Y
Barium	28.5	11.4	550	Y	N
Beryllium	0.25	ND	0.4	Y	N
Chromium	6.5	6.9	39(3)	N	N
Copper	6.6	2.3	290	Y	N
Lead	51.4	12	500(4)	Y	N
Manganese	32.3	12.5	780	Y	N
Selenium	0.38	ND	39	Y	N
Vanadium	11.5	6.6	55	Y	N
Zinc	120	21.3	2,300	Y	N

Notes: Units in milligram per kilogram.

(1) USEPA, 1993. Selecting Exposure Routes and Contaminants of Concern by Risk-Based Screening.

(2) Y/N (yes/no), denotes maximum detected value exceeded risk-based concentration.

(3) Chromium $^{+6}$

(4) USEPA, 1990. "Interim Guidance on Establishing Soil Lead Cleanup Levels at Superfund Sites."

TABLE 6-19

SUMMARY OF OVERS CREEK SHALLOW SEDIMENT INORGANIC ANALYTICAL DATA
REMEDIAL INVESTIGATION CTO-0174
MCB CAMP LEJEUNE, NORTH CAROLINA

Parameter	Maximum Detected Concentration (mg/kg)	Twice the Average Background Concentration (mg/kg)	RBC(1) (mg/kg)	Exceeded Background(2)	Exceeded RBC(2)
Aluminum	8,680	4,620	23,000	Y	N
Arsenic	0.79	1.36	0.97	Y	Y
Barium	114	11.4	550	Y	N
Beryllium	0.85	ND	0.4	Y	Y
Chromium	9.9	6.9	39(3)	Y	N
Copper	6.4	2.3	290	Y	N
Lead	8.8	12	500(4)	Y	N
Manganese	203	12.5	780	Y	N
Selenium	1.7	ND	39	Y	N
Thallium	0.31	ND	--	Y	--
Vanadium	6.8	6.6	55	Y	N
Zinc	69	21.3	2,300	Y	N

Notes: Units in milligram per kilogram.

(1) USEPA, 1993. Selecting Exposure Routes and Contaminants of Concern by Risk-Based Screening.

(2) Y/N (yes/no), denotes maximum detected value exceeded risk-based concentration.

(3) Chromium+6

(4) USEPA, 1990. "Interim Guidance on Establishing Soil Lead Cleanup Levels at Superfund Sites."

TABLE 6-20

SUMMARY TABLE OF CHEMICALS OF POTENTIAL CONCERN FOR OPERABLE UNIT NO. 5, SITE 2
REMEDIAL INVESTIGATION CTO-0174
MCB CAMP LEJEUNE, NORTH CAROLINA

Chemical of Potential Concern	Lawn and Mixing Pad Areas		Lawn and Mixing Pad Areas Time-Critical Removal Action		Former Storage Area		Former Storage Area Time-Critical Removal Action	
	Surface Soil	Subsurface Soil	Surface Soil	Subsurface Soil	Surface Soil	Subsurface Soil	Surface Soil	Subsurface Soil
Volatile Organics								
Ethylbenzene						X		X
Toluene					X	X	X	X
Xylene (total)	X	X	X	X	X	X	X	X
Semivolatile Organics								
Acenaphthene		X						
Anthracene		X						
Fluoranthene		X						
Fluorene		X						
2-Methylnaphthalene		X						
Naphthalene		X						
N-Nitrosodiphenylamine		X						
Phenanthrene		X						
Pyrene		X						
Pesticides								
alpha-Chlordane	X	X	X	X				
gamma-Chlordane	X	X	X	X				
4,4'-DDD	X	X	X	X	X	X	X	X
4,4'-DDE	X	X	X	X	X	X	X	X
4,4'-DDT	X	X	X	X	X	X	X	X
Dieldrin	X							
Heptachlor	X	X						
Inorganics								
Arsenic	X	X	X			X		X

TABLE 6-20 (Continued)

SUMMARY TABLE OF CHEMICALS OF POTENTIAL CONCERN FOR OPERABLE UNIT NO. 5, SITE 2
REMEDIAL INVESTIGATION CTO-0174
MCB CAMP LEJEUNE, NORTH CAROLINA

Chemical of Potential Concern	Groundwater	Surface Water Drainage Ditches	Sediment Railroad Drainage Ditches	Sediment Time-Critical Removal Action Railroad Drainage Ditches	Sediment Overs Creek
Volatile Organics					
Ethylbenzene	X		X		
Trichloroethene	X				
Xylene (total)	X		X		
Semivolatile Organics					
Acenaphthene	X				
2-Methylnapthalene	X		X		
2,4-Dimethylphenol	X				
Naphthalene	X		X		
Phenol	X				
Pesticides					
alpha-Chlordane			X	X	
gamma-Chlordane			X	X	
4,4'-DDD	X	X	X	X	X
4,4'-DDE			X	X	X
4,4'-DDT	X	X	X	X	X
Dieldrin			X	X	
Endofulfan II			X		
Inorganics					
Arsenic	X	X	X		X
Barium	X				
Beryllium	X	X			
Lead	X				
Vanadium	X				

Note: X = denotes chemical was retained as a chemical of potential concern

TABLE 6-21

POTENTIAL EXPOSURE PATHWAY SUMMARY AND SELECTION RATIONALE FOR CURRENT SCENARIOS
FOR OPERABLE UNIT NO. 5, SITE 2
REMEDIAL INVESTIGATION CTO-0174
MCB CAMP LEJEUNE, NORTH CAROLINA

Receptors	Exposure Route	Selected Pathway for Evaluation?	Reason for Selection or Exclusion
Civilian Base Personnel	Ingestion of on-site groundwater	No	Wells on site are not used as a drinking water source; potable water is supplied by the municipal water authority.
	Inhalation with volatile constituents while showering/bathing	No	Wells on site are not used as a drinking water source; potable water is supplied by the municipal water authority.
	Dermal contact with groundwater	No	Wells on site are not used as a drinking water source; potable water is supplied by the municipal water authority.
	Ingestion of and dermal contact with soil while working on site	Yes	Contaminated soil is in an area accessible to employees during routine maintenance duties.
	Inhalation of fugitive dusts from the soil while working on site	Yes	The lawn and mixing pad areas are partially grass-covered, and particulate emissions are possible due to wind erosion and lawn maintenance.
	Ingestion of and dermal contact with surface water while working on site	Yes	Surface water is accessible to Base personnel during routine maintenance activities.
	Ingestion of and dermal contact with sediments while working on site	Yes	Sediment is accessible to Base personnel during routine maintenance activities.
Construction Workers	Ingestion of on-site groundwater wells	No	For a future construction scenario, it would be unlikely that potable well would be installed during construction phase.
	Inhalation of volatile constituents while showering in residences	No	For a future construction scenario, it would be unlikely that potable well would be installed during construction phase.
	Dermal contact with groundwater during showering	No	For a future construction scenario, it would be unlikely that potable well would be installed during construction phase.
	Ingestion of and dermal contact with on-site subsurface soils during construction	Yes	Contaminated soil would be accessible to construction workers in lawn and mixing pad area, and former storage area.
	Inhalation of fugitive dusts emanating from on-site subsurface soils	Yes	Subsurface soil fugitive emissions could occur at Site 2 during the excavation phase of construction.
	Ingestion of and dermal contact with surface waters and sediments	No	It appears unlikely that construction workers would have to come into contact with surface water or sediment during construction.

TABLE 6-21 (Continued)

POTENTIAL EXPOSURE PATHWAY SUMMARY AND SELECTION RATIONALE FOR CURRENT SCENARIOS
FOR OPERABLE UNIT NO. 5, SITE 2
REMEDIAL INVESTIGATION CTO-0174
MCB CAMP LEJEUNE, NORTH CAROLINA

Receptors	Exposure Route	Selected Pathway for Evaluation?	Reason for Selection or Exclusion
Trespassing Older Children	Ingestion of on-site groundwater	No	Media not evaluated at Overs Creek.
	Inhalation of volatile constituents while showering	No	Media not evaluated at Overs Creek.
	Dermal contact with groundwater while showering/bathing	No	Media not evaluated at Overs Creek.
	Ingestion of and dermal contact with on-site soils	No	Media not evaluated at Overs Creek.
	Inhalation of fugitive dusts emanating from on-site soils	No	Media not evaluated at Overs Creek.
	Ingestion of and dermal contact with surface waters and sediments	Yes	Trespassing child could contact surface water and sediment while trespassing.
Trespassing Adult	Ingestion of on-site groundwater	No	Media not evaluated at Overs Creek.
	Inhalation of volatile constituents while showering	No	Media not evaluated at Overs Creek.
	Dermal contact with groundwater while showering/bathing	No	Media not evaluated at Overs Creek.
	Ingestion of and dermal contact with on-site soils	No	Media not evaluated at Overs Creek.
	Inhalation of fugitive dusts emanating from on-site soils	No	Media not evaluated at Overs Creek.
	Ingestion of and dermal contact with surface waters and sediments	Yes	Trespassing adult could contact surface water and sediment while trespassing.

TABLE 6-22

POTENTIAL EXPOSURE PATHWAY SUMMARY AND SELECTION RATIONALE FOR FUTURE SCENARIOS
FOR OPERABLE UNIT NO. 5, SITE 2
REMEDIAL INVESTIGATION CTO-0174
MCB CAMP LEJEUNE, NORTH CAROLINA

Receptors	Exposure Route	Selected Pathway for Evaluation?	Reason for Selection or Exclusion
Future Resident Children	Ingestion of on-site groundwater	Yes	Although use of groundwater is highly unlikely, groundwater could be used as a potable source in the future.
	Inhalation of volatile constituents while showering	Yes	Although use of groundwater is highly unlikely, groundwater could be used as a potable source in the future.
	Dermal contact with groundwater while showering/bathing	Yes	Although use of groundwater is highly unlikely, groundwater could be used as a potable source in the future.
	Ingestion of and dermal contact with on-site soils	Yes	Future residential children could contact soils during recreational activities.
	Inhalation of fugitive dusts emanating from on-site soils	Yes	If it is assumed that residential development would not entail landscapting which would limit the potential for dust emissions, then particulate emissions are possible due to wind erosion and lawn maintenance.
	Ingestion of and dermal contact with surface waters and sediments	Yes	Residential children could contact surface waters and sediments during recreational activities.
Future Resident Adult	Ingestion of on-site groundwater	Yes	Although use of groundwater is highly unlikely, groundwater could be used as a potable source in the future.
	Inhalation of volatile constituents while showering	Yes	Although use of groundwater is highly unlikely, groundwater could be used as a potable source in the future.
	Dermal contact with groundwater while showering/bathing	Yes	Although use of groundwater is highly unlikely, groundwater could be used as a potable source in the future.
	Ingestion of and dermal contact with on-site soils	Yes	Future residential adults could contact soils during maintenance and gardening activities.
	Inhalation of fugitive dusts emanating from on-site soils	Yes	If it is assumed that residential development would not entail landscapting which would limit the potential for dust emissions, then particulate emissions are possible due to wind erosion and lawn maintenance.
	Ingestion of and dermal contact with surface waters and sediments	Yes	Residential adults could contact surface water and sediment during recreational or maintenance activities.

TABLE 6-23

EXPOSURE ASSESSMENT SUMMARY
INCIDENTAL INGESTION AND DERMAL CONTACT OF SURFACE AND SUBSURFACE SOIL
REMEDIAL INVESTIGATION CTO-0174
MCB CAMP LEJEUNE, NORTH CAROLINA

Current Scenarios - Civilian Base Personnel; Future Scenarios - Residential Children and Adults and Construction Workers			
Input Parameter	Description	Value	Reference
ABS	Absorption Factor (dimensionless)	Organics 0.01 Inorganics 0.001	USEPA, Region IV, February 1992
AF	Soil-to-Skin Adherence Factor	1.0 mg/cm^2	USEPA, Region IV, February 1992
AT$_c$	Averaging Time Carcinogen	All 25,550 days	USEPA, December 1989
AT$_{nc}$	Averaging Time Noncarcinogen	Base Personnel 9,125 days Construction 365 days Child 2,190 days Adult 10,950 days	USEPA, December 1989
BW	Body Weight	Base Personnel 70 kg Construction Worker 70 kg Child 15 kg Adult 70 kg	USEPA, December 1989
C	Exposure Concentration	UCL mg/kg	USEPA, May 1992
CF	Conversion Factor	10E-6 kg/mg	USEPA, December 1989
ED	Exposure Duration	Base Personnel 25 years Construction Worker 1 year Child 6 years Adult 30 years	USEPA, March 1991 USEPA, December 1989
EF	Exposure Frequency	Base Personnel 32 days/yr Construction Worker 30 days/yr* Child 350 days/yr Adult 350 days/yr	USEPA, December 1989

Notes: Construction workers evaluated for subsurface soil exposure only, all other receptors evaluated for surface soil exposures.
mg/day = milligrams per day
days/yr = days per year
kg = kilogram
cm^2 = square centimeters

* Professional Judgement

TABLE 6-23 (Continued)

EXPOSURE ASSESSMENT SUMMARY
INCIDENTAL INGESTION AND DERMAL CONTACT OF SURFACE AND SUBSURFACE SOIL
REMEDIAL INVESTIGATION CTO-0174
MCB CAMP LEJEUNE, NORTH CAROLINA

Current Scenarios - Civilian Base Personnel; Future Scenarios - Residential Children and Adults and Construction Workers				
Input Parameter	Description	Value		Reference
Fi	Fraction Ingested from Contaminated Source		100%	
IR	Ingestion Rate	Base Personnel Construction Worker Child Adult	50 mg/day 480 mg/day 200 mg/day 100 mg/day	USEPA, December 1989 USEPA, March 1991
SA	Exposed Surface Area of Skin Available for Contact	Base Personnel Construction Worker Child Adult	5,900 cm^2 5,900 cm^2 2,600 cm^2 5,900 cm^2	USEPA, January 1992

Notes: Construction workers evaluated for subsurface soil exposure only, all other receptors evaluated for surface soil exposures.
mg/day = milligrams per day
days/yr = days per year
kg = kilogram
cm^2 = square centimeters
* Professional Judgement

TABLE 6-24

EXPOSURE ASSESSMENT SUMMARY
INHALATION OF PARTICULATE EMISSIONS FROM SOIL
REMEDIAL INVESTIGATION CTO-0174
MCB CAMP LEJEUNE, NORTH CAROLINA

Current Scenarios - Civilian Base Personnel Future Scenarios - Construction Workers and Residential Child and Adult				
Input Parameter	Description	Value		Reference
AT_c	Averaging Time Carcinogen	All	25,550 days	USEPA, December 1989
AT_{nc}	Averaging Time Noncarcinogen	Base Personnel	9,125 days	USEPA, December 1989
		Construction Worker	365 days	
		Child	2,190 days	
		Adult	10,950 days	
BW	Body Weight	Base Personnel	70 kg	USEPA, December 1989
		Construction Worker	70 kg	
		Child	15 kg	
		Adult	70 kg	
ED	Exposure Duration	Base Personnel	25 years	USEPA, March 1991
		Construction Worker	1 year	
		Child	6 years	
		Adult	30 years	
EF	Exposure Frequency	Base Personnel	32 days/yr	Site Specific
		Construction Worker	30 days/yr*	USEPA, December 1989
		Child	350 days	
		Adult	350 days	
IR	Inhalation Rate	Base Personnel	4.8 m^3/hr	USEPA, December 1989
		Construction Worker	4.8 m^3/hr	
		Child	2 m^3/hr	
		Adult	2.5 m^3/hr	
PEF	Particulate Emissions Factor	8E+6	mg/m^3	USEPA, May 1992

Notes: kg = kilogram
days/yr = days per year
m^3/hr = cubic meters per hour
mg/m^3 = milligrams per cubic meters

*Professional judgement

TABLE 6-25

EXPOSURE ASSESSMENT SUMMARY
INGESTION, DERMAL CONTACT, AND INHALATION OF GROUNDWATER
REMEDIAL INVESTIGATION CTO-0174
MCB CAMP LEJEUNE, NORTH CAROLINA

Future Scenarios - Residential Child and Adult				
Input Parameter	Description	Value		Reference
AT_c	Averaging Time Carcinogen	All	25,550 days	USEPA, December 1989
AT_{nc}	Averaging Time Noncarcinogen	Child	2,190 days	USEPA, December 1989
		Adult	10,950 days	
BW	Body Weight	Child	15 kg	USEPA, December 1989
		Adult	70 kg	
C	Exposure Concentration	UCL	mg/L	USEPA, May 1992
ED	Exposure Duration	Child	6 years	USEPA, March 1991
		Adult	30 years	
EF	Exposure Frequency	Child	350 days/yr	USEPA, December 1989
		Adult	350 days/yr	
ET	Exposure Time	All	0.25 hr/day	USEPA, January 1992
IR	Ingestion Rate	Child	1 L/day	USEPA, December 1989
	or	Adult	2 L/day	
	Inhalation Rate	Child/Adult	0.6 m^3/hr	
PC	Permeability Constant	Chemical Specific		USEPA, January 1992
SA	Exposed Surface Area of Skin Available for Contact	Child	8,500 cm^2	USEPA, January 1992
		Adult	22,800 cm^2	

Notes: L/day = liters per day
days/yr = days per year
kg = kilogram
cm^2 = square centimeters
hr/day = hour per day
mg/L = milligrams per liter
m^3/hr = meters cubed per hour

TABLE 6-26

EXPOSURE ASSESSMENT SUMMARY
INCIDENTAL INGESTION AND DERMAL CONTACT OF SURFACE WATER
REMEDIAL INVESTIGATION CTO-0174
MCB CAMP LEJEUNE, NORTH CAROLINA

Future Scenarios - Residential Child and Adult; Current Scenarios - Civilian Base Personnel

Input Parameter	Description	Value		Reference
AT_c	Averaging Time Carcinogen	All	25,550 days	USEPA, December 1989
AT_{nc}	Averaging Time Noncarcinogen	Child Adult Base Personnel	2,190 days 10,950 days 9,125 days	USEPA, December 1989
BW	Body Weight	Child Adult/Base Personnel	15 kg 70 kg	USEPA, December 1989
C	Exposure Concentration	UCL	mg/L	USEPA, December 1989
ED	Exposure Duration	Child Adult Base Personnel	6 yrs 30 yrs 25 yrs	USEPA, December 1989 USEPA, March 1991
EF	Exposure Frequency	Child Adult Base Personnel	46 days/yr 23 days/yr 6 days/yr	Based on climatological data
ET	Exposure Time	All	1.0 hr/day	USEPA, Region IV, 1994
IR	Ingestion Rate	All	0.01 L/hr	USEPA, Region IV, 1994
PC	Permeability Constant	Chemical Specific		USEPA, January 1992
SA	Exposed Surface Area of Skin Available for Contact	Child Adult Base Personnel	2,600 cm^2 1,800 cm^2 1,300 cm^2	USEPA, January 1992

Notes:
mg/L = milligrams per liter
hr/day = hour per day
days/yr = days per year
yrs = years
cm^2 = square centimeters
kg = kilogram
L/hr = liters per hour
cm^2 = square centimeters

TABLE 6-27

EXPOSURE ASSESSMENT SUMMARY
INCIDENTAL INGESTION AND DERMAL CONTACT OF SEDIMENT
REMEDIAL INVESTIGATION CTO-0174
MCB CAMP LEJEUNE, NORTH CAROLINA

Future Scenarios - Residential Child and Adults; Current Scenarios - Civilian Base Personnel and Trespassing Adult and Older Children				
Input Parameter	Description	Value		Reference
ABS	Absorption Factor (dimensionless)	Organics Inorganics	0.01 0.001	USEPA, Region IV, February 1992
AF	Soil-to-Skin Adherence Factor		1.0 mg/cm^2	USEPA, Region IV, February 1992
AT$_c$	Averaging Time Carcinogen	All	25,550 days	USEPA, December 1989
AT$_{nc}$	Averaging Time Noncarcinogen	Child Older Child Adult Base Personnel	2,190 days 3,285 days 10,950 days 9,125 days	USEPA, December 1989
BW	Body Weight	Child Older Child Adult Base Personnel	15 kg 37 kg 70 kg 70 kg	USEPA, December 1989
C	Exposure Concentration	UCL	mg/kg	USEPA, May 1992
CF	Conversion Factor		1.0E-06 kg/mg	USEPA, December 1989
ED	Exposure Duration	Child Older Child Adult Base Personnel	6 yrs 9 yrs 30 yrs 25 yrs	USEPA, December 1989
EF	Exposure Frequency	Child/Older Child Adult Base Personnel	56 days/yr 28 days/yr 9 days/yr	Based on climatological data
Fi	Fraction Ingestion from Contaminated Source		100%	Conservative Professional Judgement
IR	Ingestion Rate	Child Adult/Older Child Base Personnel	200 mg/day 100 mg/day 50 mg/day	USEPA, December 1989
SA	Exposed Surface Area of Skin Available for Contact	Child Older Child Adult Base Personnel	2,600 cm^2/event 3,820 cm^2/event 1,800 cm^2/event 1,300 cm^2/year	USEPA, January 1992

Notes: mg/kg = milligram per kilogram
mg/day = milligrams per day
days/yr = days per year
cm^2 = square centimeters

TABLE 6-28

TOXICITY FACTORS FOR CHEMICALS OF POTENTIAL CONCERN
REMEDIAL INVESTIGATION CTO-0174
MCB CAMP LEJEUNE, NORTH CAROLINA

	RfD (mg/kg·d)	RfI (mg/kg·d)	CSF $(mg/kg·d)^{-1}$	CSFI $(mg/kg·d)^{-1}$	WOE	Reference
Volatile Organics						
Ethylbenzene	1E-1	3E-1	--	--	D	IRIS, 1994
Toluene	2E-1	1E-1	--	--	D	IRIS, 1994
Trichloroethene	6E-3	--	1.1E-2	6E-3	B2	IRIS, 1994; USEPA, Region III
Xylene (total)	2E+1	PDG	--	--	D	IRIS, 1994
Semivolatile Organics						
Acenaphthene	6E-2	--	--	--	--	IRIS, 1994
Anthracene	3E-1	--	--	ND	D	IRIS, 1994
Fluoranthene	4E-2	ND	--	--	D	IRIS, 1994
Fluorene	4E-2	ND	--	--	D	IRIS, 1994
2-Methylnaphthalene	4E-2(1)	--	--	--	--	IRIS, 1994
2,4-Dimethylphenol	2E-2	ND	ND	ND	--	IRIS, 1994
Naphthalene	4E-2	ND	--	--	D	IRIS, 1994; HEAST, 1993
N-Nitrosodiphenylamine	--	--	4.9E-3	--	B2	IRIS, 1994
Phenanthrene	3E-2(2)	ND	ND	ND	D	IRIS, 1994
Phenol	6E-1	ND	--	--	D	IRIS, 1994
Pyrene	3E-2	ND	--	--	D	IRIS, 1994

TABLE 6-28 (Continued)

TOXICITY FACTORS FOR CHEMICALS OF POTENTIAL CONCERN
REMEDIAL INVESTIGATION CTO-0174
MCB CAMP LEJEUNE, NORTH CAROLINA

	RfD (mg/kg·d)	RfI (mg/kg·d)	CSF (mg/kg·d)$^{-1}$	CSFI (mg/kg·d)$^{-1}$	WOE	References
Pesticides						
alpha-Chlordane(3)	6E-5	UR	1.3E+0	1.3	B2	IRIS, 1994
gamma-Chlordane(3)						
Endosulfan II(4)	5E-5	--	ND	--	--	IRIS, 1994; USEPA, Region III
4,4'-DDD	ND	ND	2.4E-1	--	B2	IRIS, 1994
4,4'-DDE	ND	ND	3.4E-1	--	B2	IRIS, 1994
4,4'-DDT	5E-4	ND	3.4E-1	2.8E-8	B2	IRIS, 1994
Dieldrin	5E-5	ND	16E+0	1.61E+1	B2	IRIS, 1994
Heptachlor	5E-4	ND	4.5E+0	4.55E+0	B2	IRIS, 1994
Inorganics						
Arsenic	3E-4	ND	1.75E+0	1.5E+1	A	IRIS, 1994
Barium	7E-2	1E-4	--	--	--	IRIS, 1994; HEAST, 1993
Beryllium	5E-3	ND	4.3	8.4E+0	B2	IRIS, 1994
Lead	--	--	--	--	B2	IRIS, 1994
Vanadium	7E-3	--	--	--	--	HEAST, 1993

Notes: (1) The RfD for naphthalene is being used as a surrogate for 2-methylnaphthalene.
(2) The RfD for phenanthrene is being used as a surrogate for pyrene.
(3) Toxicity factors reported are for chlordane (total)
(4) Toxicity information is for Endosulfan

RfD - Oral Reference Dose (mg/kg-day)
RfI - Inhalation Reference Dose (mg/kg·d)
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 Table

ND - No Data
WD - Withdrawn
PG - Pending
UR - Under review by USEPA workshops.
-- - Not Determined

TABLE 6-29

INCREMENTAL LIFETIME CANCER RISKS AND HAZARD QUOTIENTS
FOR CIVILIAN BASE PERSONNEL
LAWN AND MIXING PAD AREA - CURRENT SCENARIOS
OPERABLE UNIT NO. 5 - SITE 2
REMEDIAL INVESTIGATION - CTO-0174
MCB CAMP LEJEUNE, NORTH CAROLINA

	Receptor			
	Civilian Base Personnel			
Exposure Route	ICR	Percent of Total Risk	HQ	Percent of Total Risk
Soil				
Ingestion	3E-5	(29)	0.4	(31)
Dermal Contact	7E-5	(66)	0.9	(69)
Inhalation	1E-6	(<1)	--	--
Groundwater				
Ingestion	--	--	--	--
Dermal Contact	--	--	--	--
Inhalation	--	--	--	--
Surface Water				
Ingestion	9E-9	(<1)	3E-5	(<1)
Dermal Contact	7E-8	(<1)	0.008	(<1)
Sediment				
Ingestion	5E-7	(<1)	0.002	(<1)
Dermal Contact	2E-7	(<1)	7E-4	(<1)
TOTAL	1E-4	(100)*	1.3(1)	(100)*

Notes: -- = Not evaluated or applicable.
* = Percentage may not add up to 100 because of rounding.
HQ = Hazard Quotient
ICR = Incremental Cancer Risk
(1) Total of HQs equal the Hazard Index (HI).

TABLE 6-30

INCREMENTAL LIFETIME CANCER RISKS AND HAZARD QUOTIENTS FOR CONSTRUCTION WORKER
LAWN AND MIXING PAD AREA - FUTURE SCENARIOS
OPERABLE UNIT NO. 5 - SITE 2
REMEDIAL INVESTIGATION - CTO-0174
MCB CAMP LEJEUNE, NORTH CAROLINA

	Receptor			
	Construction Worker			
Exposure Route	ICR	Percent of Total Risk	HQ	Percent of Total Risk
Subsurface Soil				
Ingestion	5E-7	(83)	0.1	(83)
Dermal Contact	1E-7	(17)	2E-2	(17)
Inhalation	1E-9	(<1)	--	--
Groundwater				
Ingestion	--	--	--	--
Dermal Contact	--	--	--	--
Inhalation	--	--	--	--
Surface Water				
Ingestion	--	--	--	--
Dermal Contact	--	--	--	--
Sediment				
Ingestion	--	--	--	--
Dermal Contact	--	--	--	--
TOTAL	6E-7	(100)*	0.1(1)	(100)*

Notes: -- = Not evaluated or applicable.
* = Percentage may not add up to 100 because of rounding.
HQ = Hazard Quotient
ICR = Incremental Cancer Risk
(1) Total of HQs equal the Hazard Index (HI).

TABLE 6-31

INCREMENTAL LIFETIME CANCER RISKS AND HAZARD QUOTIENTS FOR RESIDENTIAL CHILDREN AND ADULTS
LAWN AND MIXING PAD AREA - FUTURE SCENARIOS
OPERABLE UNIT NO. 5 - SITE 2
REMEDIAL INVESTIGATION - CTO-0174
MCB CAMP LEJEUNE, NORTH CAROLINA

	Receptor							
	Residental Child				Residental Adult			
Exposure Route	ICR	Percent of Total Risk	HQ	Percent of Total Risk	ICR	Percent of Total Risk	HQ	Percent of Total Risk
Soil								
Ingestion	1E-3	(57)	80	(72)	8E-4	(33)	8.0	(35)
Dermal Contact	4E-4	(23)	20	(18)	9E-4	(38)	10	(43)
Inhalation	1E-6	(<1)	--	--	2E-6	(<1)	--	--
Groundwater								
Ingestion	3E-4	(17)	8.2	(7)	6E-4	(25)	3	(13)
Dermal Contact	4E-5	(2)	3	(3)	1E-4	(4)	2	(9)
Inhalation	1E-7	(<1)	0.03	(<1)	1E-7	(<1)	0.007	(<1)
Surface Water								
Ingestion	8E-8	(<1)	0.001	(<1)	4E-8	(<1)	1E-4	(<1)
Dermal Contact	1E-6	(<1)	0.04	(<1)	5E-7	(<1)	3E-3	(<1)
Sediment								
Ingestion	1E-5	(<1)	0.2	(<1)	4E-6	(<1)	0.01	(<1)
Dermal Contact	4E-6	(1)	0.06	(<1)	1E-6	(<1)	0.005	(<1)
TOTAL	2E-3	(100)*	111(1)	(100)*	2E-3	(100)*	23(1)	(100)*

Notes: -- = Not evaluated or applicable.
* = Percentage may not add up to 100 because of rounding.
HQ = Hazard Quotient
ICR = Incremental Cancer Risk
(1) Total of HQs equal the Hazard Index (HI).

TABLE 6-32

INCREMENTAL LIFETIME CANCER RISKS AND HAZARD QUOTIENTS FOR CIVILIAN BASE PERSONNEL
LAWN AND MIXING PAD AREA - TIME-CRITICAL REMOVAL ACTION
CURRENT SCENARIOS
OPERABLE UNIT NO. 5 - SITE 2
REMEDIAL INVESTIGATION - CTO-0174
MCB CAMP LEJEUNE, NORTH CAROLINA

	Receptor			
	Civilian Base Personnel			
Exposure Route	ICR	Percent of Total Risk	HQ	Percent of Total Risk
Soil				
Ingestion	6E-8	(11)	4E-4	(5)
Dermal Contact	6E-8	(11)	5E-4	(6)
Inhalation	3E-7	(56)	--	--
Groundwater				
Ingestion	--	--	--	--
Dermal Contact	--	--	--	--
Inhalation	--	--	--	--
Surface Water				
Ingestion	9E-9	(2)	3E-5	(<1)
Dermal Contact	7E-8	(13)	0.008	(85)
Sediment				
Ingestion	3E-8	(6)	2E-4	(2)
Dermal Contact	9E-9	(2)	6E-5	(<1)
TOTAL	5E-7	(100)*	0.008(1)	(100)*

Notes: -- = Not evaluated or applicable.
* = Percentage may not add up to 100 because of rounding.
HQ = Hazard Quotient
ICR = Incremental Cancer Risk
(1) Total of HQs equal the Hazard Index (HI).

TABLE 6-33

INCREMENTAL LIFETIME CANCER RISKS AND HAZARD QUOTIENTS FOR CONSTRUCTION WORKER
LAWN AND MIXING PAD AREA - TIME-CRITICAL REMOVAL ACTION
FUTURE SCENARIOS
OPERABLE UNIT NO. 5 - SITE 2
REMEDIAL INVESTIGATION - CTO-0174
MCB CAMP LEJEUNE, NORTH CAROLINA

	Receptor			
	Construction Worker			
Exposure Route	ICR	Percent of Total Risk	HQ	Percent of Total Risk
Subsurface Soil				
Ingestion	1E-10	(75)	5E-5	(83)
Dermal Contact	3E-11	(23)	1E-5	(17)
Inhalation	3E-12	(2)	--	--
Groundwater				
Ingestion	--	--	--	--
Dermal Contact	--	--	--	--
Inhalation	--	--	--	--
Surface Water				
Ingestion	--	--	--	--
Dermal Contact	--	--	--	--
Sediment				
Ingestion	--	--	--	--
Dermal Contact	--	--	--	--
TOTAL	1E-10	(100)*	6E-5(1)	(100)*

Notes: -- = Not evaluated or applicable.
* = Percentage may not add up to 100 because of rounding.
HQ = Hazard Quotient
ICR = Incremental Cancer Risk
(1) Total of HQs equal the Hazard Index (HI).

TABLE 6-34

INCREMENTAL LIFETIME CANCER RISKS AND HAZARD QUOTIENTS FOR RESIDENTIAL CHILDREN AND ADULTS LAWN AND MIXING PAD AREA - TIME-CRITICAL REMOVAL ACTION FUTURE SCENARIOS OPERABLE UNIT NO. 5 - SITE 2 REMEDIAL INVESTIGATION - CTO-0174 MCB CAMP LEJEUNE, NORTH CAROLINA

	Receptor							
	Residental Child				Residental Adult			
Exposure Route	ICR	Percent of Total Risk	HQ	Percent of Total Risk	ICR	Percent of Total Risk	HQ	Percent of Total Risk
Soil								
Ingestion	3E-6	(<1)	0.08	(<1)	1E-6	(<1)	0.009	(<1)
Dermal Contact	3E-7	(<1)	0.01	(<1)	7E-7	(<1)	0.006	(<1)
Inhalation	4E-7	(<1)	--	--	5E-7	(<1)	--	--
Groundwater								
Ingestion	3E-4	(87)	8.2	(72)	6E-4	(85)	3	(60)
Dermal Contact	4E-5	(12)	3	(26)	1E-4	(14)	2	(40)
Inhalation	1E-7	(<1)	0.008	(<1)	1E-7	(<1)	0.002	(<1)
Surface Water								
Ingestion	8E-8	(<1)	0.001	(<1)	4E-8	(<1)	1E-4	(<1)
Dermal Contact	1E-6	(<1)	0.04	(<1)	5E-7	(<1)	3E-3	(<1)
Sediment								
Ingestion	1E-6	(<1)	0.02	(<1)	3E-7	(<1)	0.001	(<1)
Dermal Contact	2E-7	(13)	0.005	(<1)	7E-8	(1)	4E-4	(<1)
TOTAL	1E-4	(100)*	11(1)	(100)*	7E-4	(100)*	5(1)	(100)*

Notes: -- = Not evaluated or applicable.
* = Percentage may not add up to 100 because of rounding.
HQ = Hazard Quotient
ICR = Incremental Cancer Risk
(1) Total of HQs equal the Hazard Index (HI).

TABLE 6-35

INCREMENTAL LIFETIME CANCER RISKS AND HAZARD QUOTIENTS FOR CIVILIAN BASE PERSONNEL FORMER STORAGE AREA - CURRENT SCENARIOS OPERABLE UNIT NO. 5 - SITE 2 REMEDIAL INVESTIGATION - CTO-0174 MCB CAMP LEJEUNE, NORTH CAROLINA

	Receptor			
	Civilian Base Personnel			
Exposure Route	ICR	Percent of Total Risk	HQ	Percent of Total Risk
Soil				
Ingestion	8E-8	(29)	0.001	(24)
Dermal Contact	2E-7	(71)	0.003	(>5)
Inhalation	6E-15	(<1)	3E-9	(<1)
Groundwater				
Ingestion	--	--	--	--
Dermal Contact	--	--	--	--
Inhalation	--	--	--	--
Surface Water				
Ingestion	--	--	--	--
Dermal Contact	--	--	--	--
Sediment				
Ingestion	--	--	--	--
Dermal Contact	--	--	--	--
TOTAL	3E-7	(100)*	0.004(1)	(100)*

Notes: -- = Not evaluated or applicable.
* = Percentage may not add up to 100 because of rounding.
HQ = Hazard Quotient
ICR = Incremental Cancer Risk
(1) Total of HQs equal the Hazard Index (HI).

TABLE 6-36

INCREMENTAL LIFETIME CANCER RISKS AND HAZARD QUOTIENTS FOR CONSTRUCTION WORKER
FORMER STORAGE AREA - FUTURE SCENARIOS
OPERABLE UNIT NO. 5 - SITE 2
REMEDIAL INVESTIGATION - CTO-0174
MCB CAMP LEJEUNE, NORTH CAROLINA

	Receptor			
	Construction Worker			
Exposure Route	ICR	Percent of Total Risk	HQ	Percent of Total Risk
Subsurface Soil				
Ingestion	2E-8	(47)	0.004	(87)
Dermal Contact	3E-9	(7)	6E-4	(13)
Inhalation	2E-8	(47)	3E-10	(<1)
Groundwater				
Ingestion	--	--	--	--
Dermal Contact	--	--	--	--
Inhalation	--	--	--	--
Surface Water				
Ingestion	--	--	--	--
Dermal Contact	--	--	--	--
Sediment				
Ingestion	--	--	--	--
Dermal Contact	--	--	--	--
TOTAL	4E-8	(100)*	0.005(1)	(100)*

Notes: -- = Not evaluated or applicable.
* = Percentage may not add up to 100 because of rounding.
HQ = Hazard Quotient
ICR = Incremental Cancer Risk
(1) Total of HQs equal the Hazard Index (HI).

TABLE 6-37

INCREMENTAL LIFETIME CANCER RISKS AND HAZARD QUOTIENTS FOR RESIDENTIAL CHILDREN AND ADULTS
FORMER STORAGE AREA - FUTURE SCENARIOS
OPERABLE UNIT NO. 5 - SITE 2
REMEDIAL INVESTIGATION - CTO-0174
MCB CAMP LEJEUNE, NORTH CAROLINA

	Receptor							
	Residental Child				Residental Adult			
Exposure Route	ICR	Percent of Total Risk	HQ	Percent of Total Risk	ICR	Percent of Total Risk	HQ	Percent of Total Risk
Soil								
Ingestion	4E-6	(1)	0.2	(2)	2E-6	(<1)	0.03	(<1)
Dermal Contact	1E-6	(<1)	0.06	(<1)	2E-6	(<1)	0.03	(<1)
Inhalation	7E-14	(<1)	1E-8	(<1)	8E-15	(<1)	1E-9	(<1)
Groundwater								
Ingestion	3E-4	(87)	8.2	(72)	6E-4	(85)	3	(59)
Dermal Contact	4E-5	(12)	3	(26)	1E-4	(14)	2	(40)
Inhalation	1E-7	(<1)	.03	(<1)	1E-7	(<1)	7E-3	(<1)
Surface Water								
Ingestion	--	--	--	--	--	--	--	--
Dermal Contact	--	--	--	--	--	--	--	--
Sediment								
Ingestion	--	--	--	--	--	--	--	--
Dermal Contact	--	--	--	--	--	--	--	--
TOTAL	3E-4	(100)*	12(1)	(100)*	7E-4	(100)*	5(1)	(100)*

Notes: -- = Not evaluated or applicable.
* = Percentage may not add up to 100 because of rounding.
HQ = Hazard Quotient
ICR = Incremental Cancer Risk
(1) Total of HQs equal the Hazard Index (HI).

TABLE 6-38

INCREMENTAL LIFETIME CANCER RISKS AND HAZARD QUOTIENTS FOR CIVILIAN BASE PERSONNEL
FORMER STORAGE AREA - TIME-CRITICAL REMOVAL ACTION
CURRENT SCENARIOS
OPERABLE UNIT NO. 5 - SITE 2
REMEDIAL INVESTIGATION - CTO-0174
MCB CAMP LEJEUNE, NORTH CAROLINA

	Receptor			
	Civilian Base Personnel			
Exposure Route	ICR	Percent of Total Risk	HQ	Percent of Total Risk
Soil				
Ingestion	9E-9	(31)	9E-5	(31)
Dermal Contact	2E-8	(69)	2E-4	(69)
Inhalation	4E-16	(<1)	3E-9	(<1)
Groundwater				
Ingestion	--	--	--	--
Dermal Contact	--	--	--	--
Inhalation	--	--	--	--
Surface Water				
Ingestion	--	--	--	--
Dermal Contact	--	--	--	--
Sediment				
Ingestion	--	--	--	--
Dermal Contact	--	--	--	--
TOTAL	3E-8	(100)*	3E-4(1)	(100)*

Notes: -- = Not evaluated or applicable.
* = Percentage may not add up to 100 because of rounding.
HQ = Hazard Quotient
ICR = Incremental Cancer Risk
(1) Total of HQs equal the Hazard Index (HI).

TABLE 6-39

INCREMENTAL LIFETIME CANCER RISKS AND HAZARD QUOTIENTS FOR CONSTRUCTION WORKER
FORMER STORAGE AREA - TIME-CRITICAL REMOVAL ACTION
FUTURE SCENARIOS
OPERABLE UNIT NO. 5 - SITE 2
REMEDIAL INVESTIGATION - CTO-0174
MCB CAMP LEJEUNE, NORTH CAROLINA

	Receptor			
	Construction Worker			
Exposure Route	ICR	Percent of Total Risk	HQ	Percent of Total Risk
Subsurface Soil				
Ingestion	2E-8	(47)	4E-3	(87)
Dermal Contact	3E-9	(7)	6E-4	(13)
Inhalation	2E-8	(47)	3E-10	(<1)
Groundwater				
Ingestion	--	--	--	--
Dermal Contact	--	--	--	--
Inhalation	--	--	--	--
Surface Water				
Ingestion	--	--	--	--
Dermal Contact	--	--	--	--
Sediment				
Ingestion	--	--	--	--
Dermal Contact	--	--	--	--
TOTAL	4E-8	(100)*	0.005(1)	(100)*

Notes: -- = Not evaluated or applicable.
* = Percentage may not add up to 100 because of rounding.
HQ = Hazard Quotient
ICR = Incremental Cancer Risk
(1) Total of HQs equal the Hazard Index (HI).

TABLE 6-40

INCREMENTAL LIFETIME CANCER RISKS AND HAZARD QUOTIENTS FOR RESIDENTIAL CHILDREN AND ADULTS
FORMER STORAGE AREA - TIME-CRITICAL REMOVAL ACTION
FUTURE SCENARIOS
OPERABLE UNIT NO. 5 - SITE 2
REMEDIAL INVESTIGATION - CTO-0174
MCB CAMP LEJEUNE, NORTH CAROLINA

	Receptor							
	Residental Child				Residental Adult			
Exposure Route	ICR	Percent of Total Risk	HQ	Percent of Total Risk	ICR	Percent of Total Risk	HQ	Percent of Total Risk
Soil								
Ingestion	4E-7	(<1)	0.02	(<1)	2E-7	(<1)	0.002	(<1)
Dermal Contact	1E-7	(<1)	0.005	(<1)	3E-7	(<1)	0.002	(<1)
Inhalation	5E-15	(<1)	1E-8	(<1)	6E-16	(<1)	1E-9	(<1)
Groundwater								
Ingestion	3E-4	(88)	8.2	(73)	6E-4	(86)	3	(60)
Dermal Contact	4E-5	(12)	3	(27)	1E-4	(14)	2	(40)
Inhalation	1E-7	(<1)	0.03	(<1)	1E-7	(<1)	0.007	(<1)
Surface Water								
Ingestion	--	--	--	--	--	--	--	--
Dermal Contact	--	--	--	--	--	--	--	--
Sediment								
Ingestion	--	--	--	--	--	--	--	--
Dermal Contact	--	--	--	--	--	--	--	--
TOTAL	3E-4	(100)*	22(1)	(100)*	7E-4	(100)*	5(1)	(100)*

Notes: -- = Not evaluated or applicable.
* = Percentage may not add up to 100 because of rounding.
HQ = Hazard Quotient
ICR = Incremental Cancer Risk
(1) Total of HQs equal the Hazard Index (HI).

TABLE 6-41

INCREMENTAL LIFETIME CANCER RISKS AND HAZARD QUOTIENTS FOR TRESPASSING OLDER CHILDREN AND ADULTS OVERS CREEK - CURRENT SCENARIOS OPERABLE UNIT NO. 5 - SITE 2 REMEDIAL INVESTIGATION - CTO-0174 MCB CAMP LEJEUNE, NORTH CAROLINA

	Receptor							
	Older Child				Adult			
Exposure Route	ICR	Percent of Total Risk	HQ	Percent of Total Risk	ICR	Percent of Total Risk	HQ	Percent of Total Risk
Soil								
Ingestion	--	--	--	--	--	--	--	--
Dermal Contact	--	--	--	--	--	--	--	--
Inhalation	--	--	--	--	--	--	--	--
Groundwater								
Ingestion	--	--	--	--	--	--	--	--
Dermal Contact	--	--	--	--	--	--	--	--
Inhalation	--	--	--	--	--	--	--	--
Surface Water								
Ingestion	--	--	--	--	--	--	--	--
Dermal Contact	--	--	--	--	--	--	--	--
Sediment								
Ingestion	8E-8	(67)	1E-3	(95)	7E-8	(78)	3E-4	(98)
Dermal Contact	4E-8	(33)	5E-5	(5)	2E-8	(22)	5E-6	(2)
TOTAL	1E-7	(100)*	0.001(1)	(100)*	9E-8	(100)*	3E-4(1)	(100)*

Notes: -- = Not evaluated or applicable.
* = Percentage may not add up to 100 because of rounding.
HQ = Hazard Quotient
ICR = Incremental Cancer Risk
(1) Total of HQs equal the Hazard Index (HI).

TABLE 6-42

TOTAL SITE INCREMENTAL LIFETIME CANCER RISK AND HAZARD INDICES
OPERABLE UNIT NO. 5 - SITE 2
REMEDIAL INVESTIGATION - CTO-0174
MCB CAMP LEJEUNE, NORTH CAROLINA

	Lawn and Mixing Pad Areas		Lawn and Mixing Pad Areas - Time Critical Removal Action		Former Storage Area		Former Storage Area - Time Critical Removal Action		Overs Creek	
Receptors	ICR	HI	ICR	HI	ICR	HI	ICR	HI	ICR	HI
Civilian Base Personnel	1E-4	1.3	5E-7	0.008	3E-7	0.004	3E-8	3E-4	--	--
Construction Worker	6E-7	0.1	1E-10	6E-5	4E-8	.005	4E-8	.005	--	--
Child Resident	2E-3	111	3E-4	11	3E-4	12	3E-4	11	--	--
Adult Resident	2E-3	23	7E-4	5	7E-4	5	7E-4	5	--	--
Trespassing Child	--	--	--	--	--	--	--	--	1E-7	1E-3
Trespassing Adult	--	--	--	--	--	--	--	--	9E-8	3E-4

Notes: ICR = Incremental Lifetime Cancer Risk
HI = Hazard Index

Shading indicates that risk level is not within or fell above acceptable levels.

TABLE 6-43

SUMMARY OF UNCERTAINTIES IN THE RESULTS OF THE HUMAN HEALTH RISK ASSESSMENT
OPERABLE UNIT NO. 5, SITE 2
REMEDIAL INVESTIGATION - CTO-0174
MCB CAMP LEJEUNE, NORTH CAROLINA

	Potential Magnitude for Over-Estimation of Risks	Potential Magnitude for Under-Estimation of Risks	Potential Magnitude for Over or Under-Estimation of Risks
Environmental Sampling and Analysis			
Sufficient samples may not have been taken to characterize the media being evaluated.			Low
Systematic or random errors in the chemical analysis may yield erroneous data.			Low
Exposure Assessment			
The standard assumptions regarding body weight, exposure period, life expectancy, population characteristics, and lifestyle may not be representative of the actual exposure situations.			Moderate
The use of the 95th percentile upper confidence level data in the estimation of the RME.	Moderate		
Assessing future residential property use when the likelihood of residential development is low.	High		
The use of total concentrations for groundwater to evaluate potential chronic daily intakes associated with potable use.	High		
The amount of media intake is assumed to be constant and representative of any actual exposure.			Low
Toxicological Assessment			
Toxicological indices derived from high dose animal studies, extrapolated to low dose human exposure.	Moderate		
Lack of promulgated toxicological indices for inhalation pathway.		Low	
Lack of quantitative evaluation of tentatively identified compounds detected in the soil and sediment.		Low	

TABLE 6-43 (Continued)

SUMMARY OF UNCERTAINTIES IN THE RESULTS OF THE HUMAN HEALTH RISK ASSESSMENT
OPERABLE UNIT NO. 5, SITE 2
REMEDIAL INVESTIGATION - CTO-0174
MCB CAMP LEJEUNE, NORTH CAROLINA

	Potential Magnitude for Over-Estimation of Risks	Potential Magnitude for Under-Estimation of Risks	Potential Magnitude for Over or Under-Estimation of Risks
<u>Risk Characterization</u>			
Assumption of additivity in the quantitation of cancer risks without consideration of synergism, antagonism, promotion and initiation.			Moderate
Assumption of additivity in the estimation of systemic health effects without consideration of synergism, antagonism, etc.			Moderate
Additivity of risks by individual exposure pathways (dermal and ingestion and inhalation)			Low
Compounds not quantitatively evaluated.		Low	

Notes:

Low - Assumptions categorized as "low" may effect risk estimates by less than one order of magnitude.

Moderate - Assumptions categorized as "moderate" may effect estimates of risk by between one and two orders of magnitude.

High - Assumptions categorized as "high" may effect estimates of risk by more than two orders of magnitude.

Source: <u>Risk Assessment Guidance for Superfund, Volume 1, Part A: Human Health Evaluation Manual</u>. USEPA, 1989a.

7.0 BASELINE ECOLOGICAL RISK ASSESSMENT

This section presents the ecological risk assessment (ERA) that has been conducted at Site 2 to assess the potential impacts to ecological receptors from contaminants detected at the site.

7.1 Introduction

This ERA for Site 2 has been prepared in accordance with the scope of work identified under Task 6 in the Final Remedial Investigation/Feasibility Study Work Plan, prepared by Baker Environmental, Inc. (Baker), under Contract Task Order (CTO) 0174 (Baker, 1993). The ERA has been conducted in conjunction with a remedial investigation/feasibility study (RI/FS) at Site 2 under the Department of Navy's Comprehensive Long-Term Environmental Action - Navy (CLEAN) Program, Contract N62470-89-D-4814.

The Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) as amended by the Superfund Amendments and Reauthorization Act of 1986 directs USEPA to protect human health and the environment with respect to releases or potential releases of contaminants from abandoned hazardous waste sites (USEPA, 1989b). In addition, there are various federal and state standards and screening values concerning environmental protection that are considered in this report. For example, these standards and screening values include comparisons of contaminant concentrations in surface water to State Water Quality Standards and Sediment Screening Values. This ERA has been prepared to fulfill the requirements of CERCLA by determining if contaminants at Site 2 are impacting the environment.

7.1.1 Objectives of the Ecological Risk Assessment

The objective of this ERA was to evaluate if past reported storage and dispensing practices at Site 2 potentially are adversely impacting the ecological integrity of the terrestrial and aquatic habitats on, or adjacent to the site. This assessment also evaluated the potential effects of contaminants at Site 2 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 of the Ecological Risk Assessment

This ERA evaluated and analyzed the results from the RI and historical data collected during previous studies. The RI included sampling and chemical analysis of the surface water, sediments, soil, and groundwater. Information used to evaluate sensitive environments was obtained from historical data and previous studies conducted at MCB Camp Lejeune, North Carolina.

This ERA focuses on adverse impacts to aquatic and terrestrial receptors. If potential risks to the ecological receptors are considered significant, further ecological evaluation of the site and surrounding areas may be warranted.

The risk assessment methodologies used in this evaluation are consistent with those outlined in the Framework for Ecological Risk Assessment (USEPA, 1992a). In addition, information found in the following documents was used to supplement the USEPA guidance document:

- U.S. EPA Supplemental Risk Assessment Guidance for Superfund, Volume II, Environmental Evaluation Manual (USEPA, 1989c)
- Ecological Assessment of Hazardous Waste Sites: A Field and Laboratory Reference (USEPA, 1989d)
- Rapid Bioassessment Protocols for use in Streams and Rivers: Benthic Macroinvertebrates and Fish (USEPA, 1989e)

7.1.3 Organization of The Ecological Risk Assessment

Based on the USEPA Framework for Ecological Risk Assessment, an ERA consists of three main components: (1) problem formulation, (2) analysis, and, (3) risk characterization (USEPA, 1992a). The problem formulation section includes a preliminary characterization of exposure and effects of the stressors to the ecological receptors. During the analysis, the data is evaluated to determine the exposure and potential effects on the ecological receptors from the stressors. Finally, in the risk characterization the likelihood of adverse effects occurring as a result of exposure to a stressor are evaluated. This section 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 should include 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, 1992a).

The results of the various site investigations indicate the presence of pesticides and/or other contaminants in the surface water, 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 contaminants detected at Site 2, an ERA was performed.

Three types of data 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 enables the assessor to determine the relative contribution of other potential causes of the observed effects to the ecological receptors (as measured by the ecological endpoints) that may be unrelated to the toxic effects of the COPCs, (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, soil and groundwater to evaluate the presence, concentrations, and variabilities of the COPCs. Ecological surveys were not conducted as part of Baker field activities; however, based on observations and available habitats, potential ecological receptors were identified. Finally, toxicological information for the COPCs detected in the media were obtained 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 site model. The following sections discuss each of these components, and how they were evaluated in the 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, and surface soils. Contaminants in the subsurface soils and groundwater were not evaluated because most ecological receptors are not expected to be directly exposed to contaminants in these media.

The nature and extent of these contaminants were discussed in Section 4.0 of this report. Table 7-1 lists the contaminants that were detected in each media. Some of the soil and sediment at Site 2 is proposed to be removed in the future. This removal is termed the TCRA. Section 1.4 of this report contains a more detailed discussion of the proposed TCRA.

7.2.1.1 Contaminants of Potential Concern

The COPCs for the ERA were selected following the same procedures (i.e., frequency of detection) as those used for selecting the COPCs for the human health RA (see Section 6.2). Some of the COPCs included in the ERA were different than those included in the human health RA because they may adversely impact the ecological integrity at the site whereas they may not pose a risk to humans.

Contaminants of Potential Concern - Surface Water

Surface water samples were collected at Site 2 from the Railroad Track Drainage Ditches and Overs Creek. The following organics detected in the surface water samples were not addressed in the ERA because they are common laboratory and/or decontamination contaminants: acetone and chloroform. Carbon disulfide was not addressed in the ERA because of the low frequency of detection and low concentration.

The following inorganics detected in the surface water samples were not addressed in the ERA because they are naturally occurring elements and are not expected to adversely impact the ecological environment at the detected concentrations: calcium, magnesium, potassium, and sodium.

The following chemicals detected in the surface water samples that were not excluded for the reasons above were retained as COPCs in the ERA: 4,4'-DDD, 4,4-DDT, aluminum, arsenic, barium, beryllium, chromium, copper, iron, lead, manganese, vanadium, and zinc.

Contaminants of Potential Concern - Sediments

The following organics detected in the sediment samples were not addressed in the ERA because they are common laboratory and/or decontamination contaminants: acetone and 2-butanone. None of the PAHs in the sediments were included in the ERA because they were detected at typical background concentrations for urban areas (see Section 6.2.4).

The following inorganics detected in the sediment samples were not addressed in the ERA because they are naturally occurring elements, are not expected to adversely impact the ecological environment at the detected concentrations, or they were infrequently detected: antimony, calcium, magnesium, potassium, selenium, sodium and thallium.

The following chemicals detected in the sediment samples that were not excluded for the reasons above were retained as COPCs in the ERA: endosulfan II, ethylbenzene, xylene, 4,4'-DDD, 4,4'-DDE, 4,4'-DDT, dieldrin, alpha-chlordane, and gamma-chlordane, aluminum, arsenic, barium, beryllium, chromium, copper, iron, lead, manganese, vanadium, and zinc.

After the proposed TCRA of the sediments, endosulfan II and ethylbenzene were no longer detected in the sediments. The other COPCs in the sediment were still detected.

Contaminants of Potential Concern - Surface Soils

Surface soil samples were collected in the area surrounding the Lawn and Mixing Pad Area and the Former Storage Area. The following organics detected in the surface soil samples were not addressed in the ERA because they are common laboratory and/or decontamination contaminants: acetone, 2-butanone, bis(2-ethylhexyl)phthalate and di-n-butyl phthalate, and methylene chloride. None of the PAHs in the surface soils were included in the ERA because they were detected at typical background concentrations for urban areas (see Section 6.2.1).

The following inorganics detected in the surface soil were not addressed in the ERA because they are naturally occurring elements, and are not expected to adversely impact the ecological environment at the detected concentrations, or they were infrequently detected: aluminum, calcium, cobalt, magnesium, manganese, potassium, selenium, silver, sodium and thallium.

The following chemicals detected in the surface soil samples that were not excluded for the reasons above were retained as COPCs in the ERA: toluene, total xylene, 4,4'-DDD, 4,4'-DDE, 4,4'-DDT, dieldrin, heptachlor, alpha-chlordane, and gamma-chlordane, arsenic, barium, beryllium, cadmium, chromium, copper, iron, lead, mercury, vanadium, and zinc.

After the proposed TCRA of the surface soils, dieldrin and heptachlor were no longer detected in the surface soils. The other COPCs in the surface soils were still detected.

7.2.1.2 Physical/Chemical Characteristics

Section 5.1 contains a detailed discussion of the chemical and physical properties of the contaminants detected at Site 2. The following section contains a brief discussion of the physical/chemical characterizations as they relate to the ecological receptors.

Table 7-2 contains values for bioconcentration factors, water solubility, organic carbon partition coefficient, and vapor pressure for the COPCs detected in the sediments, surface water and surface soil samples. All of these values were not available for some of the COPCs at Site 2. Information from this table was used to assess the fate and transport of the constituents and the potential risks to the ecological receptors. The following paragraphs discuss the significance of each parameter included in the table.

Bioconcentration factors (BCF) measure the tendency for a chemical to partition from the water column or sediment and concentrate in aquatic organisms. This factor is important for ecological receptors because chemicals with high bioconcentration factors could accumulate in lower-order species and subsequently accumulate to toxic levels in higher-order species that consume the lower-order species. Bioconcentration factors among the metals range from 19 for beryllium to 350,000 for manganese, and 10.7 for toluene to 54,000 for 4,4'-DDT for the organics.

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 soil but may bioconcentrate in organisms to a significant degree. Water solubility for metals is negligible because they are practically insoluble in water. The water solubility of the organics range from less than 0.1 mg/L for some pesticides to 535 mg/L for toluene.

The organic carbon partition coefficient (K_{oc}) 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 K_{oc} range from 240 ml/g for total xylene to 4×10^6 ml/g for 4,4'-DDE. K_{oc} values are negligible for metals.

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. The vapor pressure for the organics range from 9.6 mm Hg for ethylbenzene to 28.1 mm Hg for toluene. The vapor pressure for the other COPCs are low or negligible.

7.2.2 Ecosystem Potentially at Risk

Based on the site-specific and regional ecology, many ecological receptors are potentially at risk from contaminants at the site. Contaminants were identified in the surface water, sediment, soil and groundwater. 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, birds and other terrestrial flora and fauna. Most ecological receptors are not expected to directly contact contaminants detected in the subsurface soil, or the groundwater; therefore, these pathways were not evaluated in the ERA.

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: North Carolina Water Quality Standards, USEPA Water Quality Screening Values, Ambient Water Quality Criteria Documents, the Aquatic Information Retrieval Database, National Oceanic and Atmospheric Administrative

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). These WQS meet the requirements of both federal and state law. These standards are regulatory values and are enforceable. They are used to evaluate the quality of waters in North Carolina.

The USEPA Region IV Waste Management Division (Region IV) has adopted Water Quality Screening Values (WQSV) for chemicals detected at hazardous waste sites (USEPA, 1992b). These values are intended as preliminary screening tools to review chemical data from hazardous waste sites. Exceedences of the WQSVs 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 kind 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 have 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 also can be evaluated using these documents.

The Aquatic Information Retrieval Database (AQUIRE) database is an online 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 from contaminants.

Currently, promulgated sediment quality criteria do not exist. Until these criteria are developed, USEPA Region IV is using Sediment Screening Values (SSV) compiled by the National Oceanic and Atmospheric Administration (NOAA) for evaluating the potential for chemical constituents in sediments to cause adverse biological effects (USEPA, 1992b). 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 Site 2. 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, and USEPA recommends conducting toxicity tests as a follow-up. Finally, if contaminant concentrations are below the ER-L, adverse effects on the biota are considered unlikely (USEPA, 1992b).

There are no standards, criteria, or other screening values for assessing potential impacts to terrestrial ecological receptors from contaminants in soil. A literature search was conducted to identify levels of inorganic contaminants in the soil that could cause adverse effects to terrestrial flora and invertebrates. However, this 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 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 are not similar.

Finally, Terrestrial Reference Values (TRVs) for evaluating estimated chronic daily intakes (CDIs) were calculated from available toxicity data. Terrestrial reference values were developed from No-Observed-Adverse-Effect-Levels (NOAELs) or Lowest-Observed-Adverse-Effect-Levels (LOAELs) obtained from the Integrated Risk Information System (IRIS) or toxicological profiles. These values are used to assess the potential effects of contaminants on terrestrial fauna (e.g., birds, deer, rabbits).

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 reasons 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 COPC. 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 tests). 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 (USEPA, 1992a). 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) (Suter, 1993). 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, 1989d). 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 viability of populations of aquatic and terrestrial floral and faunal species. Specifically, as discussed further in this report (Section 7.1.4.2), the ERA will focus on decreased viability to aquatic organisms, deer, rabbits, and quail.

Aquatic organisms (e.g., fish) 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 of aquatic organisms). The endpoint may be predicted by contaminant concentrations in media exceeding published toxicity values. Finally, aquatic organisms are susceptible to the COPCs at Site 2.

Terrestrial organisms (e.g., rabbits, deer, 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. The endpoint is defined with a subject (rabbits, deer and quail), and a characteristic of the subject (decreased viability of rabbits, deer, and quail). The TRVs can be used to predict risks to terrestrial organisms. Finally, terrestrial organisms are susceptible to the COPCs at Site 2.

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 (e.g., it would be inappropriate to use abundance of a deer population to assess the effects on a one-acre site) 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 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

Aquatic biological samples (e.g., fish, benthic macroinvertebrates) were not collected as part of the field activities at Site 2. However, tadpoles were observed in the water in the drainage ditches, and other aquatic species (e.g., benthic macroinvertebrates) may exist in the water and sediment in the drainage ditches. As will be discussed later in this report, the populations of aquatic organisms in the drainage ditches are not expected to be socially or biologically significant.

Although no aquatic organisms were observed in Overs Creek, fish and benthic macroinvertebrates most likely inhabit the creek due to its habitat and physical characteristics. Therefore, aquatic organisms are potential ecological receptors at risk in Overs Creek. The following paragraphs discuss how decreased viability to the aquatic species at Site 2 was evaluated in the ERA.

Contaminant concentrations detected in the surface water at Site 2 were compared to the NC DEHNR WQS, USEPA WQSV, and other toxicity values obtained from the AWQC documents and AQUIRE to determine if there were any exceedences of the published values. In addition, the log normal upper 95 percent confidence limit or the maximum value detected were compared to the WQS and the acute and chronic WQSVs using the Quotient Index (QI) method. The QI is simply the COPC concentration divided by the standard or screening values. A QI greater than unity indicates a potential for adverse effects to aquatic life. The log normal upper 95 percent confidence limit were used to represent a conservative estimate of exposure at the site. If the variability in measured concentration values is great and the log normal upper 95 percent confidence limit was greater than the maximum detected value, the maximum detected value was used to calculate the QI.

Contaminant concentrations detected in the sediments at Site 2 were compared to the NOAA SSVs to determine if there were any exceedences in the established values. In addition, the upper 95 percent confidence limit or the maximum value detected was compared to the ER-L and ER-M using the QI method. If the variability in measured concentration values is great and the log normal upper 95 percent confidence limit was greater than the maximum detected value, the maximum detected value was used to calculate the QI.

Terrestrial Endpoints

As discussed earlier in this report, several terrestrial faunal species inhabit MCB Camp Lejeune including deer, birds, and small mammals and potentially are exposed to the COPCs at Site 2. Potential effects from contaminants detected at Site 2 on these species were evaluated by comparing the CDI doses to the TRVs. In addition, COPC concentrations in the soil were compared to published plant and earthworm toxicity information to evaluate potential effects to terrestrial flora and invertebrates.

7.2.5 The Conceptional Site Model

This section of the report contains a list of hypotheses regarding how the stressors might affect ecological components of the natural environment at Site 2:

- Aquatic receptors potentially may be adversely affected by exposure to contaminated water and sediment.
- 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 contaminants via ingested organisms and vegetation.

7.3 Analysis Phase

The next phase after the problem formulation is the analysis, which consists of the technical evaluation of 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 four environmental media; surface water, sediment, soil, and groundwater. The analytical results of these investigations, extent of contamination, and source identification are presented in Section 4.0 of this report. Only one round of sampling was collected for the remedial investigations, therefore the temporal pattern of change cannot be determined.

7.3.1.2 Ecosystem Characterization

This section includes a discussion of the regional ecology, study area description, and sensitive environments at and adjacent to Site 2. A discussion of the site history is discussed in Section 1.0 of this report.

Regional Ecology

The following section describes the regional ecology at MCB Camp Lejeune including the regional flora and fauna and the associated surface water bodies.

Regional Flora and Fauna

MCB Camp Lejeune, North Carolina, is approximately 108,800 acres, with 84 percent of the area covered by forests (USMC, 1987). The base drains primarily to the New River or its tributaries including Northeast Creek, Southwest Creek, Wallace Creek, French Creek, Bear Head Creek, Freeman Creek, and Duck Creek. The soil types range from sandy loams to fine sand and muck, with the dominant series being sandy loam (USMC, 1987).

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

Water Body Description

The Railroad Track Drainage Ditches adjacent to Site 2 drain to Overs Creek, which is a tributary to Northeast Creek. This portion of Northeast Creek is designated as Class SC HQW NSW (NC DEHNR, 1992a, 1992b). The SC classification is for tidal salt waters protected for aquatic life propagation and survival, fishing, wildlife, and secondary recreation. The HQW (High Quality Water) classification is because this portion of Northeast Creek is designated as a primary fish nursery area by the Marine Fisheries Commission (MFC) (NCMFC, 1992). Finally, the NSW (Nutrient Sensitive Waters) classification is for waters subject to growths of microscopic or macroscopic vegetation requiring limitations on nutrient inputs (NC DEHNR, 1992a, 1992b). Northeast Creek is classified as Inland Waters above, and Coastal Waters below, the railroad bridge (NC MFC, 1992). Northeast Creek is designated as Coastal Waters at its confluence with Overs Creek. The New River, downstream of Northeast Creek, is designated as Class SC NSW.

Overs Creek is classified as an unnamed stream since it is not named on the USGS Camp Lejeune quadrangle. According to the regulations (NC DEHNR, 1992a, 1992b), any stream which is not named in the schedule of stream classifications carries the same classification as that assigned to the stream segment to which it is a tributary. An exception would be an unnamed freshwater tributary to tidal saltwaters which would be designated as Class C; which are freshwaters with the same use designation as Class SC waters. Therefore, Overs Creek is designated as Class SC. The Railroad Track Drainage Ditches are intermittent and not tidally influenced, therefore it is designated as Class C.

Northeast Creek is reported as a large tidal salt water bay that is unproductive for fresh water fishing. The creek is an important nursery area for brackish water species. Game fish in this creek include pumpkinseed, chain pickerel, redfin pickerel, and southern flounder. Non-game fish include, atlantic menhaden, tidewater silverside, stripped mullet, mosquito fish, pinfish, green goby, naked goby, and longnose gar. Aquatic vegetation include, rush, cattail, and burred.

Site Description and Ecology

The land at Site 2 is primarily flat, but dips sharply at the Railroad Track Drainage Ditches. The area immediately surrounding the Mixing Pad Area and the Former Storage Area is grass. All of the soil borings were located in these open grass areas. Forested areas consisting primarily of Loblolly Pine and filler trees surround the grass areas north, south, and southeast of the site, including the upper reaches of Overs Creek.

Drainage along the eastern edge of the Building 712 area is toward the drainage ditches that run in a north-northwest direction towards Overs Creek. Drainage along the western edge of the Former Storage Area also is toward the drainage ditches. Another drainage ditch extends westward from the Building 712 area, underneath Holcomb Boulevard.

At the time of the surface water sampling, there was an insufficient volume of water for samples to be collected at most of the stations in the drainage areas. Although, tadpoles were observed in the Railroad Track Drainage Ditches, the water in the ditch is usually shallow and intermittent in nature. No surface water samples could be collected in the Holcomb Boulevard drainage area because of a lack of water. The potential for an ecologically significant population of aquatic organisms to inhabit the drainage ditches is low.

The effluent from the water treatment plant appeared to be the primary source of water in the upper reaches of Overs Creek; the sediment was dry approximately 10 to 15 feet upstream from the water treatment plant's discharge. It is thought that the ponded water immediately upstream of the treatment plant's discharge to Overs Creek is from backflow of the effluent. No aquatic life was observed in Overs Creek. However, based on Baker's previous sampling experience at MCB Camp Lejeune (see below), and based on the habitat and physical characteristics of the creek, Overs Creek has the potential to support a variety of aquatic life species including fish and benthic macroinvertebrates.

Deer, rabbits and birds were the only terrestrial faunal species observed at Site 2. Based on the regional ecology, and due to the wooded areas around Site 2, there is the potential for other terrestrial fauna to periodically visit the site.

Baker has conducted several ecological surveys at MCB Camp Lejeune. These surveys were conducted in Wallace Creek, Bearhead Creek, Everett Creek, the New River and several unnamed tributaries to the New River. During these surveys, several fish and benthic macroinvertebrate species were collected, along with blue crabs and mussels. Some of the sampling stations were located in the headwaters of the creeks that were similar in size and habitat as the headwaters of Overs Creek. Fish and benthic macroinvertebrates were collected from the creek reaches that were similar to Overs Creek. Therefore, there are most likely fish and benthic macroinvertebrates in Overs Creek in the areas where the COPCs were detected.

Sensitive Environments

This section describes the sensitive environments that were evaluated at Site 2. These sensitive environments include wetlands, threatened and endangered species, and other potentially sensitive environments.

Wetlands

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

The U.S. Fish and Wildlife Service (FWS) prepared a National Wetlands Inventory (NWI) map for the Camp Lejeune, North Carolina quadrangle by stereoscopic analysis of high altitude aerial photographs (USDI, 1982). Site 2 is included in this map (see Appendix P for a copy of the NWI map). The wetlands were identified on the photographs based on vegetation, visible hydrology, and geography in accordance with Classification of Wetland and Deep-Water Habitats of the United States (Cowardin, et al, 1979). NWI maps are intended for a 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.

No wetlands have been identified adjacent to Site 2 from the NWI map. A site specific wetland delineation has not been conducted at the Site 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 the North Carolina Wildlife Resources Commission, under the North Carolina Endangered Species Act (G.S. 113-331 to 113-337). The protected species fall into one of the following status classifications: Federal or state endangered, threatened or candidate species, state special concern, state significantly rare, or state watch list. While only the Federal or state threatened or endangered and state special concern species are protected from certain actions, the other classified species have the potential for protection in the future.

Table 7-3 lists the protected faunal species (either endangered, threatened, or special concern) and the only Federally endangered or threatened floral species that have been identified in previous studies within the boundaries of MCB Camp Lejeune (USMC, 1991; LeBlond, 1991; Fussell, 1991; and Walters, 1991). The following paragraphs discuss the protected species observed at MCB Camp Lejeune during previous studies.

A Peregrine falcon was spotted approximately five miles southeast of Site 2 (Fussell, 1991). These birds potentially may inhabit or feed in areas surrounding Site 2 because of their large foraging range. Black skimmers and piping plovers were observed near the New River Inlet (Fussell, 1991). These birds primarily inhabit shore line areas and, therefore, are not expected to be found at Site 2. Bachmans sparrows and Red-cockaded woodpeckers were observed at numerous locations throughout southern MCB Camp Lejeune. None of these species were observed at Site 2 during intensive investigations previously conducted for MCB Camp Lejeune, therefore, there is a low potential for them to exist at Site 2 (Fussell, 1991; Walters, 1991).

Sea turtles and sea turtle nests have been observed downstream of Site 2 in the New River on Onslow Beach. Sea turtles do not swim very far up the New River because of the low salinity, therefore, they are not expected to inhabit areas of Site 2 (USMC, 1991). The American alligator is known to inhabit the New River Estuary and has been observed in Wallace Creek, which is a tributary to the New River, south of Northeast Creek. Therefore, there is the potential for the alligator to inhabit Northeast Creek, and possibly the lower reaches of Overs Creek.

A protected floral species and special-interest community survey previously was conducted at Camp Lejeune (LeBlond, 1991). From this list, the Rough-leaf loosestrife was the only Federally threatened or endangered plant species found on the Marine Corps Base. Several state endangered or threatened and Federal and state candidate species were found on the MCB. None of these protected floral species were identified at Site 2 during this previous investigation (LeBlond, 1991).

Other Sensitive Environments

In addition to wetlands and protected species, the presence of other sensitive environments, including those listed in 40 CFR Part 300, were evaluated. These sensitive environments are evaluated when assessing potential hazardous waste sites using the Hazard Ranking System. These sensitive environments and their presence or absence at Site 2 are discussed below.

- Marine Sanctuary - Site 2 is not located within a Marine Sanctuary (NCMFC, 1992).

- National Park - Site 2 is not located within a National Park (NPS, 1991).

- Designated Federal Wilderness Area - Site 2 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 portion of Northeast Creek downstream of Overs Creek, and Overs Creek are designated as coastal waters by the Marine Resources Commission (NCMFC, 1992). Activities in coastal waters, along with any land disturbing activities (e.g., construction, digging, etc.) within the water and within the 75 feet buffer zone will require a permit or authorization under CAMA (NC DEHNR, 1993a).

- Sensitive Areas Identified under the National Estuary Program (NEP) or Near Coastal Waters Program (NCWP) - Site 2 is not located within a Sensitive Area identified under the NEP or NCWP (USEPA, 1993).

- Critical Areas Identified under the Clean Lakes Program - Site 2 is not located within a Critical Area identified under the Clean Lakes Program (NPS, 1991).

- National Monument - Site 2 is not located within a National Monument (NPS, 1991).

- National Seashore Recreational Area - Site 2 is not located within a National Seashore Recreational Area (NPS, 1991).

- National Lakeshore Recreational Area - Site 2 is not located within a National Lakeshore Recreational Area (NPS, 1991).

- National Preserve - Site 2 is not located within a National Preserve (NPS, 1991).

- National or State Wildlife Refuge - Site 2 is not located within a National or State Wildlife Refuge (NCWRC, 1992).

- Unit of the Coastal Barrier Resource Program - Site 2 is not located within a unit of the Coastal Barrier Resource Program (USDI, 1993).

- Administratively Proposed Federal Wilderness Area - Site 2 is not located within an Administratively Proposed Federal Wilderness Area (WS, 1989, 1993).

- Spawning Areas Critical for the maintenance of fish/shellfish species within river, lake, or coastal tidal waters - There are probable spawning areas for resident fish species within the lower reaches of Overs Creek. However, no specific spawning areas critical for the maintenance of fish/shellfish species in Overs Creek have been designated as such by state agencies (NC DEHNR, 1993b).

- 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 2 are not migratory pathways or feeding areas critical for the maintenance of anadromous fish species because there is not a significant population of anadromous fish in Overs Creek, Northeast Creek, or the New River downstream of Northeast Creek (NC DEHNR, 1993b).

- Terrestrial areas utilized for breeding by large or dense aggregations of animals - As discussed in the Regional Ecology section of this report, several large and dense aggregations of terrestrial species inhabit MCB Camp Lejeune. Therefore, there is the potential for breeding of these animals on, or adjacent to, Site 2.

- National river reach designated as Recreational - Overs Creek or Northeast Creek are not designated as National Recreational Rivers (NPS, 1990, 1993).

- Federal designated Scenic or Wild River - Overs Creek or Northeast Creek are not Federally designated Scenic or Wild Rivers (NPS, 1990, 1993).

- State land designated for wildlife or game management - Site 2 is not located within a State game land (NCWRC, 1992).

- State designated Scenic or Wild River - Overs Creek or Northeast Creek are not State designated Scenic or Wild Rivers (NCMFC, 1992).

- State designated Natural Area - Site 2 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 2 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, 1992b). The section of Northeast Creek to which Overs Creek discharges, is designated as a primary nursery area by the MFC (NC DEHNR, 1992b).

- Areas of Significant Value - Site 2 is not located within a State Area of Significant Value (LeBlond, 1991).

- State Registered Natural Resource Area - Site 2 is not located within a State Registered Natural Resource Area (LeBlond, 1991).

7.3.1.3 Exposure Analysis/Profile

The next step in the characterization of exposure is to combine the spatial and temporal distributions of both the ecological component and the stressor to evaluate exposure. This section of the ERA addresses and quantifies each exposure pathway via surface water, sediment, soil, groundwater, and air.

To determine if ecological exposure via these pathways may occur in the absence of remedial actions, an analysis was conducted including the identification and characterization of the exposure pathways. 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 2 including surface water, sediments, soil, groundwater and air.

Surface Water Exposure Pathway

Potential release sources to be considered when evaluating the surface water pathway are contaminated surface soils and groundwater. The release mechanisms to be considered are surface runoff and groundwater seepage. The potential routes to be considered for ecological exposure to the contaminated surface waters are ingestion and dermal contact. Potential exposure points for ecological receptors include species living in, or coming in contact with, the surface water on-site or off-site and downgradient relative to tidal influence.

Contaminants of potential concern were detected in the surface water demonstrating a release from a source to the surface water transport medium. Potential receptors that may be exposed to the COPCs in surface waters include: fish, benthic macroinvertebrates, deer, birds, and other aquatic and terrestrial life.

Aquatic organisms (i.e. fish, benthic macroinvertebrates) are exposed to contaminants in the surface water by ingesting water while feeding and by direct contact. In addition, 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. Potential decreased viability of aquatic receptors from COPCs in the surface water were evaluated in this ERA by direct comparisons of contaminant concentrations in the surface water to published water quality standards and criteria.

Terrestrial faunal receptors potentially are 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 reside in the contaminated waters. In addition, terrestrial species may ingest organisms (e.g., fish, insects, plants) that have bioconcentrated contaminants from the surface water. Potential decreased viability of terrestrial receptors from COPCs in the surface water was evaluated in this ERA by estimating the CDI dose and comparing this dose to TRVs representing acceptable daily doses in mg/kg/day.

Sediment Exposure Pathway

The potential release source to be considered in evaluating the sediment pathway are contaminated surface soils and groundwater. The release mechanisms to be considered are groundwater seepage and surface runoff. The potential routes to be considered for ecological exposure to the contaminated sediments are ingestion and dermal contact. Potential exposure points for ecological receptors include species living in, or coming in contact with, the sediments.

Contaminants of potential concern were detected in the sediment demonstrating a release from a source to the sediment transport medium. Potential receptors that may be exposed to contaminated sediments include benthic macroinvertebrates, bottom feeding fish, aquatic vegetation and other aquatic life.

Aquatic organisms (i.e. fish, benthic macroinvertebrates) are exposed to contaminants in the sediments by ingesting sediments 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. Potential decreased viability of aquatic receptors from contaminants in the sediment were evaluated in this ERA by direct comparisons of contaminant concentrations in the sediments to NOAA SSVs.

Terrestrial faunal receptors potentially are exposed to contaminants in the sediments through ingestion and dermal contact. The magnitude of the exposure depends on their feeding habits and the amount of time they reside in the contaminated sediments. In addition, terrestrial species may ingest organisms (e.g., fish, insects, plants) that have bioconcentrated contaminants from the sediments. Potential decreased viability of terrestrial receptors from contaminants in the sediments was qualitatively evaluated in this ERA.

Soil Exposure Pathway

Potential release sources to be considered in evaluating the soil pathway are surface or buried wastes and contaminated soil. The release mechanisms to be considered are fugitive dust, leaching, tracking, and surface runoff. The transport medium is the soil. The potential routes to be considered for ecological exposure to the contaminated soils are ingestion and dermal contact. Potential exposure points for ecological receptors include species living in, or coming in contact with, the soils.

Contaminants of potential concern were detected in the surface soil demonstrating a release from a source to the surface soil transport medium. Potential receptors that may be exposed to contaminants in surface soil at/or around surface soil in the areas of detected COPCs include: rabbits, birds, plants, and other terrestrial life.

Terrestrial receptors potentially are exposed to contaminants in the soils through ingestion, dermal contact, and/or direct uptake (for flora). The magnitude of the exposure depends on their feeding habits and the amount of time they reside in the contaminated soils. In addition, terrestrial species may ingest organisms (e.g., insects, plants) that have bioconcentrated contaminants from the soils. Potential decreased viability of terrestrial receptors from contaminants in the surface soils was evaluated in this ERA by estimating the CDI dose and comparing this dose to TRVs representing acceptable daily doses in mg/kg/day, and direct comparisons of soil concentrations to literature toxicity value for plants and invertebrates.

Groundwater Exposure Pathway

The potential release source to be considered in evaluating the groundwater pathway are contaminated soils. The release mechanism to be considered is leaching. The routes to be considered for ecological exposure to the contaminated groundwater are ingestion and dermal contact. Groundwater discharge to area surface waters may represent a pathway for contaminant migration. Since organisms are not directly exposed groundwater at Site 2, the groundwater to surface water exposure will be evaluated in the surface water section of the ERA.

Air Exposure Pathway

There are two potential release mechanisms to be considered in evaluating the atmospheric pathway: release of contaminated particulates and volatilization from surface soil, groundwater and surface water. The potential exposure points for receptors are areas on, or adjacent to the site.

No data has 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 viability 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 standards and screening values. Potential ecological effects to terrestrial receptors were evaluated by comparison of soil concentrations of COPCs to literature toxicity values for plants and invertebrates, and by comparing the CDIs to TRVs. The following sections further discuss these comparisons used to evaluate the potential ecological effects to aquatic and terrestrial receptors from the COPCs at Site 2.

7.3.2.1 Water Quality

Table 7-4 contains the freshwater North Carolina WQSs and the USEPA WQSVs for the COPCs detected in the Railroad Track Drainage Ditches. Table 7-5 contains the saltwater North Carolina WQSs and the USEPA WQSVs for the COPCs detected in Overs Creek. This data was used to evaluate decreased viability of aquatic organisms from COPCs in the surface water.

The water quality values for the following metals in freshwater are water hardness dependent: cadmium, chromium III, copper, lead, and zinc. In general, the higher the water hardness (in mg/L of $CaCO_3$) the higher the water quality value. A hardness concentration of 50 mg/L $CaCO_3$ was used to calculate these values since actual hardness data was not available.

The following COPCs detected in the surface water samples do not have freshwater and saltwater WQSs or WQSVs for them: aluminum, barium, iron, manganese, and vanadium. The potential impact to aquatic species from these chemicals in the surface water was evaluated using the results of acute and chronic tests obtained from the AQUIRE database (AQUIRE, 1993).

7.3.2.2 Sediment Quality

Table 7-6 contains the NOAA SSVs for hazardous waste sites for the COPCs at Site 2 before the TCRA of the sediments. Table 7-7 contains the NOAA SSVs for hazardous waste sites for the COPCs at Site 2 after the TCRA of the sediments. All the sediment samples at Site 2 were grouped together for summary statistics, so Tables 7-6 and 7-7 include the sediment data from all the samples. Sediment samples were collected from zero to six inches, and six to twelve inches at each of the sediment stations so there were two samples from each station. This data was used to evaluate decreased viability of aquatic organisms from COPCs in the sediment.

The following COPCs detected in the sediments do not have NOAA SSVs for them: aluminum, barium, beryllium, iron, manganese, vanadium, endosulfan II, and ethylbenzene. There is limited, if any, data assessing the effects on aquatic organisms exposed to these chemicals in sediment samples. Therefore, the effects of these chemicals on aquatic organisms was not determined.

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 soils contaminated by the following chemicals were obtained from various studies in the literature: arsenic, barium, beryllium, chromium, copper, lead, manganese, mercury, silver, vanadium, and zinc. This data was used to evaluate decreased viability of terrestrial flora and invertebrates from COPCs in the soil.

7.3.2.4 Terrestrial Chronic Daily Intake

As discussed above, there are no standards, criteria, or other screening values for assessing potential impacts to terrestrial ecological receptors from contaminants in soils. However, there are models that can be used to estimate the exposure of contaminants to terrestrial receptors. The following describes the procedures used to evaluate the potential soil exposure to terrestrial fauna at Site 2 by both direct and indirect exposure to COPCs via surface water, soil, and food-chain transfer.

Contaminants of potential concern at Site 2 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, and the bobwhite quail. The exposure points for these receptors are the surface soils, surface water, and vegetation. The routes for terrestrial exposure to the COPCs in the soil and water are incidental soil ingestion, surface water ingestion, and vegetation ingestion.

Total exposure of the terrestrial receptors to the COPCs in the soil and surface waters was determined by estimating the CDI dose and comparing this dose to TRVs representing acceptable daily doses in mg/kg/day. For this analysis, TRVs were developed from NOAELs or LOAELs obtained from IRIS (IRIS, 1993) or other toxicological data in the literature (Table 7-8).

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 2 from contaminants identified at the site.

The risk characterization utilizes laboratory analytical results from the environmental media samples collected during the RI. The analytical results are presented and discussed in Section 4.0 - Nature and Extent of Contamination. This section also includes a comparison of pesticide concentrations at Site 2 with pesticides found throughout MCB Camp Lejeune.

Tables 7-4 and 7-5 contain a comparison of the COPCs identified in the surface water to the standards and screening values to determine if they exceeded the published values. In addition, data from AQUIRE was used to evaluate aluminum, barium, iron, manganese, and vanadium since these COPCs did not have freshwater and saltwater WQSs or WQSVs. The maximum detected concentration of these chemicals in the surface water were below the adverse effects levels obtained from the database. Therefore, no decrease in viability of ecological receptors from these chemicals is expected. Figures 4-15 through 4-18 graphically display which contaminants exceeded the standards or screening values in each sample. The QI of the maximum detected value, and WQS and WQSVs were calculated for each COPC (see Table 7-9). The 95 percent upper confidence interval was not used because it was higher than the maximum. A QI greater than unity indicates a potential for decreased viability of aquatic life.

Tables 7-6 and 7-7 contain a comparison of the COPCs identified in the sediment to the ARARs to determine if they exceeded the published values. Figures 4-11 through 4-14 graphically display which contaminants exceeded the standards or screening values in each sample. The QI of the log normal 95 percent confidence interval or maximum detected value and the ER-L and ER-M were calculated for each COPC (see Table 7-10). A QI greater than unity indicates a possibility for adverse effects to aquatic life, and USEPA recommends conducting toxicity tests as a follow-up.

Total exposure of the terrestrial receptors to the COPCs in the soil and surface waters was determined by estimating the CDI dose and comparing this dose to TRVs representing acceptable daily doses in mg/kg/day. The estimated CDI dose of the receptors to soils, surface water, and vegetation was determined using the following equation:

$$E = \frac{(Cw)(Iw) + \left[(Cs)(Bv)(Iv) + (Cs)(Is) \right][H]}{BW}$$

Where:

E = 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, 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

Bioconcentration of the COPCs was calculated using the soil to plant transfer coefficient (Bv) for organic (Travis, 1988) and metals (Baes, 1984). The concentrations of the COPCs in the soil (Cs), were the maximum detected concentration of each COPC in the Former Storage Area and the Lawn and Mixing Pad Areas. The concentrations of each COPC in the surface water were the maximum detected value from Overs Creek and the Railroad Track Drainage Ditches since the 95 percent upper confidence interval was greater than the maximum value.

The exposure parameters used in the CDI calculations are presented in Table 7-11 and are summarized for each receptor below.

For the white-tailed deer, the feeding rate is 1.6 kg/day (Dee, 1991). The incidental soil ingestion rate is 0.019 kg/day (Scarano, 1993). The rate of drinking water ingestion is 1.1 L/day (Dee, 1991). The rate of vegetation ingestion is 1.6 kg/day. The body weight is 45.4 kg (Newell, 1987), and the home range is 454 acres (USDI, 1984).

For the cottontail rabbit, the feeding rate is 0.1 kg/day (Newell, 1987). The incidental soil ingestion rate is 0.002 kg/day (Newell, 1987). The rate of drinking water ingestion is 0.185 L/day (Federal Register, 1993). The rate of vegetation ingestion is 0.1 kg/day. The body weight is 2 kg (Newell, 1987), and the home range is 10 acres (USDI, 1985).

For the bobwhite quail, the feeding rate is 0.01 kg/day (Newell, 1987). The incidental soil ingestion rate is 0.001 kg/day (Newell, 1987). The rate of drinking water ingestion is 0.013 L/day (Federal Register, 1993). The rate of vegetation ingestion is 0.01 kg/day. The body weight is 0.1 kg (Newell, 1987), and the home range is 12.1 acres (USDI, 1985).

The QI approach was used to characterize the risk to terrestrial receptors. This approach characterized the potential effects by comparing the CDIs for each COPCs to the TRVs and is calculated as follows:

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

Where:

QI = Quotient Index
E = Total Exposure, mg/kg/day

TRV = Terrestrial Reference Value, mg/kg/day

Tables 7-12 through 7-14 contain the QI for the COPCs in each of the areas. A QI of less than unity indicate a low likelihood of adverse effects while a QI above unity indicate the likelihood of an adverse effect to the receptor.

The following sections discuss the results of the standards and screening value comparisons as they relate to each of the media at the site. Also included in these sections is the terrestrial CDI compared to the TRVs, the COPCs in the soils compared to published soil toxicity data, and an evaluation of the potential impacts to threatened and endangered species, wetlands, and other sensitive environments.

7.4.1 Overs Creek

The following sections discuss the results of the risk characterization in Overs Creek. These sections contain a comparison of the contaminants detected in the surface water (see Table 7-5) and sediments (see Table 7-6) to their respective standards and screening values.

7.4.1.1 Water Quality

Two surface water samples collected in Overs Creek were analyzed for TCL organics, TCL PCBs, and TAL inorganics. Three surface water samples collected in Overs Creek were analyzed for TCL pesticides. Copper exceeded the WQS, and the acute and chronic WQSVs in both of the surface water samples analyzed for TAL inorganics with a QI of 2.33 for the WQS, and 2.41 for the acute and chronic WQSVs. No other TAL inorganics exceeded any of the surface water standards or screening values in Overs Creek. None of the TCL organics, TCL PCBs, or TCL pesticides exceeded any of the surface water standards or screening values in Overs Creek.

Copper exceeded the acute and chronic water quality values in both samples in Overs Creek, downstream and upstream of the confluence with the Railroad Track Drainage Ditches. The downstream sample contained 7 µg/L of copper, while the upstream sample contained 4 µg/L of copper. Because only one upstream sample and one downstream sample was collected and analyzed for TAL inorganics in Overs Creek, the difference in copper concentrations between the two samples could not be statistically evaluated. Copper use at Site 2 has not been documented, and it is a naturally occurring metal.

7.4.1.2 Sediment Quality

Sediment samples collected from two stations in Overs Creek were analyzed for TCL organics, TCL PCBs, and TAL inorganics, while sediment samples collected from three stations in Overs Creek were analyzed for TCL pesticides. None of the TCL organics, TCL PCBs, or TAL inorganics in Overs Creek exceeded the SSVs. 4,4'-DDE exceeded the ER-L in four samples, and the ER-M in three samples. 4,4'-DDD exceeded the ER-L in five samples, and the ER-M in three samples. 4,4'-DDT exceeded the ER-L in four samples, and the ER-M in three samples.

The following COPCs had QIs greater than unity when compared to the ER-L and ER-M values before and after the proposed sediment TCRA: dieldrin, 4,4'-DDE, 4,4'-DDT, alpha-chlordane, and gamma chlordane. All the sediment samples at Site 2 were grouped for the statistics, and the 95 percent confidence interval from this grouping was used when calculating the QI. The maximum concentrations of pesticides were significantly higher in the samples collected in the Railroad Track Drainage Ditches than in Overs Creek or the Holcomb Boulevard Drainage Area.

Several of the pesticide COPCs detected in the sediments in Overs Creek exceeded the screening values, therefore, there is a potential for a decreased viability of aquatic life in Overs Creek from the pesticide COPCs in the sediments. The pesticides from Site 2 do not appear to be migrating very far from the site as indicated by the sharp decrease in pesticide concentrations in the sediment in Overs Creek as compared to the pesticide concentrations in the Railroad Track Drainage Ditches. In addition, pesticides concentrations in Overs Creek are at similar concentrations as those found throughout MCB Camp Lejeune (see Section __). Therefore, the pesticide concentration in Overs Creek may be due to the widespread pesticide spraying that has occurred at MCB Camp Lejeune.

7.4.2 Railroad Drainage Ditches

The following sections discuss the results of the risk characterization in the Railroad Track Drainage Ditches. These sections contain a comparison of the contaminants detected in the surface water (see Table 7-4) and sediments (see Tables 7-6 and 7-7) to their respective standards and screening values.

7.4.2.1 Water Quality

One surface water sample collected in the Railroad Track Drainage Ditches was analyzed for TAL inorganics. In this sample, aluminum exceeded the acute and chronic WQSVs, beryllium exceeded the chronic WQSV, chromium exceeded the chronic WQSV and copper exceeded the WQS and the acute and chronic WQSVs. Iron exceeded the WQS and chronic WQSV, lead exceeded the chronic WQSV, and zinc exceeded the WQS and the acute and chronic WQSVs. No other TAL inorganics detected in the Railroad Track Drainage Ditches exceeded any of the surface water standards or screening values. Aluminum, beryllium, copper, iron, lead, zinc occur naturally in the environment. Their use at Site 2 has not been documented.

Four surface water samples collected in the Railroad Track Drainage Ditches were analyzed for TCL pesticides. 4,4'-DDD exceeded the acute and chronic WQSV in all four of the surface water samples and 4,4'-DDT exceeded the WQS and chronic WQSV in all two of the surface water samples. No other TCL pesticides or organics detected in the Railroad Drainage Ditch exceeded any of the surface water ARARs. Pesticide use at Site 2 has been documented, and therefore, these pesticides appear to be site-related.

The following COPCs in the Railroad Track Drainage Ditches had QIs greater than unity when compared to the WQSs: copper, iron, zinc, and 4,4'-DDT. The following COPCs had ratios greater than unity when compared to the acute WQSV: aluminum, copper, zinc, and 4,4'-DDD. The following COPCs had ratios greater than unity when compared to the chronic WQSV: aluminum, beryllium, copper, iron, lead, zinc, 4,4'-DDD, and 4,4'-DDT.

The surface water in the Railroad Track Drainage Ditches are normally shallow and intermittent in flow so the aquatic ecology in this ditch is most likely stressed by naturally occurring changes in the physical characteristics (e.g., temperature, low dissolved oxygen, drought conditions). Therefore, although there is a potential for decreased viability of aquatic life from COPCs in the surface water, there is not expected to be an ecologically significant aquatic population in the Railroad Track Drainage Ditches to be impacted.

7.4.2.2 Sediment Quality

Sediment samples collected from seven, eight, and twelve stations in the Railroad Track Drainage Ditches were analyzed for TCL organics, TCL semivolatiles and TCL PCBs, respectively. None of these contaminants exceeded the ER-L of ER-M values in any of the samples.

Sediment samples collected from eight stations in the Railroad Track Drainage Ditches were analyzed for TAL inorganics. Lead exceeded the ER-L in one sample and zinc was equal to the ER-L in one sample. No other TAL inorganics exceeded the ER-L of ER-M values in any of the samples. Lead and zinc occur naturally in the environment. Their use at Site 2 has not been documented.

Sediment samples collected from 19 stations in the Railroad Track Drainage Ditches were analyzed for TCL pesticides. 4,4'-DDE exceeded the ER-L in 30 samples, and the ER-M in 29 samples. 4,4'-DDD exceeded the ER-L in 37 samples, and the ER-M in 27 samples. 4,4'-DDT exceeded the ER-L in 35 samples, and the ER-M in 31 samples. Alpha-chlordane exceeded the ER-L (for total chlordane) in 11 samples, and the ER-M (for total chlordane) in eight samples. Finally, gamma-chlordane exceeded the ER-L (for total chlordane) in seven samples, and the ER-M (for total chlordane) in five samples.

Pesticide use at Site 2 has been documented, and therefore, these pesticides appear to be site-related. As discussed in the section above, the aquatic ecology in the Railroad Track Drainage Ditches are most likely stressed by naturally occurring changes in the physical characteristics. Therefore, although there is a potential for decreased viability of aquatic life from COPCs in the sediment, there is not expected to be an ecologically significant aquatic population in the Railroad Track Drainage Ditches to be impacted.

7.4.2.3 Sediment Quality-Post TCRA

The five sediment samples that will be removed during the proposes TCRA are all located in the Railroad Track Drainage Ditches. After the sediment TCRA, zinc will be equal to the ER-L in one sample. No other TAL inorganics will exceed the ER-L or ER-M values in any of the remaining samples.

Of the remaining samples, 4,4'-DDE will exceed the ER-L in 23 samples, and the ER-M in 21 samples. 4,4'-DDD will exceed the ER-L in 27 samples, and the ER-M in 19 samples. 4,4'-DDT will exceed the ER-L in 27 samples, and the ER-M in 18 samples. Alpha-chlordane will exceed the ER-L (for total chlordane) in seven samples, and the ER-M (for total chlordane) in five samples. Finally, gamma-chlordane will exceed the ER-L (for total chlordane) in four samples, and the ER-M (for total chlordane) in three samples.

As discussed in the section above, the aquatic ecology in the Railroad Track Drainage Ditches is most likely stressed by naturally occurring changes in the physical characteristics. Therefore, although there is a potential for decreased viability of aquatic life from COPCs in the sediment, there is not expected to be an ecologically significant aquatic population in the Railroad Track Drainage Ditches to be impacted.

7.4.3 Holcomb Boulevard Drainage Ditch

The following sections discuss the results of the risk characterization in Holcomb Boulevard Drainage Ditch. These sections contain a comparison of the contaminants detected in the sediments (see Table 7-6) to their screening values.

7.4.3.1 Water Quality

No surface water samples were collected in the Holcomb Boulevard Drainage Ditch because water not present at the time of the sampling.

7.4.3.2 Sediment Quality

Sediment samples collected from both stations in the Holcomb Boulevard Drainage Ditch were analyzed for TCL PCBs and TCL pesticides. 4,4'-DDE exceeded the ER-L in four samples, and the ER-M in three samples. 4,4'-DDD exceeded the ER-L in four samples, and the ER-M in one sample. 4,4'-DDT exceeded the ER-L in four samples, and the ER-M in three samples. Dieldrin exceeded the ER-L in two samples and the ER-M in one sample. Alpha-chlordane exceeded the ER-L (for total chlordane) in three samples, and the ER-M (for total chlordane) in one sample. Finally, gamma-chlordane exceeded the ER-L (for total chlordane) in three samples, and the ER-M (for total chlordane) in one sample.

Pesticide use at Site 2 has been documented, however, pesticide concentrations in the Holcomb Boulevard Drainage Ditch are of similar concentrations as those found throughout MCB Camp Lejeune. Therefore, the pesticide concentrations in the Holcomb Boulevard Drainage Ditch may be due to the widespread pesticide spraying that has occurred at MCB Camp Lejeune.

There was no water in this drainage area at the time of the sampling. Therefore, although there is the potential for adverse impacts to aquatic life in the Holcomb Boulevard Drainage Ditch due to the pesticide COPCs in the sediments, there is not expected to be an ecologically significant aquatic population in this drainage area to be impacted.

7.4.4 Lawn and Mixing Pad Areas

The following sections discuss the results of the risk characterization in Lawn and Mixing Pad Areas. These sections contain a comparison of the COPCs detected in the surface soils to the concentrations of the contaminants in soil that caused adverse effects to plants and terrestrial invertebrates. This data was obtained from various sources in the literature.

7.4.4.1 Soil Quality

Arsenic concentrations ranged from 0.52 to 4.3 mg/kg in the surface soils at the Lawn and Mixing Pad Areas which were below the 25 mg/kg that depressed crop yields (USDI, 1988). Barium concentrations ranged from 5.1 to 25.9 mg/kg, which were below the 2,000 mg/kg that induce plant toxicity (Adriano, 1986). Beryllium concentrations of 0.22 mg/kg were found in the surface soils which were below the 0.500 mg/kg limit for neutral to alkaline fine-textured soils (Adriano, 1986). Chromium concentrations of 3 to 12.7 mg/kg were found in the surface soils which is greater than the 10 mg/kg in soil caused mortality in the earthworm species Pheretima pesthuma, (Hopkin, 1989).

Copper concentrations ranged from 0.46 to 19.9 mg/kg, which were below the 50 mg/kg level that interfered with the reproduction activity of the earthworm species Allolobuphora caliginosa (Hopkin, 1989). The phytoxicity of lead was reported to be lower than that of copper (50 mg/kg); lead concentrations ranged from 5.7 to 225 which were greater than this concentration (Adriano, 1986). Manganese concentrations ranged from 2.1 to 63.9 mg/kg which were are lower than the mean U.S. soil concentration of 560 mg/kg (Adriano, 1986).

Mercury concentrations ranged from 0.25 to 0.69 mg/kg in the surface soils, which is less than the 0.79 mg/kg that caused toxicity to earthworms. (USDI, 1987). Vanadium concentrations ranged from 3.1 to 14.5 mg/kg in the surface soils which was less than the U.S. average of 58 mg/kg in soils (Adriano, 1986). Finally, zinc concentrations ranged from 3.8 to 52.8 which are less than the 450 to 1,400 mg/kg that caused plant toxicity (Adriano, 1986).

In summary, chromium and lead were the only inorganic COPCs detected in the surface soils at concentrations that potentially may decrease the viability of terrestrial invertebrates and flora in this area. Chromium and lead occur naturally in the environment. Their use at Site 2 has not been documented and therefore, they do not appear to be site related.

7.4.4.2 Soil Quality-Post TCRA

After the proposed TCRA of soils in the Lawn and Mixing Pad Areas, arsenic concentrations will range from 0.52 to 1.1 mg/kg, which will be less than the 25 mg/kg that have been reported to depressed crop yields (USDI, 1988). Barium concentrations in the surface soils will range from 5.1 to 21.4 mg/kg, which is less than the 2,000 mg/kg that induce plant toxicity (Adriano, 1986). Chromium concentrations will range from 3 to 6.2J mg/kg in the surface soil which is less than the 10 mg/kg in soil caused mortality in the earthworm species Pheretima pesthuma (Hopkin, 1989).

Copper concentrations will range from 0.46 to 6.8 mg/kg, which will be less than the 50 mg/kg level that interfered with the reproduction activity of the earthworm species Allolobuphora caliginosa (Hopkin, 1989). The phytoxicity of lead was reported to be lower than that of copper (50 mg/kg); lead will be detected at concentrations of 6.9 to 133 mg/kg in the surface soils which will be higher than this concentration (Adriano, 1986). Manganese concentrations will range from 2.1 to 11.3 mg/kg in the surface soils which will be less than the mean U.S. soil concentration of 560 mg/kg (Adriano, 1986).

Vanadium concentrations will range from 3.1 to 8.8 mg/kg in the surface soils which will be less than the U.S. average of 58 mg/kg in soils (Adriano, 1986). Finally, zinc concentrations will range from 3.8 to 52.8 mg/kg in the surface soils which will be less than the 450 to 1,400 mg/kg that caused plant toxicity (Adriano, 1986). Beryllium, mercury and silver will not be detected in the surface soils after the proposed TCRA.

In summary, lead was the only inorganic COPC detected in the surface soils in the Lawn and Mixing Pad Areas after the proposed TCRA at concentrations that potentially may decrease the viability of terrestrial invertebrates and flora in this area. Lead occurs naturally in the environment. Its use at Site 2 has not been documented.

7.4.5 Former Storage Area

The following sections discuss the results of the risk characterization in Former Storage Area.

7.4.5.1 Soil Quality

In the surface soils at the Former Storage Area, arsenic concentrations ranged from 0.69J to 0.86 mg/kg which were below the 25 mg/kg that depressed crop yields (USDI, 1988). Barium concentrations ranged from 9.7 to 14 mg/kg, which were below the 2,000 mg/kg that induced plant toxicity (Adriano, 1986). Beryllium concentrations ranged from 0.23 to 0.24 mg/kg which were below the 500 mg/kg limit for neutral to alkaline fine-textured soils (Adriano, 1986). Chromium concentrations ranged from 6.6 to 9.8 mg/kg in the surface soils which were less than the 10 mg/kg in soils that caused mortality in the earthworm species Pheretima pesthuma (Hopkin, 1989).

Copper concentrations ranged from 0.47 to 8.2 mg/kg, which were below the 50 mg/kg level that interfered with the reproduction activity of the earthworm species Allolobuphora caliginosa (Hopkin, 1989). The phytoxicity of lead was reported to be lower than that of copper (50 mg/kg); lead concentrations in the surface soils at the Former Storage Area ranged from 5.6 to 10.4 mg/kg which was lower than this concentration (Adriano, 1986). Manganese concentrations ranged from 5.9 to 20.4 mg/kg in the surface soils which is lower than the mean U.S. soil concentration of 560 mg/kg (Adriano, 1986). Mercury concentrations ranged from 0.34 to 0.44 mg/kg, which were less than the 0.79 mg/kg that caused toxicity to earthworms (USDI, 1987).

The silver concentration in the surface soils of 0.71 mg/kg is less than the 11 mg/kg that was lethal to bush beans in solution (Adriano, 1986). Vanadium concentrations ranged from 8.5 to 11.2 mg/kg in the surface soils which was less than the U.S. average of 58 mg/kg in soils (Adriano, 1986). Finally, zinc concentrations ranged from 7.5 to 51.9 mg/kg which are less than the 450 to 1,400 mg/kg that caused plant toxicity (Adriano, 1986).

None of the inorganic COPCs were detected in the surface soils at concentrations that potentially may decrease the viability of terrestrial invertebrates and flora in this area.

7.4.5.2 Soil Quality - Post TCRA

None of the inorganic COPCs were detected at the Former Storage Area in the surface soils at concentration that potentially may decrease the visibility of terrestrial invertebrates and flora. Therefore, an evaluation of the potential effects of terrestrial invertebrates and flora in the surface soils after the proposed TCRA was not conducted.

7.4.6 Terrestrial Chronic Daily Intake Model

The CDI model was used to assess decreased viability of terrestrial species from exposure to contaminants in surface water and surface soils. The surface soil data was grouped separately for the Former Storage Area and the Mixing Pad Area for the statistics. Therefore, QI was calculated for each area (Note: the surface water samples were included in the calculations for each area).

In the Former Storage Area before and after the proposed TCRA, the QI of the CDI to the TRVs for each of the COPCs were less than unity for each of the three species (see Tables 7-12 and 7-13). Overall, the QIs for the pesticides were the highest. The total QI of all the COPCs in the Former Storage Area before the proposed TCRA was 0.230 for the quail, 0.538 for the rabbit, and 0.00344 for the deer, and 0.0857 for the quail, 0.0346 for the rabbit, and 0.00325 for the deer after the proposed TCRA. This difference between the species is based primarily on the difference in size of their home range, with the quails home range being the smallest, and the deer's home range being the largest. Therefore, there is a low likelihood that the COPCs in the surface water and surface soils in the Former Storage Area are decreasing the viability of terrestrial species.

In the Lawn and Mixing Pad Areas before the proposed TCRA of the soils, the QI of the CDI to the TRVs for each of the COPCs were greater than unity for the quail and the rabbit (see Table 7-14). The QIs were greater than unity for the quail and rabbit. The QI was less than unity for the deer. Overall, the QIs for the pesticides were the highest. The total QI of all the COPCs in the Lawn and Mixing Pad Areas was 82 for the quail, 14.1 for the rabbit, and 0.163 for the deer. This difference is based primarily on the difference in size of their home range, with the quail's home range being the smallest, and the deer's home range being the largest.

Therefore, there is a high likelihood that the COPCs in the surface water and surface soils in the Lawn and Mixing Pad Areas are decreasing the viability of terrestrial species before the proposed TCRA of the soils.

Finally, in the Lawn and Mixing Pad Areas after the proposed TCRA of the soils, the QI of the CDI to the TRVs for each of the COPCs were less than unity for each of the three species (see Table 7-15). Overall, the QIs for the pesticides were the highest. The total QI of all the COPCs in the Lawn and Mixing Pad Areas was 0.123 for the quail, 0.0385 for the rabbit, and 0.00328 for the deer. This difference is based primarily on the difference in size of their home range, with the quail's home range being the smallest, and the deer's home range being the largest. Therefore, there is a low likelihood that the COPCs in the surface water and surface soils in the Lawn and Mixing Pad Areas are decreasing the viability of terrestrial species after the proposed TCRA of the soils.

7.4.7 Threatened and/or Endangered Species

Several threatened and/or endangered species inhabit MCB Camp Lejeune. However, none of these species are known to frequent with any regularity, or breed at Site 2. Therefore, potential adverse impacts to these protected species from contaminants at Site 2 appear to be low.

7.4.8 Flora/Wetlands

No wetlands were identified at Site 2 from the NWI maps, however, a site specific wetland study has not been conducted.

7.4.9 Other Sensitive Environments

Northeast Creek and Overs Creek are designated as coastal waters by the Marine Resources Commission. Activities in coastal waters, along with any land disturbing activities (e.g., construction, digging, etc.) within the water and within the 75 feet buffer zone will require a permit or authorization under CAMA (NCDEHNP, 1993a). For the tidal waters, any land disturbing activities (e.g., construction, digging, etc.) within the water and within the 75 feet buffer zone will require a permit or authorization. There do not appear to be any activities that will occur in the waters at these locations, and therefore no authorization under CAMA would be required for remedial activities at Site 2.

There are probably spawning areas for resident fish species within the lower reacher of Overs Creek. However, specific spawning areas critical for the maintenance of fish/shellfish species in Overs Creek have not been designated by state agencies. The potential impacts to the fish in these waters have already been discussed in this report. These same impacts would apply to fish in the spawning areas. However, the fish/shellfish in these spawning areas may be more susceptible to chemical stresses due to the higher sensitivity of the reproductive life stages of organisms to these types of stresses.

No areas within the boundaries of Site 2 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. However, it should be noted that the section of Northeast Creek in which Overs Creek discharges, is designated as a primary nursery area by the Marine Fisheries Commission. The potential impacts to the fish in these waters have already been discussed in this report. These same impacts would apply to fish in the nursery areas. However, the fish in these nursery areas may be more susceptible to chemical stresses due to the higher sensitivity of juvenile organisms to these types of stresses.

The potential impact to terrestrial organisms that are present at Site 2 is discussed in earlier sections of this report. The terrestrial organisms that may be breeding in contaminated areas at Site 2 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

The ecological significance section of this ERA summarizes the overall risks to the ecology at the site as a whole. This section is important to determine the overall impacts to the ecological integrity at the site from the COPCs detected in the media, and to determine which COPCs are impacting the site to the greatest degree. This section is also necessary to provide the risk managers with the requisite information, to be used in conjunction with the human health risk assessment, in order to determine the appropriate remedial action at the site for the protection of public health and the environment.

7.5.1 Aquatic Endpoints

The measurement endpoints used to assess the aquatic environment is decreased viability of aquatic organisms. Based on the potential habitat, and other physical characteristics, the most significant populations of aquatic organisms at the site potentially are in Overs Creek. The water in the Railroad Track Drainage Ditches and the Holcomb Boulevard Drainage Ditch was either shallow or nonexistent, and intermittent in flow. Therefore, there is not expected to be a significant population of aquatic life in these areas.

Copper was the only COPC detected in the surface water in Overs Creek at concentrations that exceeded any of the standards or screening values. It exceeded the criteria and screening value in both the upstream and downstream samples and does not appear site-related. Pesticides were detected in the sediments in Overs creek at concentrations that potentially may decrease the viability of aquatic life. These pesticides may be related to past storage and dispensing practices at Site 2, but is more likely due to the widespread pesticide spraying that has occurred at MCB Camp Lejeune because of the relatively low concentrations in the sediments.

Several of the inorganic and pesticide COPCs exceeded one or more of the standards or screening values in surface water and/or sediment samples collected in the Railroad Tank Drainage Ditches. Although there is a potential for decreased viability of aquatic life from COPCs in the surface water and/or sediments, there is not expected to be an ecologically significant aquatic population in this drainage area to be impacted.

Several of the pesticide COPCs exceeded one or more of the screening values in sediment samples collected in the Holcomb Boulevard Drainage Ditch. Although there is a potential for decreased viability of aquatic life in the Holcomb Boulevard Drainage Ditch from the pesticide COPCs in the sediments, there is not expected to be an ecologically significant aquatic population in this drainage area to be impacted.

Pesticides are not only potentially toxic to aquatic life through a direct exposure pathway, but as indicated by their high BCF value, they have a high potential to bioconcentrate pesticides in organisms. Aquatic life inhabiting Overs Creek and/or the Railroad Tank Drainage Ditches at Site 2 have the potential to bioconcentrate pesticides. Therefore, other fauna that feed upon these aquatic organisms will be exposed to pesticides via this indirect exposure pathway.

Overall, pesticides appear to be the most significant site-related COPCs that have the potential for decreasing the viability of aquatic organisms at Site 2.

7.5.2 Terrestrial Endpoints

The measurement endpoints used to assess the terrestrial environment is decreased viability of terrestrial organisms. Based on the soil toxicity data for plants and terrestrial invertebrates (earthworms), lead and chromium were detected in concentrations that potentially may decrease the viability of terrestrial invertebrates and floral species in the Mixing Pad Area surface soils. Lead was the only inorganic COPC detected in concentrations that potentially may decrease the viability of terrestrial invertebrates and floral species in the Mixing Pad Area after the proposed TCRA of surface soils. Finally, no inorganic COPCs were detected in concentrations that potentially may decrease the viability of terrestrial invertebrates and floral species in the Former Storage Area.

Other terrestrial organisms (e.g., rabbits, birds, deer) may be exposed to contaminants in the surface soils and surface water by ingestion. Based on the comparison of the CDI to the TRVs there is a low likelihood that the COPCs in the Former Storage Area are decreasing the viability of terrestrial organisms. In the soils at the Lawn and Mixing Pad Areas, there is a high likelihood that the COPCs are decreasing the viability of terrestrial organisms. This likelihood is based on a QI of greater than unity for the pesticides. After the proposed TCRA of soils at the Lawn and Mixing Pad Areas, there is a low likelihood that the COPCs in this area would decrease the viability of terrestrial organisms. This likelihood is based on a QI of less than unity for the pesticides.

Overall, pesticides appear to be the most significant site-related COPCs that have the potential for decreasing the viability of terrestrial organisms at Site 2.

7.5.3 Threatened and Endangered Species

Potential adverse impacts to threatened or endangered species from contaminants at Site 2 appear to be low, because none of these species are known to breed or frequent with any regularity at Site 2.

7.5.4 Wetlands

No wetlands were identified at Site 2 from the NWI maps.

7.5.5 Other Sensitive Environments

There are probably spawning and nursery areas for resident fish species within the lower reaches of Overs Creek. The pesticides from Site 2 do not appear to be migrating very far from the site as indicated by the sharp decrease in pesticide concentrations in the sediment in Overs Creek as compared to the pesticide concentrations in the Railroad Track Drainage Ditches. Therefore, there is a low potential for decreased viability of fish spawning or nursing in the lower reaches of Overs Creek.

7.5.6 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.

There is uncertainty in the ecological endpoint comparison. The values used in the ecological endpoint comparison (the WQS, WQSV or 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 ERA 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 ecological endpoints. Therefore, potential effects to ecological receptors from these chemicals cannot be determined.

The NOAA 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. In addition, the toxicity of several of the metals (cadmium, copper, lead, and zinc) to aquatic organisms increases or decreases based on water hardness. Because water hardness was not available, a default value of 50 mg/L of $CaCO_3$ was used. This default value may either over or underestimate the potential risks to aquatic organisms from COPCs in the surface water.

Several contaminants in the surface water and sediment exceeded applicable ARAR values. Many of the surface water and sediment samples were collected from areas that were not considered ecologically significant (drainage ditches). Therefore, although the ARARs may have been exceeded in these samples, the potential for them to impact aquatic life may not be significant.

Finally, there is also uncertainty in the CDI models used to evaluate decreased viability to terrestrial receptors. Many of the input parameters are based on default values (i.e., ingestion rate) that may or may not adequately represent to 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. Finally, terrestrial species will also be exposed to contaminants be ingesting fauna that have accumulated contaminants. This additional exposure route was not evaluated in this ERA because the high uncertainty associated with this exposure route.

TABLE 7-1

LIST OF CHEMICALS DETECTED IN THE SURFACE WATER, SEDIMENT, AND SURFACE SOIL
BASELINE ECOLOGICAL RISK ASSESSMENT
SITE 2 - REMEDIAL INVESTIGATION CTO-0174
MCB CAMP LEJEUNE, NORTH CAROLINA

Chemicals	Surface Water	Sediment	Sediment Post-TCRA	Surface Soils Former Storage Area	Surface Soils Former Storage Area Post-TCRA	Surface Soils Mixing Pad Area	Surface Soils Mixing Pad Area Post-TCRA
Aluminum	X	X	X	X	X	X	X
Antimony		X					
Arsenic	X	X	X	X	X	X	X
Barium	X	X	X	X	X	X	X
Beryllium	X	X	X	X	X	X	
Cadmium						X	X
Calcium	X	X	X	X	X	X	X
Chromium	X	X	X	X	X	X	X
Chrysene		X	X				
Cobalt						X	X
Copper	X	X	X	X	X	X	X
Cyanide							
Iron	X	X	X	X	X	X	X
Lead	X	X	X	X	X	X	X
Magnesium	X	X	X	X	X	X	X
Manganese	X	X	X	X	X	X	X

TCRA - Time Critical Removal Action

TABLE 7-1 (Continued)

LIST OF CHEMICALS DETECTED IN THE SURFACE WATER, SEDIMENT, AND SURFACE SOIL
BASELINE ECOLOGICAL RISK ASSESSMENT
SITE 2 - REMEDIAL INVESTIGATION CTO-0174
MCB CAMP LEJEUNE, NORTH CAROLINA

Chemicals	Surface Water	Sediment	Sediment Post-TCRA	Surface Soils Former Storage Area	Surface Soils Former Storage Area Post-TCRA	Surface Soils Mixing Pad Area	Surface Soils Mixing Pad Area Post-TCRA
Mercury				X	X	X	
Nickel							
Potassium	X	X	X	X	X	X	X
Selenium		X	X	X	X	X	
Silver				X	X	X	
Sodium	X	X	X	X	X	X	X
Thallium		X	X			X	X
Vanadium	X	X	X	X	X	X	X
Zinc	X	X	X	X	X	X	X
2-butanone		X		X	X		
2-methylnapthalene		X					
4,4'-DDD	X	X	X	X	X	X	X
4,4'-DDE		X	X	X	X	X	X
4,4'-DDT	X	X	X	X	X	X	X
4-methyl-2-pentanone							
Acenapthene		X					
Acetone	X	X	X	X	X		
Alpha-Chlorodane		X	X			X	X

TABLE 7-1 (Continued)

LIST OF CHEMICALS DETECTED IN THE SURFACE WATER, SEDIMENT, AND SURFACE SOIL BASELINE ECOLOGICAL RISK ASSESSMENT SITE 2 - REMEDIAL INVESTIGATION CTO-0174 MCB CAMP LEJEUNE, NORTH CAROLINA

Chemicals	Surface Water	Sediment	Sediment Post-TCRA	Surface Soils Former Storage Area	Surface Soils Former Storage Area Post-TCRA	Surface Soils Mixing Pad Area	Surface Soils Mixing Pad Area Post-TCRA
Benzo(a)anthracene		X	X				
Benzo(a)pyrene		X	X				
Benzo(b)fluoranthene		X	X				
Benzo(g,h,i)perylene							
Benzo(k)fluoranthene		X	X				
Bis(2-chloroethyl)ether							
Bis(2-ethylhexyl)phthalate				X		X	X
Carbon disulfide	X						
Chloroform	X						
Chyrsene							
Di-n-butyl phthalate				X	X	X	
Dibenzo(a,h)anthracene							
Dieldrin		X	X	X		X	
Endosulfan II		X					
Ethylbenzene		X					
Fluoranthene		X	X				
Fluorene		X					
Gamma-chlorodane		X	X			X	X
Heptachlor						X	

TABLE 7-1 (Continued)

LIST OF CHEMICALS DETECTED IN THE SURFACE WATER, SEDIMENT, AND SURFACE SOIL BASELINE ECOLOGICAL RISK ASSESSMENT SITE 2 - REMEDIAL INVESTIGATION CTO-0174 MCB CAMP LEJEUNE, NORTH CAROLINA

Chemicals	Surface Water	Sediment	Sediment Post-TCRA	Surface Soils Former Storage Area	Surface Soils Former Storage Area Post-TCRA	Surface Soils Mixing Pad Area	Surface Soils Mixing Pad Area Post-TCRA
Indeno(1,2,3-cd)pyrene							
Methylene chloride						X	X
Napthalene		X					
Phenanthrene		X					
Phenol							
Pyrene		X	X				
Toluene				X	X	X	X
Total Xylene		X		X	X	X	X

TCRA - Proposed Time Critical Removal Action

TABLE 7-2

PHYSICAL/CHEMICAL CHARACTERISTICS OF THE CONTAMINANTS OF POTENTIAL CONCERN BASELINE ECOLOGICAL RISK ASSESSMENT SITE 2 - REMEDIAL INVESTIGATION CT0-0174 MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminants of Potential Concern	BCF (L/kg)	Water Solubility (mg/l)	Organic Carbon Partition Coefficient (ml/g)(1)	Vapor Pressure (mm Hg)
Aluminum	ND(3)	ND(1, 2)	ND	ND(1)
Arsenic	350(3)	ND(1, 2)	ND	(1, 2)
Barium	ND(3)	ND(1, 2)	ND	(1, 2)
Beryllium	19(3)	ND(1, 2)	ND	(1, 2)
Chromium	190(3)	ND(1, 2)	ND	(1, 2)
Copper	23,000(3)	ND(1, 2)	ND	(1, 2)
Iron	ND(3)	ND(1, 2)	ND	ND(1)
Lead	1700(3)	ND(1, 2)	ND	(1, 2)
Manganese	350,000(3)	ND(1, 2)	ND	ND(1)
Mercury	86,000(3)	ND(1, 2)	ND	0.002(3)
Selenium	5,700(3)	ND(1, 2)	ND	(1, 2)
Silver	28(3)	ND(1, 2)	ND	(1, 2)
Vanadium	ND(1)	ND(1, 2)	ND	ND(1)
Zinc	970(3)	ND(1, 2)	ND	(1, 2)
Ethyl benzene	37.5(3)	170(3)	1,100	9.6(3)
Toluene	10.7(1)	535(3)	300	28.1(3)
Xylenes (total)	ND(1)	198(1)	240	10(1)
Dieldrin	6,800(3)	0.2(3)	1,700	(1, 2)
4,4'-DDE	51,000	(1, 2)	4,000,000	(1, 2)
4,4'-DDD	ND	(1, 2)	800,000	(1, 2)
4,4'-DDT	54,000	(1, 2)	200,000	(1, 2)
alpha-Chlordane(4)	14,000	0.56	140,000	1x10^{-5}
gamma-Chlordane (4)	14,000	0.56	140,000	1x10^{-5}
Heptachlor	15,700	0.18	12,000	0.0003
Endosulfan II	ND	ND	ND	ND

(1) U.S. EPA, 1986
(2) Negligible (less than 0.1)
(3) SPHEM, 1986
(4) Characteristics are for total chlordane

ND - No Data
BCF - Bioconcentration Factors

TABLE 7-3

PROTECTED SPECIES WITHIN MCB CAMP LEJEUNE
SITE 2 - REMEDIAL INVESTIGATION CTO-0174
MCB CAMP LEJEUNE, NORTH CAROLINA

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

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

* The observer did not differentiate between the American eastern peregrine falcon [E(f), E(s)] or the Arctic peregrine falcon [T(f), T(s)].

TABLE 7-4

SURFACE WATER DATA SUMMARY - RAILROAD DRAINAGE DITCHES
FREQUENCY AND RANGE OF DETECTION
COMPARED TO FRESHWATER NORTH CAROLINA WQSs AND USEPA WQSVs
SITE 2 - REMEDIAL INVESTIGATION CTO-0174
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminants of Potential Concern	Surface Water Standards and Screening Values			Containment Frequency/Range		Comparison to Standards and Screening Values		
	North Carolina (NCWQS)(1)	Region IV(2) Screening Values		No of Positive Detects/No. of Samples	Range of Positive Detections	No. of Positive Detects Above NCWQS	No. of Positive Detects Above Screening Values	
		Acute	Chronic				Acute	Chronic
Inorganics: (μg/L)								
Aluminum	Not Established	750	87	1/1	10,100	NA	1/1	1/1
Arsenic	50	360	190	1/1	3.3	0/1	0/1	0/1
Barium	Not Established	Not Established	Not Established	1/1	85	NA	NA	NA
Beryllium	6.5	16	0.53	1/1	1.0	0/1	0/1	1/1
Chromium (4)	50	984.32	117.32	1/1	14	0/1	0/1	0/1
Copper(4)	7	9.22	6.54	1/1	31	1/1	1/1	1/1
Iron	1,000	Not Established	1,000	1/1	4,410	1/1	NA	1/1
Lead(4)	25	33.78	1.32	1/1	23.4	0/1	0/1	1/1
Manganese	Not Established	Not Established	Not Established	1/1	58	NA	NA	NA
Vanadium	Not Established	Not Established	Not Established	1/1	15B	NA	NA	NA
Zinc(4)	50	65.04(4)	58.91(4)	1/1	418	1/1	1/1	1/1
Pesticides/PCBs: (μg/L)								
4,4'-DDD	Not Established	0.064	0.0064	4/4	0.11-2.3	NA	4/4	4/4
4,4'-DDT	0.001	1.1	0.001	2/4	0.76-0.94	2/2	0/2	2/2

Notes: (1) NCWQS - North Carolina Water Quality Standard for Freshwater Aquatic Life
(2) USEPA Region IV Freshwater Surface Water Screening Value for Hazardous Waste Sites
(3) NA - Not Applicable
(4) Hardness Dependent (Based on 50 mg/L $CaCO_3$)

TABLE 7-5

SURFACE WATER DATA SUMMARY - OVERS CREEK
FREQUENCY AND RANGE OF DETECTION
COMPARED TO SALTWATER NORTH CAROLINA WQSs AND USEPA WQSVs
SITE 2 - REMEDIAL INVESTIGATION CTO-0174
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminants of Potential Concern	Surface Water Standards and Screening Values			Containment Frequency/Range		Comparison to Standards and Screening Values		
	North Carolina (NCWQS)(1)	Region IV(2) Screening Values		No of Positive Detects/No. of Samples	Range of Positive Detections	No. of Positive Detects Above NCWQS	No. of Positive Detects Above Screening Values	
		Acute	Chronic				Acute	Chronic
Inorganics: (µg/L)								
Aluminum	Not Established	Not Established	Not Established	2/2	251-556	NA(3)	NA	NA
Barium	Not Established	Not Established	Not Established	2/2	18-25	NA	NA	NA
Copper(4)	3	2.9	2.9	2/2	4-7	2/2	2/2	2/2
Iron	Not Established	Not Established	Not Established	2/2	182-413	NA	NA	NA
Manganese	Not Established	Not Established	Not Established	2/2	4-24	NA	NA	NA

Notes: (1) NCWQS - North Carolina Water Quality Standard for Saltwater Aquatic Life
(2) USEPA Region IV Saltwater Surface Water Screening Value for Hazardous Waste Sites
(3) NA - Not Applicable
(4) Hardness Dependent (Based on 50 mg/L $CaCO_3$)

TABLE 7-6

SEDIMENT DATA SUMMARY - OVERS CREEK AND DRAINAGE DITCHES
FREQUENCY AND RANGE OF DETECTION
COMPARED TO NOAA SEDIMENT SCREENING VALUES
SITE 2 - REMEDIAL INVESTIGATION CTO-0174
MCB CAMP LEJEUNE, NORTH CAROLINA

	NOAA(1) Sediment Screening Value		Contaminant Frequency/Range		Comparison to Screening Values	
Contaminants of Potential Concern	ER-L(2)	ER-(3)	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
Inorganics: (mg/kg)						
Aluminum	Not Established	Not Established	20/20	1,030-9,780	NA(4)	NA
Arsenic	33	85	10/20	0.5-1.4	0/10	0/10
Barium	Not Established	Not Established	20/20	3.1-114	NA	NA
Beryllium	Not Established	Not Established	3/20	0.25-0.86	NA	NA
Chromium	80	145	18/20	2.2-10.3	0/18	0/18
Copper	70	390	19/20	0.67-6.6	0/19	0/19
Iron	Not Established	Not Established	20/20	453-14,900	NA	NA
Lead	35	110	20/20	2.2-51.4	1/20	0/20
Manganese	Not Established	Not Established	19/20	2.2-203	NA	NA
Vanadium	Not Established	Not Established	20/20	2.1-14	NA	NA
Zinc	120	270	20/20	1.4-120	1/20	0/20

Notes:
(1) NOAA - National Oceanic and Atmospheric Administration
(2) ER-L - Effects Range - Low
(3) ER-M - Effects Range - Median
(4) NA - Not Applicable
(5) Sediment Screening Values are for total chlordane.

TABLE 7-6 (Continued)

SEDIMENT DATA SUMMARY - OVERS CREEK AND DRAINAGE DITCH DITCHES
FREQUENCY AND RANGE OF DETECTION
COMPARED TO NOAA SEDIMENT SCREENING VALUES
SITE 2 - REMEDIAL INVESTIGATION CTO-0174
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminants of Potential Concern	NOAA(1) Sediment Screening Value		Contaminant Frequency/Range		Comparison to Screening Values	
	ER-L(2)	ER-M(3)	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	2/48	7.5-12	2/2	1/2
4,4' - DDE	2	15	39/48	5.7-17,000	39/39	35/39
4,4' - DDD	2	20	45/48	4.2-710,000	45/45	31/45
4,4' - DDT	1	7	43/48	4.7-80,000	43/43	37/43
Alpha-chlordane	0.5(5)	6(5)	14/48	2.3-2,400	14/14	9/14
Gamma-chlordane	0.5(5)	6(5)	10/48	2.8-170	10/10	6/10
Endosulfan II	Not Established	Not Established	1/48	5.2	NA	NA
Volatiles: (µg/kg)						
Ethylbenzene	Not Established	Not Established	1/18	680	NA	NA

Notes: (1) NOAA - National Oceanic and Atmospheric Administration
(2) ER-L - Effects Range - Low
(3) ER-M - Effects Range - Median
(4) NA - Not Applicable
(5) Sediment Screening Values are for total chlordane.

TABLE 7-7

TIME CRITICAL REMOVAL ACTION - SEDIMENT DATA SUMMARY - OVERS CREEK AND RAILROAD TRACK DRAINAGE DITCHES
FREQUENCY AND RANGE OF DETECTION
COMPARED TO NOAA SEDIMENT SCREENING VALUES
SITE 2 - REMEDIAL INVESTIGATION CTO-0174
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminants of Potential Concern	NOAA(1) Sediment Screening Value		Contaminant Frequency/Range		Comparison to Screening Values	
	ER-L(2)	ER-(3)	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
Inorganics: (mg/kg)						
Aluminum	Not Established	Not Established	16/16	1,030-9,780	NA(4)	NA
Arsenic	33	85	8/16	0.5-1.4	0/8	0/8
Barium	Not Established	Not Established	16/16	3.1-114	NA	NA
Beryllium	Not Established	Not Established	3/16	0.25-0.86	NA	NA
Chromium	80	145	14/16	2.2-10.1	0/14	0/14
Copper	70	390	15/16	0.67-6.6	0/15	0/15
Iron	Not Established	Not Established	16/16	453-14,900	NA	NA
Lead	35	110	16/16	2.2-15.5	0/16	0/16
Manganese	Not Established	Not Established	15/16	2.2-203	NA	NA
Vanadium	Not Established	Not Established	16/16	2.1-13.7	NA	NA
Zinc	120	270	16/16	1.4-120	1/16	0/16

Notes:
(1) NOAA - National Oceanic and Atmospheric Administration
(2) ER-L - Effects Range - Low
(3) ER-M - Effects Range - Median
(4) NA - Not Applicable
(5) Sediment Screening Values are for total chlordane.

TABLE 7-7 (Continued)

TIME CRITICAL REMOVAL ACTION - SEDIMENT DATA SUMMARY - OVERS CREEK AND RAILROAD TRACK DRAINAGE DITCHES
FREQUENCY AND RANGE OF DETECTION
COMPARED TO NOAA SEDIMENT SCREENING VALUES
SITE 2 - REMEDIAL INVESTIGATION CTO-0174
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminants of Potential Concern	NOAA(1) Sediment Screening Value		Contaminant Frequency/Range		Comparison to Screening Values	
	ER-L(2)	ER-M(3)	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	2/38	7.5-12	2/2	1/2
4,4' - DDE	2	15	31/38	5.7-3,900	31/31	27/31
4,4' - DDD	2	20	36/38	4.2-4,400	36/36	23/36
4,4' - DDT	1	7	35/38	4.7-6,200	35/35	24/35
Alpha-chlordane	0.5(5)	6(5)	10/38	2.3-190	10/10	6/10
Gamma-chlordane	0.5(5)	6(5)	7/38	2.8-170	7/7	4/7

Notes:
(1) NOAA - National Oceanic and Atmospheric Administration
(2) ER-L - Effects Range - Low
(3) ER-M - Effects Range - Median
(4) NA - Not Applicable
(5) Sediment Screening Values are for total chlordane.

TABLE 7-8

TERRESTRIAL REFERENCE VALUES
SITE 2 - REMEDIAL INVESTIGATION CTO-0174
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminants of Potential Concern	Soil to Plant Transfer Coefficient (Bv)	Toxicity Reference Value (TRV) mg/kg/day
Toluene	1.023(1, 3)	223(4)
Xylene (total)	0.505(1, 3)	179(4)
4,4'-DDE	0.003(1, 3)	0.05(4)
4,4'-DDD	0.010(1, 3)	0.05(4)
4,4'-DDT	0.010(1, 3)	0.05(4)
Dieldrin	0.367(1, 3)	0.005(4)
Chlordane (total)	0.467(1, 3)	0.055(4)
Heptachlor	0.111(1, 3)	0.15(4)
Arsenic	0.040(2)	16(5)
Barium	0.150(2)	30(4)
Beryllium	0.010(2)	0.54(6)
Cadmium	0.550(2)	4.7(7)
Chromium	0.008(2)	2.7(8)
Copper	0.400(2)	300(4)
Lead	0.045(2)	27.4(4)
Mercury	0.900(2)	7.4(9)
Vanadium	0.006(2)	0.7(10)
Zinc	1.500(2)	38(11)

NA - No information to determine TRV
(1) Travis, 1988
(2) Baes, 1984
(3) U.S. EPA, 1986
(4) IRIS, 1993
(5) USDH, 1992a
(6) IRIS, 1991
(7) USDH, 1992b
(8) USDH, 1991
(9) ATSDR, 1988
(10) HEAST, 1991
(11) ATSDR, 1989

TABLE 7-9

SURFACE WATER QUOTIENT INDEX FOR OVERS CREEK AND RAILROAD TRACK DRAINAGE DITCHES
SITE 2 - REMEDIAL INVESTIGATION CTO-0174
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminants of Potential Concern	Surface Water Concentration (µg/L)	North Carolina Quotient Index WQS[1]	USEPA Region IV WQSV[2] Quotient Index	
			Acute	Chronic
Overs Creek				
Copper	7.00	2.33	2.41	2.41
Drainage Ditch Areas				
Aluminum	10,100	NA	13.47	116.09
Beryllium	1.00	0.15	0.06	1.89
Copper	31.00	4.43	3.36	4.74
Iron	4,410	4.41	NA	4.41
Lead	23.40	0.94	0.69	17.73
Zinc	418.00	8.36	6.43	7.10
4-4'-DDD	2.30	NA	35.94	359.38
4,4'-DDT	0.94	940.00	0.85	940.00

Notes: (1) WQS - Water Quality Standards
(2) WQSV - Water Quality Screening Values
NA - Not Applicable
Surface water concentrations are the maximum detected values since the log normal 95% confidence limit was equal to or higher than the maximum value.

TABLE 7-10

SEDIMENT QUOTIENT INDEX FOR OVERS CREEK, THE RAILROAD TRACK DRAINAGE DITCHES, AND THE HOLCOMB BOULEVARD DRAINAGE AREA
SITE 2 - REMEDIAL INVESTIGATION CTO-0174
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminants of Potential Concern	Sediment Concentration (mg/kg)	Sediment Concentration Post-TCRA (mg/kg)	NOAA SSV[(1)] Quotient Index		NOAA SSV Quotient Index Post-TCRA	
			ER-L[(2)]	ER-M[(3)]	ER-L	ER-M
Lead	16.1	10.4	0.46	0.15	0.30	0.10
Zinc	77.4	120	0.65	0.29	1.00	0.44
Dieldrin	12	12	600	1.5	600	1.5
4,4'-DDE	1,559	324	780	104	162	22
4,4'-DDT	56,030	4,290	56,030	8,004	4,290	613
Alpha-chlordane	120.8	19.2	241.6	20.1	38.4	3.2
Gamma-chlordane	92.5	17.2	185.0	15.4	34.4	2.9

Notes: (1) NOAA SSVs - National Oceanic and Atmospheric Administration Sediment Screening Values
(2) ER-L - Effects Range - Low
(3) ER-M - Effects Range - Median
NA - Not Applicable
TCRA - Proposed Time Critical Removal Action
Surface water concentrations are the log normal 95% confidence limit unless that value was higher than the maximum detected value, then the maximum was used.

TABLE 7-11

TERRESTRIAL CHRONIC DAILY INTAKE MODEL EXPOSURE PARAMETERS(1)
SITE 2 - REMEDIAL INVESTIGATION CTO-0174
MCB CAMP LEJEUNE, NORTH CAROLINA

Exposure Parameter	Units	White-Tailed Deer	Cotton-Tail Rabbit	Bobwhite Quail
Food Source Ingestion	--	Vegetation 100%	Vegetation 100%	Vegetation 100%
Feeding Rate	kg/d	1.6(2)	0.1(3)	0.01(3)
Incident Soil Ingestion	kg/d	0.019(1)	0.002(3)	0.001(3)
Rate of Drinking Water Ingestion	L/d	1.1(2)	0.185(4)	0.013(4)
Rate of Vegetation Ingestion	kg/d	1.6(2)	0.1	0.01
Body Weight	kg	45.4(2)	2(3)	0.1(3)
Home Range Size	acres	454(2)	10(6)	12.10(5)

(1) Scarano, 1993
(2) Dee, 1991
(3) Newell, 1987
(4) Federal Register, 1993
(5) USDI, 1985
(6) USDI, 1984

TABLE 7-12

SUMMARY OF QUOTIENT INDEX VALUES AT THE FORMER STORAGE AREA
SITE 2 - REMEDIAL INVESTIGATION CTO-0174
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminants of Potential Concern	Quail Bobwhite	Cottontail Rabbit	Whitetail Deer
Toluene	3.02×10^{-6}	2.18×10^{-6}	5.45×10^{-7}
Xylene (total)	3.72×10^{-6}	2.69×10^{-6}	6.78×10^{-7}
4,4'-DDE	3.68×10^{-3}	5.73×10^{-4}	2.90×10^{-5}
4,4'-DDD	2.56×10^{-2}	7.52×10^{-3}	1.15×10^{-3}
4,4'-DDT	1.58×10^{-1}	2.74×10^{-2}	7.42×10^{-4}
Dieldrin	2.59×10^{-3}	1.59×10^{-3}	2.52×10^{-4}
Chlordane (total)	1.35×10^{-4}	8.22×10^{-5}	1.16×10^{-5}
Heptachlor	3.16×10^{-5}	1.94×10^{-5}	4.10×10^{-6}
Arsenic	8.25×10^{-5}	3.37×10^{-5}	5.19×10^{-6}
Barium	1.23×10^{-3}	6.22×10^{-4}	7.40×10^{-5}
Beryllium	6.01×10^{-4}	2.32×10^{-4}	4.55×10^{-5}
Cadmium	6.76×10^{-5}	4.94×10^{-5}	1.29×10^{-5}
Chromium	3.58×10^{-3}	9.33×10^{-4}	1.31×10^{-4}
Copper	1.16×10^{-4}	6.17×10^{-5}	3.30×10^{-6}
Lead	5.21×10^{-4}	1.91×10^{-4}	2.22×10^{-5}
Mercury	4.48×10^{-4}	2.50×10^{-4}	4.15×10^{-6}
Vanadium	1.54×10^{-2}	3.83×10^{-3}	5.38×10^{-4}
Zinc	1.78×10^{-2}	1.05×10^{-2}	4.12×10^{-4}
TOTAL	2.30×10^{-1}	5.38×10^{-2}	3.44×10^{-3}

TABLE 7-13

SUMMARY OF QUOTIENT INDEX VALUES AT THE FORMER STORAGE AREA
TIME/CRITICAL REMOVAL ACTION
SITE 2 - REMEDIAL INVESTIGATION CTO-0174
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminants of Potential Concern	Quail Bobwhite	Cottontail Rabbit	Whitetail Deer
Toluene	3.02×10^{-6}	2.18×10^{-6}	5.45×10^{-7}
Xylene, total	3.73×10^{-6}	2.69×10^{-6}	6.78×10^{-7}
4,4'-DDE	2.76×10^{-3}	4.48×10^{-4}	2.77×10^{-5}
4,4'-DDD	1.24×10^{-2}	5.34×10^{-3}	1.13×10^{-3}
4,4'-DDT	1.46×10^{-2}	3.75×10^{-3}	4.78×10^{-4}
Dieldrin	1.46×10^{-2}	7.61×10^{-3}	3.44×10^{-4}
Chlordane, total	8.31×10^{-4}	4.44×10^{-4}	1.72×10^{-5}
Heptachlor	1.27×10^{-4}	5.51×10^{-5}	4.61×10^{-6}
Arsenic	7.40×10^{-5}	3.15×10^{-5}	5.16×10^{-6}
Barium	1.23×10^{-3}	6.22×10^{-4}	7.40×10^{-5}
Beryllium	6.01×10^{-4}	2.32×10^{-4}	4.55×10^{-5}
Cadmium	6.90×10^{-4}	3.80×10^{-4}	1.79×10^{-5}
Chromium	3.52×10^{-3}	9.23×10^{-4}	1.30×10^{-4}
Copper	1.16×10^{-4}	6.17×10^{-5}	3.30×10^{-6}
Lead	5.21×10^{-4}	1.91×10^{-4}	2.22×10^{-5}
Mercury	4.48×10^{-4}	2.50×10^{-4}	4.15×10^{-6}
Vanadium	1.54×10^{-2}	3.83×10^{-3}	5.38×10^{-4}
Zinc	1.78×10^{-2}	1.05×10^{-2}	4.12×10^{-4}
TOTAL	8.57×10^{-2}	3.46×10^{-2}	3.25×10^{-3}

TABLE 7-14

SUMMARY OF QUOTIENT INDEX VALUES AT THE MIXING PAD AREA
SITE 2 - REMEDIAL INVESTIGATION CTO-0174
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminants of Potential Concern	Quail Bobwhite	Cottontail Rabbit	Whitetail Deer
Toluene	3.09×10^{-6}	2.22×10^{-6}	5.46×10^{-7}
Xylene (total)	3.67×10^{-6}	2.66×10^{-6}	6.78×10^{-7}
4,4'-DDE	5.35×10^{-1}	7.23×10^{-2}	7.34×10^{-4}
4,4'-DDD	$2.28 \times 10^{+1}$	$3.77 \times 10^{+0}$	4.32×10^{-2}
4,4'-DDT	$5.71 \times 10^{+1}$	$9.42 \times 10^{+0}$	1.06×10^{-1}
Dieldrin	$1.13 \times 10^{+0}$	5.68×10^{-1}	8.86×10^{-3}
Chlordane (total)	3.48×10^{-1}	1.81×10^{-1}	2.77×10^{-3}
Heptachlor	3.43×10^{-3}	1.30×10^{-3}	2.26×10^{-5}
Arsenic	3.51×10^{-4}	1.03×10^{-4}	6.12×10^{-6}
Barium	2.22×10^{-3}	1.03×10^{-3}	8.00×10^{-5}
Beryllium	6.21×10^{-4}	2.35×10^{-4}	4.56×10^{-5}
Cadmium	1.38×10^{-3}	7.48×10^{-4}	2.36×10^{-5}
Chromium	5.03×10^{-3}	1.16×10^{-3}	1.33×10^{-4}
Copper	3.00×10^{-4}	1.55×10^{-4}	4.72×10^{-6}
Lead	1.04×10^{-2}	2.87×10^{-3}	5.84×10^{-5}
Mercury	8.08×10^{-4}	4.50×10^{-4}	7.24×10^{-6}
Vanadium	2.16×10^{-2}	4.74×10^{-3}	5.48×10^{-4}
Zinc	4.69×10^{-2}	2.72×10^{-2}	6.71×10^{-4}
TOTAL	$8.20 \times 10^{+1}$	$1.41 \times 10^{+1}$	1.63×10^{-1}

TABLE 7-15

SUMMARY OF QUOTIENT INDEX VALUES AT THE MIXING PAD AREA
TIME-CRITICAL REMOVAL ACTION
SITE 2 - REMEDIAL INVESTIGATION CTO-0174
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminants of Potential Concern	Bobwhite Quail	Cottontail Rabbit	Whitetail Deer
Toluene	3.09×10^{-6}	2.22×10^{-6}	5.46×10^{-7}
Xylene, total	3.67×10^{-6}	2.66×10^{-6}	6.78×10^{-7}
4,4'-DDE	1.97×10^{-2}	2.74×10^{-3}	5.03×10^{-5}
4,4'-DDD	1.07×10^{-2}	5.07×10^{-3}	1.12×10^{-3}
4,4'-DDT	4.04×10^{-2}	8.02×10^{-3}	5.26×10^{-4}
Dieldrin	2.72×10^{-3}	1.65×10^{-3}	2.53×10^{-4}
Chlordane (total)	1.57×10^{-3}	8.30×10^{-4}	2.30×10^{-5}
Heptachlor	3.20×10^{-5}	1.95×10^{-5}	4.10×10^{-6}
Arsenic	1.09×10^{-4}	4.06×10^{-5}	5.29×10^{-6}
Barium	1.90×10^{-3}	8.97×10^{-4}	7.80×10^{-5}
Beryllium	2.34×10^{-4}	1.71×10^{-4}	4.49×10^{-5}
Cadmium	1.38×10^{-3}	7.48×10^{-4}	2.36×10^{-5}
Chromium	2.79×10^{-3}	8.10×10^{-4}	1.29×10^{-4}
Copper	1.11×10^{-4}	5.94×10^{-5}	3.26×10^{-6}
Lead	6.19×10^{-3}	1.73×10^{-3}	4.30×10^{-5}
Mercury	1.76×10^{-6}	1.28×10^{-6}	3.28×10^{-7}
Vanadium	1.42×10^{-2}	3.66×10^{-3}	5.37×10^{-4}
Zinc	2.06×10^{-2}	1.21×10^{-2}	4.37×10^{-4}
TOTAL	1.23×10^{-1}	3.85×10^{-2}	3.28×10^{-3}

8.0 CONCLUSIONS AND RECOMMENDATIONS

This section presents the conclusions of the remedial investigation, and the human health and ecological risk assessments. Recommendations for further action are also provided in this section.

8.1 Conclusions

Based on the results of the various environmental investigations at Site 2 and the baseline RA, the following conclusions were developed:

- The soil and sediment in the Mixing Pad Area are contaminated with elevated levels of pesticides and SVOCs and arsenic that may be associated with former site operation activities. Releases to the environment from mixing of pesticides and from petroleum-based solvents that were used to mix herbicides and operate and clean pesticide/herbicide spraying equipment is likely the source of this contamination.

- Soil, sediment and surface water throughout the site appear to have been impacted by the former practice of general base-wide spraying of pesticides. Generally, pesticide concentrations in the Lawn Area and in the Former Storage Area environmental media are several orders of magnitude less than the pesticide concentrations in the Mixing Pad Area.

- The environmental media in the Lawn Area has not been impacted by site operation activities.

- Carbon Disulfide was detected in low concentrations in surface water in an upstream sampling station in Overs Creek. Carbon disulfide was not detected in the soil or sediment samples collected within the boundaries of Site 2. There is no record of its use on site. It is doubtful that the presence of carbon disulfide is due to site activities.

- Shallow groundwater in the Former Storage Area has been impacted by VOC contamination. Ethylbenzene and xylenes (total) have been detected in three monitoring wells in this area. The highest level of VOC contamination was detected in a groundwater sample collected from monitoring well 2GW3. VOCs were detected in this well during previous investigations. The extent of VOC contamination appears to be limited to the vicinity of the Former Storage Area. The second round of groundwater sampling confirmed this.

- Low concentrations of SVOCs, pesticides, and inorganics were also detected in groundwater samples.

- The source of shallow groundwater VOC and SVOC contamination in the Former Storage Area is undetermined. Similar contaminants were detected at low concentrations (8 µg/kg maximum) in a soil sample collected in the vicinity of monitoring well 2GW3, indicating a surface or near surface source (underground storage tank, surface spill) may have been present in this area.

- Pesticide, inorganic (arsenic) and SVOC contamination in shallow groundwater in the Mixing Pad Area is likely attributable to pesticide handling and the cleaning of pesticide and herbicide spraying equipment.

- TCE was detected in a low concentration (5 µg/L) in deep monitoring well 2GW3D during the initial groundwater sampling. There is no evidence (documentation, soil samples, shallow groundwater samples) to indicate that the presence of TCE is related to operation activities at Site 2. TCE and other chlorinated hydrocarbons have been detected in deep groundwater in other parts of MCB Camp Lejeune. TCE was not detected during the second round of sampling.

- A TCRA is currently being planned for the pesticide contaminated soil and sediment in the Mixing Pad Area and Former Storage Area. The human health and ecological risk assessment were each conducted under two scenarios: (1) a TCRA will not take place; and (2) a TCRA will take place. The results of the human health risk assessment indicate that the current overall carcinogenic health risk to civilian base personnel working at Site 2 ranges from 1E-4 in the Lawn and Mixing Pad Areas to 3E-7 in the Former Storage Area. However, when the analytical results are evaluated under the second (TCRA) scenario, the risk was estimated to range from 3E-7 in the Lawn and Mixing Pad Area to 3E-8 in the Former Storage Area. In addition, after the TCRA, overall systemic health risks were estimated at levels below a HI of 1.0 in the Lawn and Mixing Pad Areas, which indicates that systemic health are not likely. The HIs for the Former Storage Area fell below 1.0, before the TCRA.

- The results of the ecological risk assessment indicate the following:
  - Pesticides in sediments along the drainage ditch and Overs Creek results in a potential decrease in the viability of aquatic receptors under both RA scenarios.
  - Pesticides in the soil in the Mixing Pad Area result in a potential decrease in the viability of terrestrial receptors under the no TCRA scenario. Under the TCRA scenario, there is no decrease in the viability of terrestrial receptors.
  - There is no decrease in viability of aquatic or terrestrial receptors in the Former Storage Area under either RA scenarios.

8.2 Recommendations

1. A TCRA should be conducted on the pesticide contaminated soil and sediment in the Mixing Pad Area. The concrete pads should also be removed.

2. Until the TCRA takes place, access to the Mixing Pad Area should be restricted.

3. The general vicinity of Site 2 has been proposed to be a groundwater preservation area for consideration as a potential water supply well field site (Geophex, 1991; page 32). This should be reevaluated in light of the results of the RI, particularly the analytical results from deep monitoring well 2GW3D.

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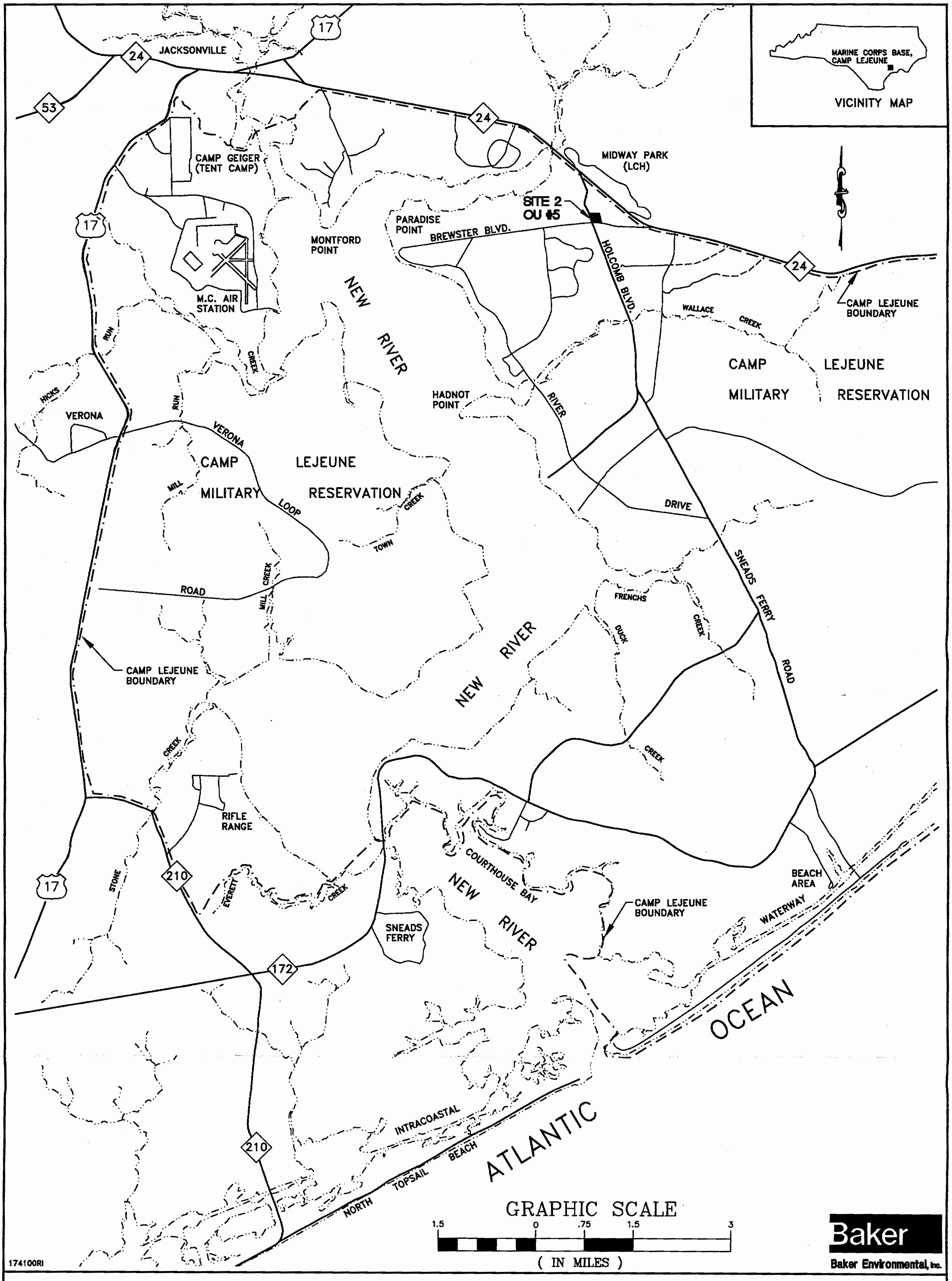


FIGURE 1-1
LOCATION MAP
OPERABLE UNIT No.5, SITE 2
REMEDIAL INVESTIGATION CTO-0174
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

01273R012

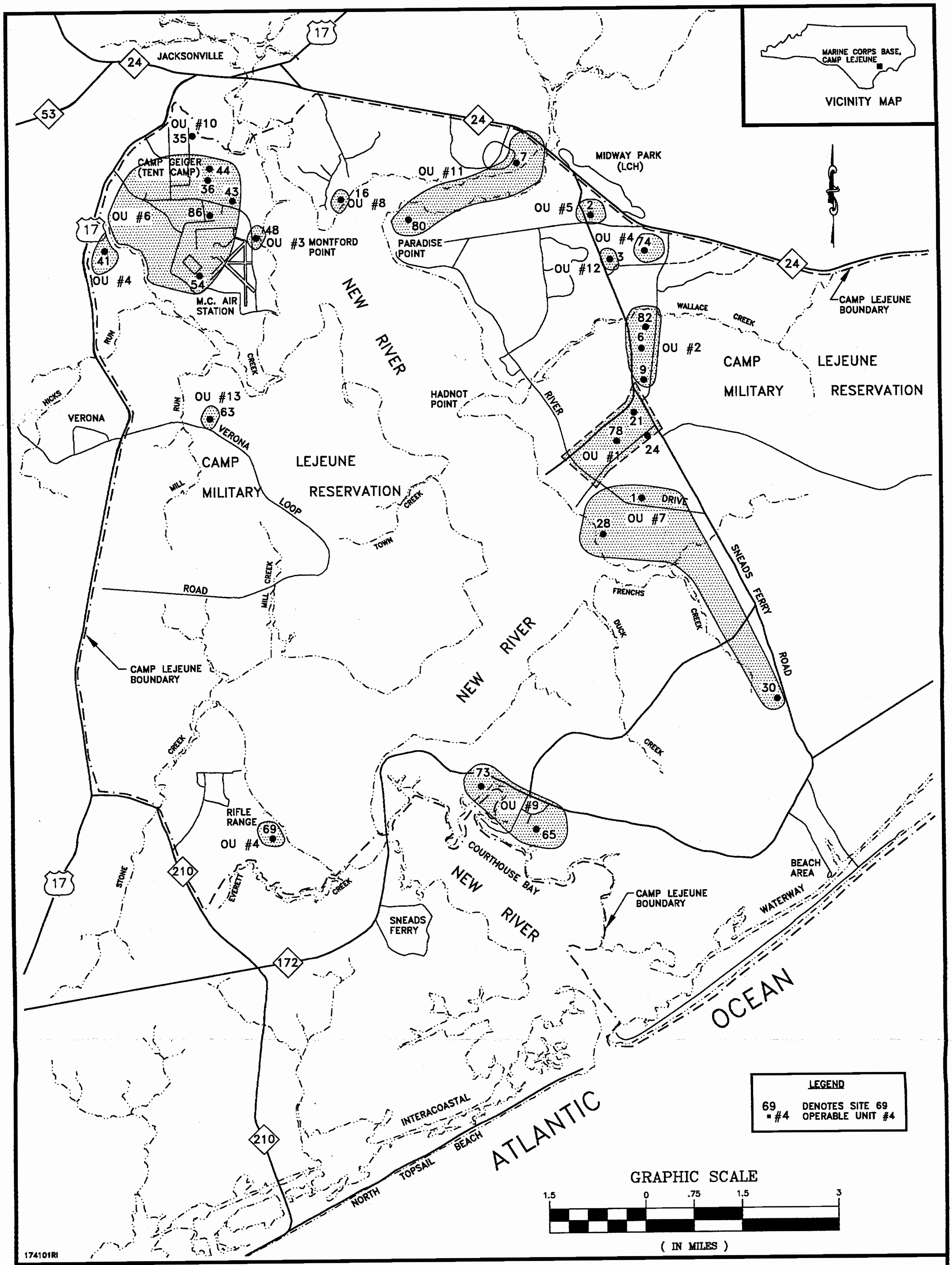
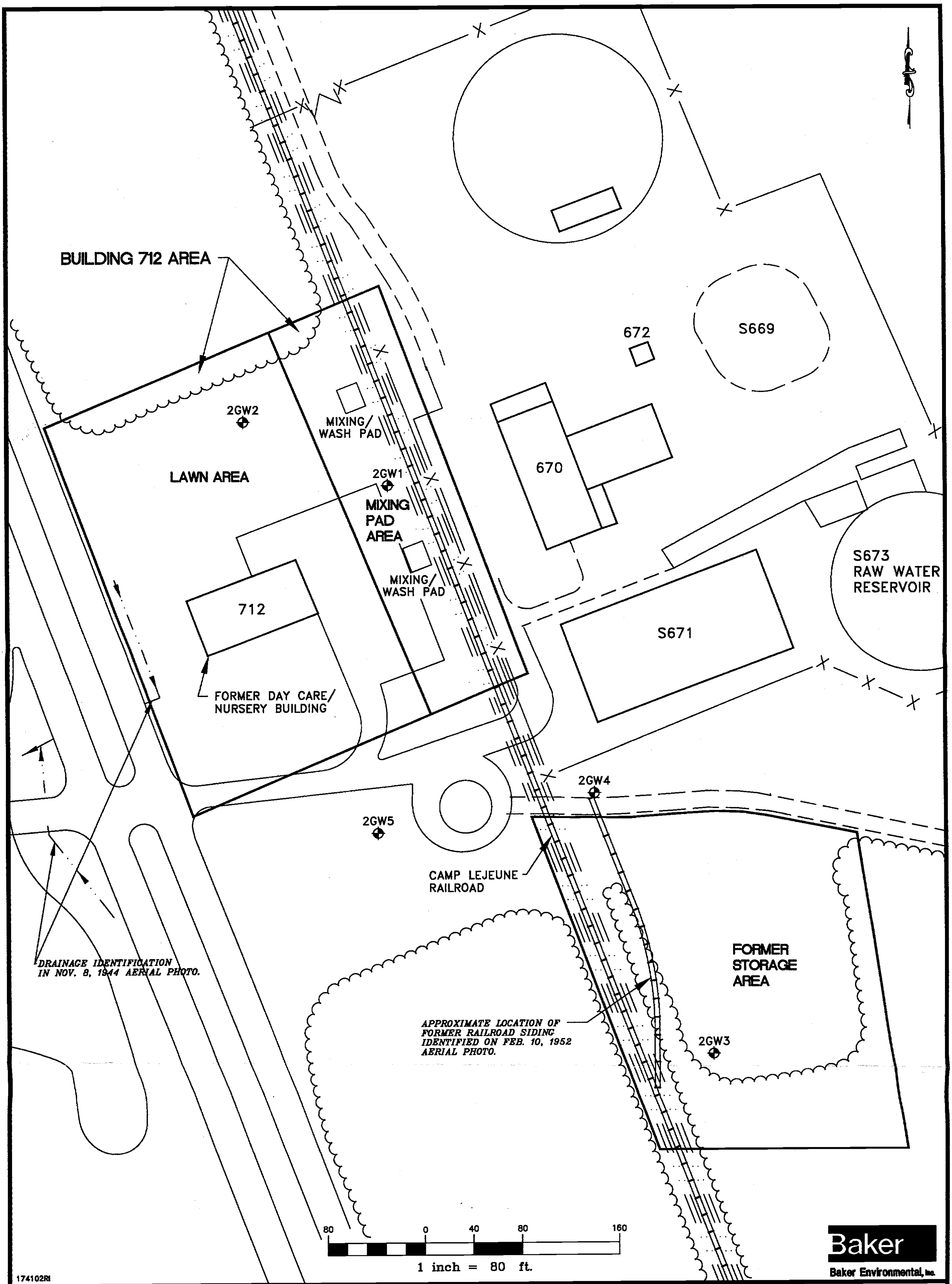


FIGURE 1-2
OPERABLE UNITS AND SITE LOCATIONS AT
MARINE CORPS BASE CAMP LEJEUNE
REMEDIAL INVESTIGATION CTO-0174
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

01273R022



LEGEND

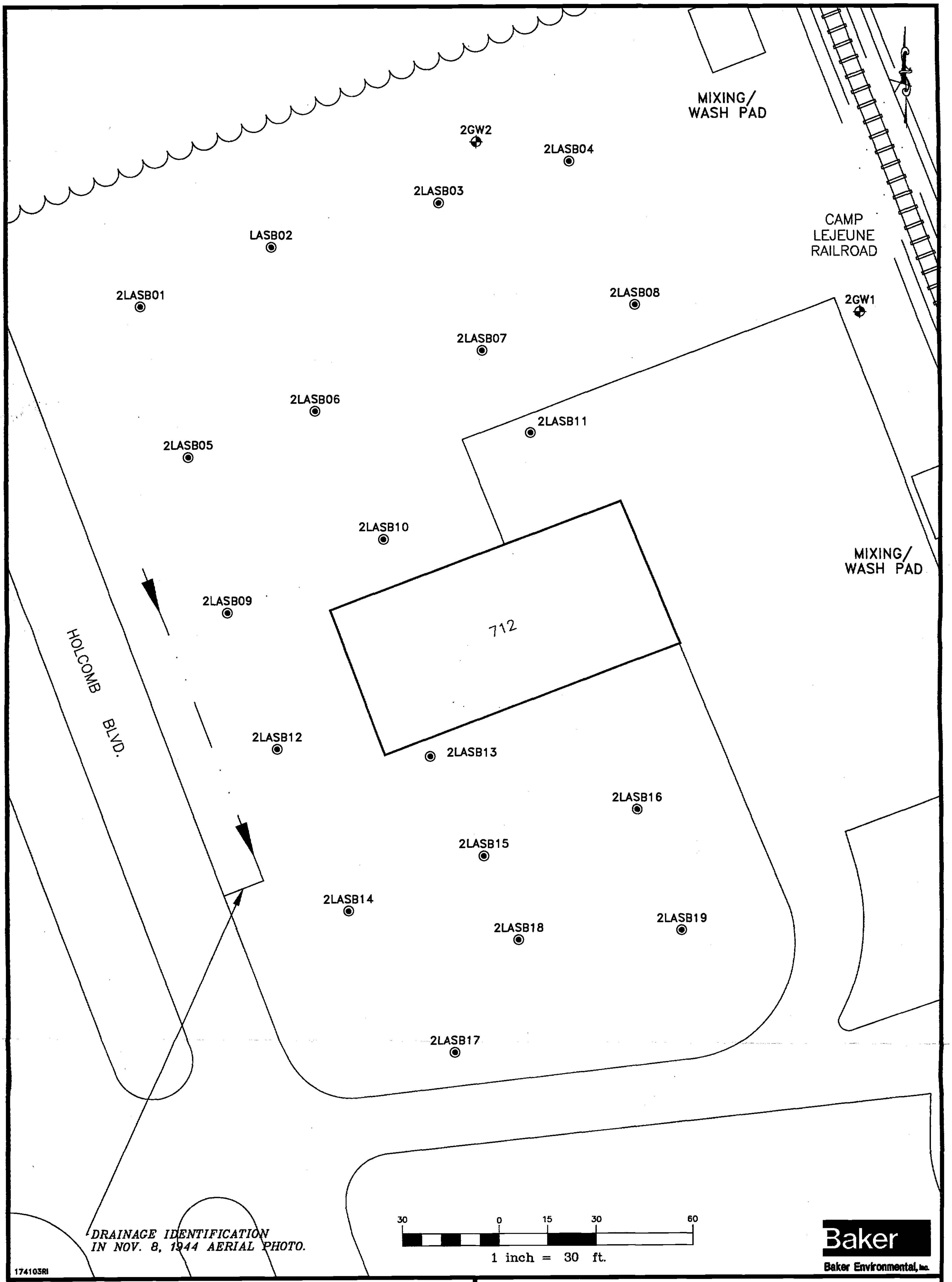
2GW1 ⊕ EXISTING SHALLOW MONITORING WELL

SOURCE: LANTDIV, FEB. 1992

FIGURE 1-3
STUDY AREA
SITE 2
REMEDIAL INVESTIGATION CTO-0174

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

01273R032



LEGEND

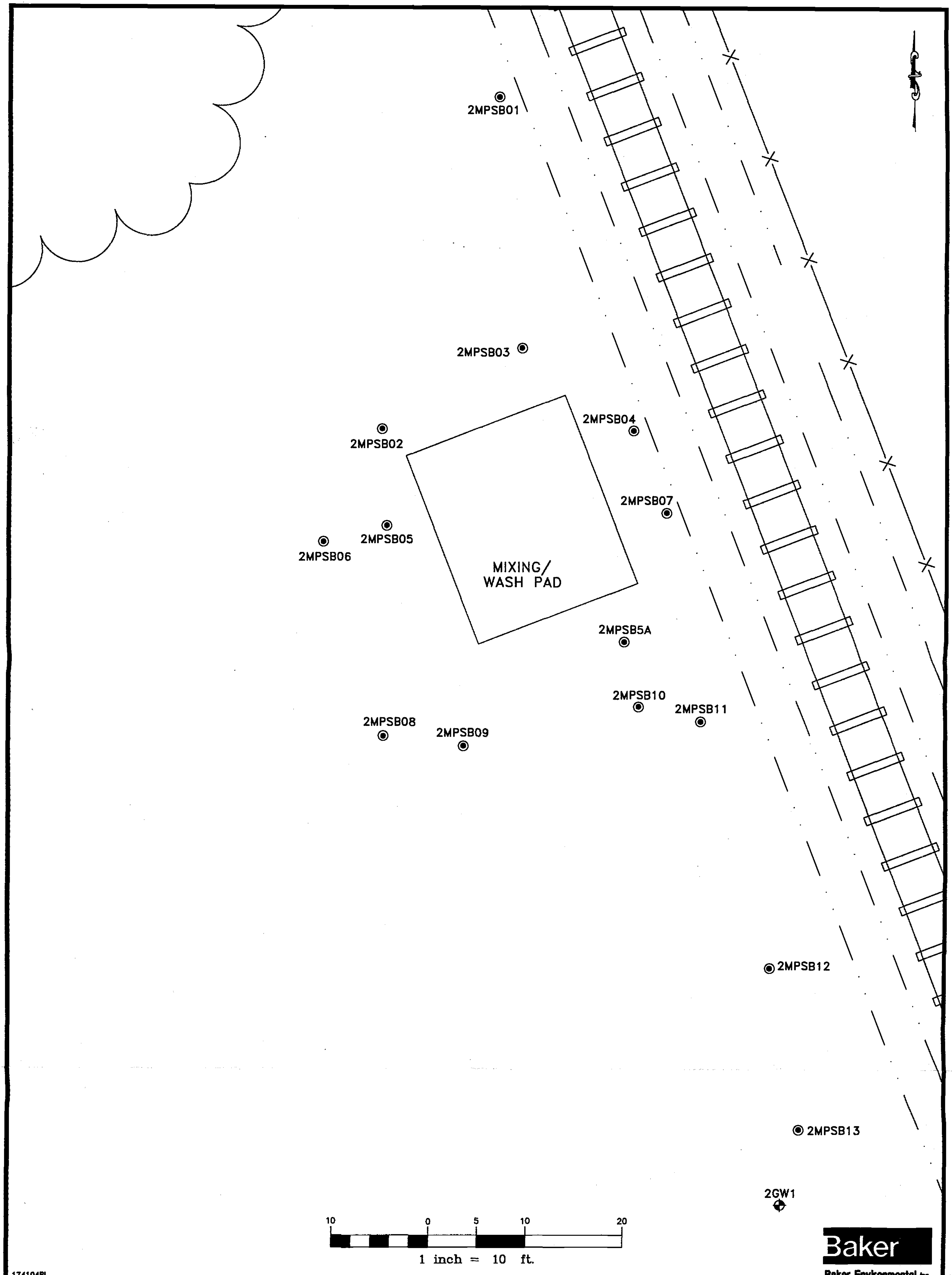
2GW1 ⊕ MONITORING WELL LOCATION

2LASB01 ◉ SOIL BORING LOCATION

SOURCE: LANTDIV, FEB. 1992

FIGURE 2-1
SOIL SAMPLING LOCATIONS
LAWN AREA
SITE 2
REMEDIAL INVESTIGATION – CTO-0174
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

01273 R04Z



174104RI

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LEGEND

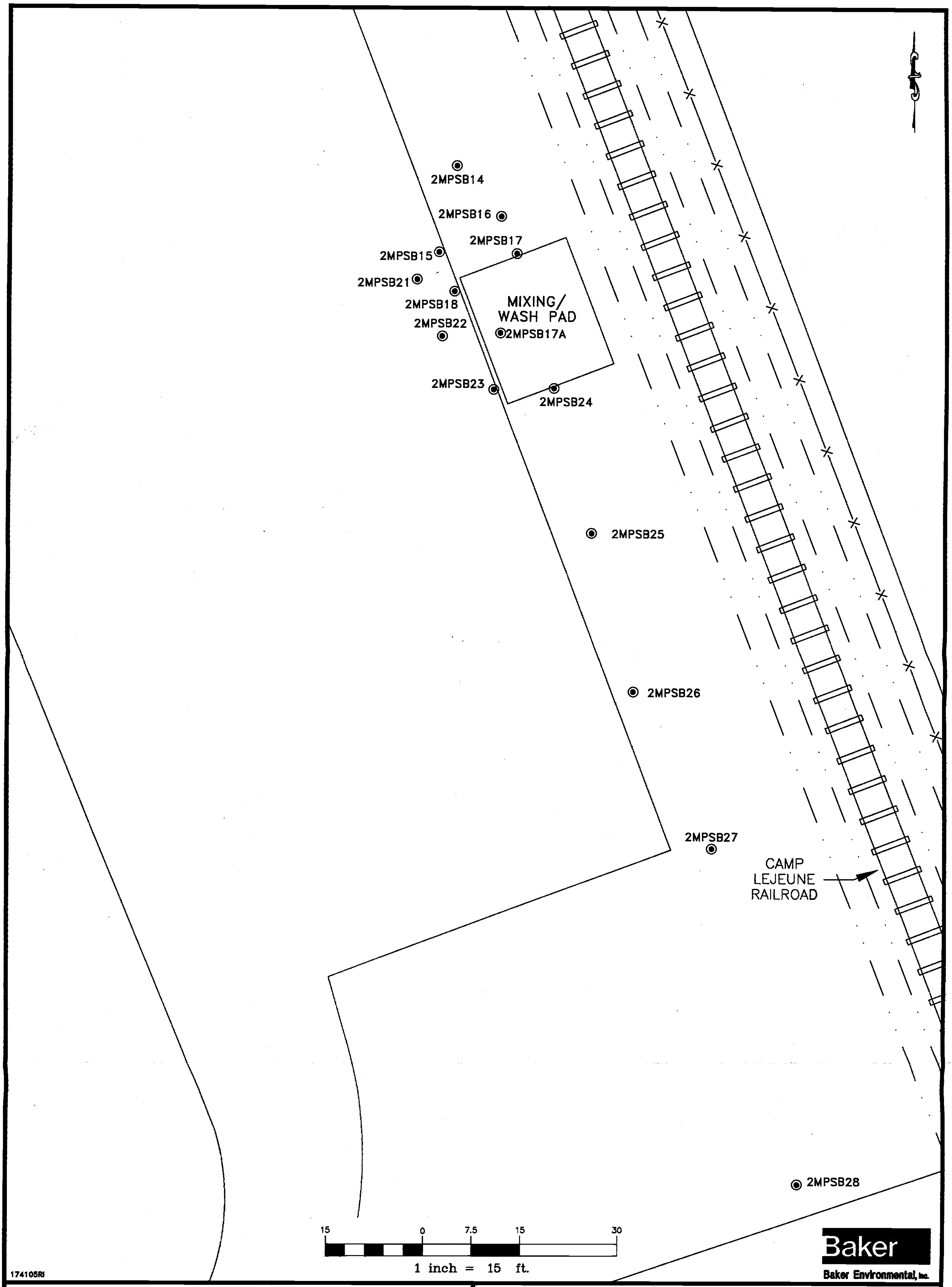
2GW1 ⊕ MONITORING WELL LOCATION

2MPSB01 ◉ SOIL BORING LOCATION

SOURCE: LANTDIV, FEB. 1992

FIGURE 2-2
SOIL SAMPLING LOCATIONS
NORTH MIXING PAD AREA
SITE 2
REMEDIAL INVESTIGATION CTO-0174
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

01273R052



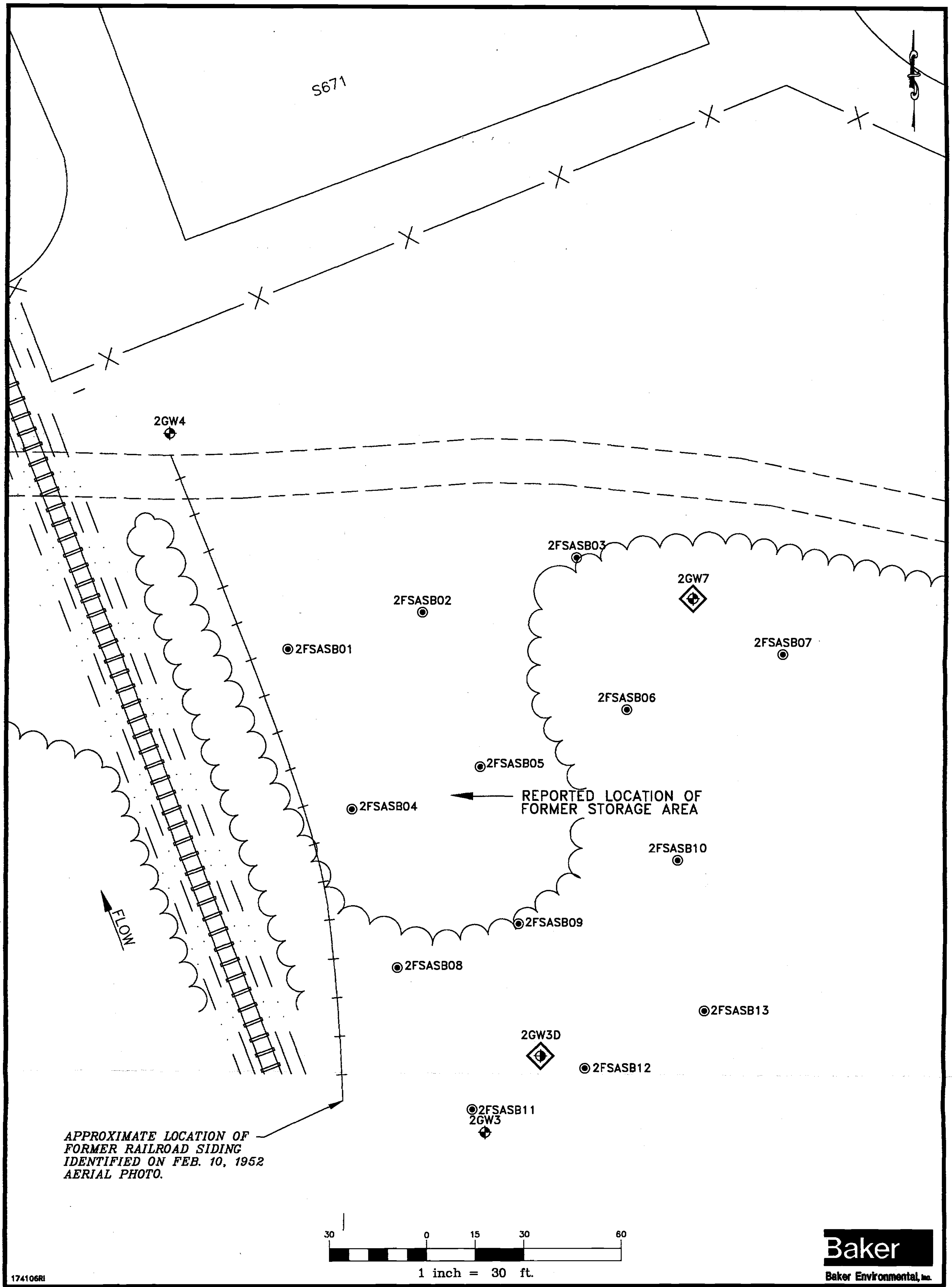
LEGEND

2MPSB14 ◉ SOIL BORING

SOURCE: LANTDIV, FEB. 1002

FIGURE 2-3
SOIL SAMPLING LOCATIONS
SOUTH MIXING PAD AREA
SITE 2
REMEDIAL INVESTIGATION CTO-0174
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

01273R062



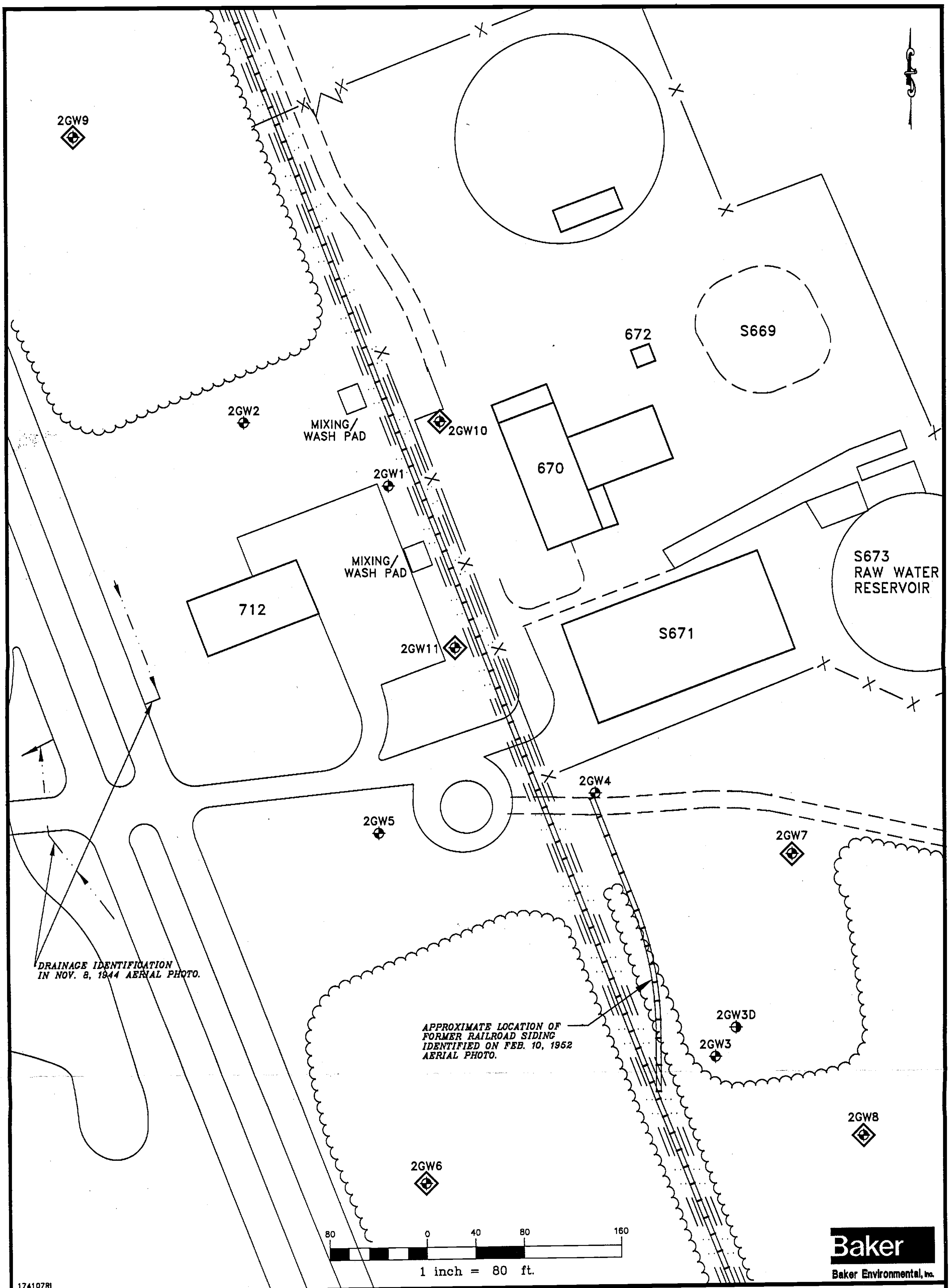
LEGEND

2FSASB01 ◉	SOIL BORING LOCATION
2GW3 ⊕	SHALLOW MONITORING WELL LOCATION
2GW3D ⊕	DEEP MONITORING WELL LOCATION
2GW7 ◈	SOIL BORING CONVERTED TO MONITORING WELL

SOURCE: LANTDIV, FEB. 1992

FIGURE 2-4
SOIL SAMPLING LOCATIONS
FORMER STORAGE AREA
SITE 2
REMEDIAL INVESTIGATION CTO-0174
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

01273 R07Z



LEGEND

2GW1 ⊕ EXISTING SHALLOW MONITORING WELL

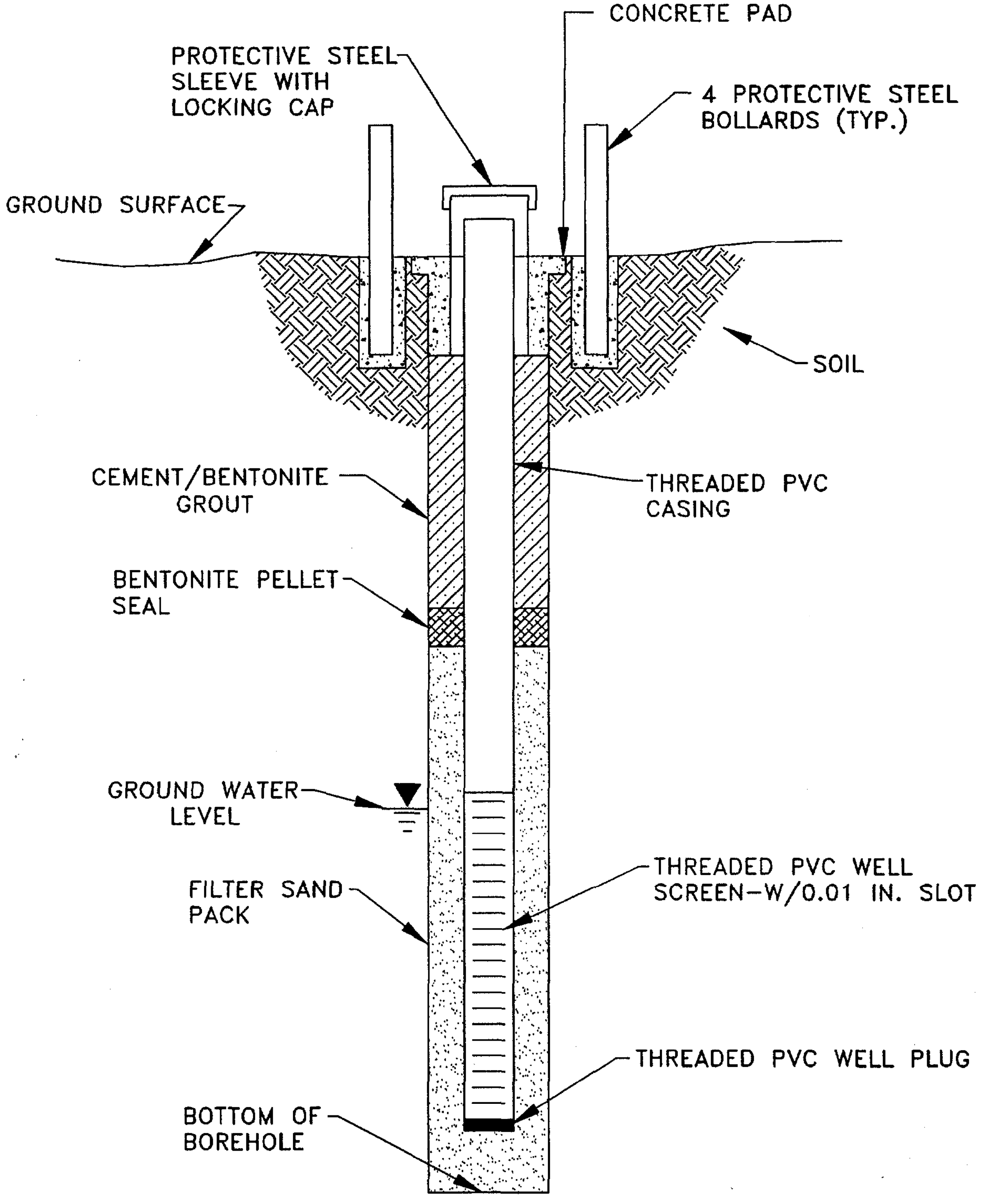
2GW3D ◈ NEWLY INSTALLED SHALLOW MONITORING WELL

2GW3D ⊕ NEWLY INSTALLED DEEP MONITORING WELL

SOURCE: LANTDIV, FEB. 1992

FIGURE 2-5
GROUNDWATER MONITORING WELL
LOCATION MAP
SITE 2
REMEDIAL INVESTIGATION - CTO-0174
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

01273R082



N.T.S.

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FIGURE 2-6
TYPICAL SHALLOW GROUNDWATER
MONITORING WELL CONSTRUCTION DIAGRAM
REMEDIAL INVESTIGATION CTO-0174

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

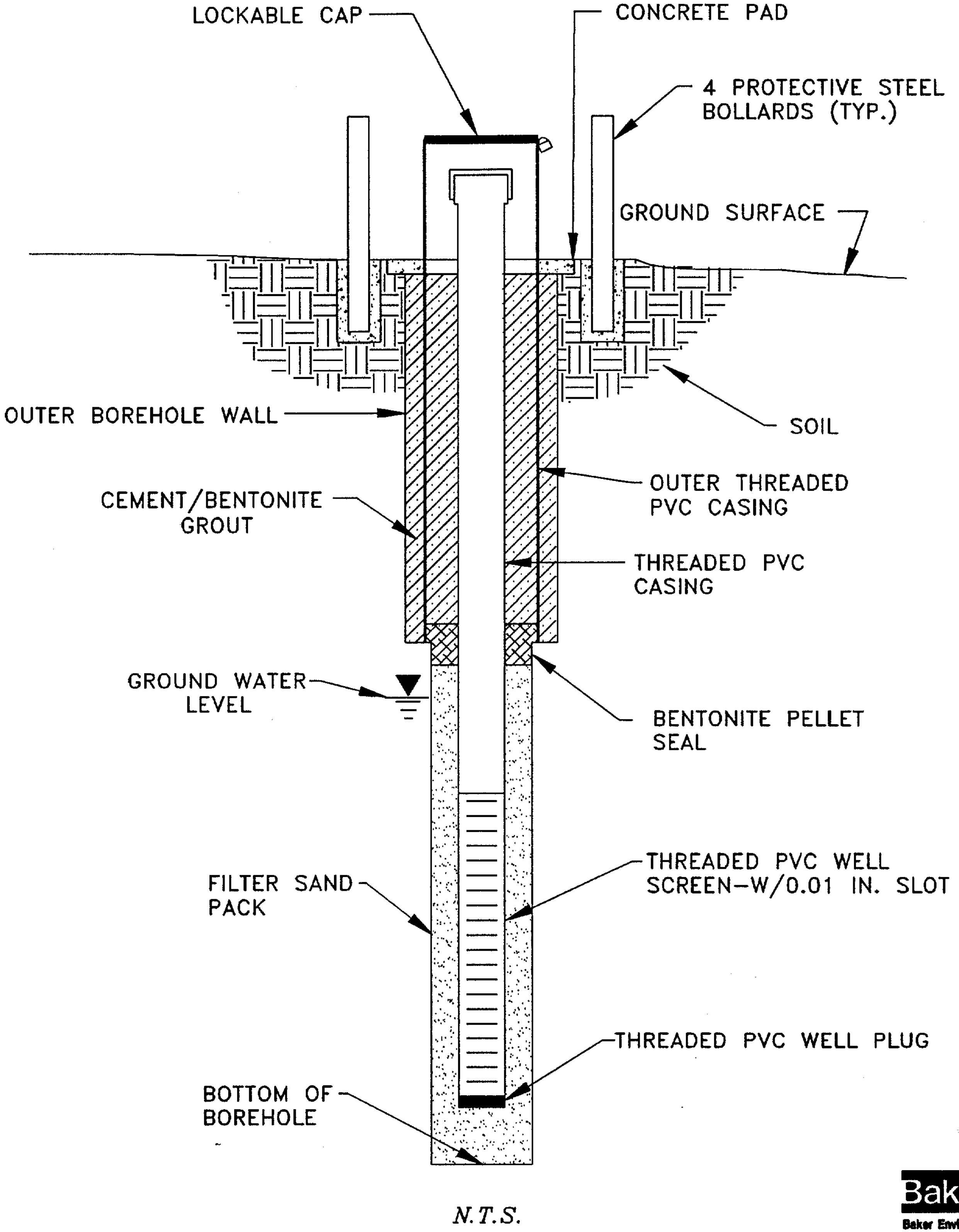

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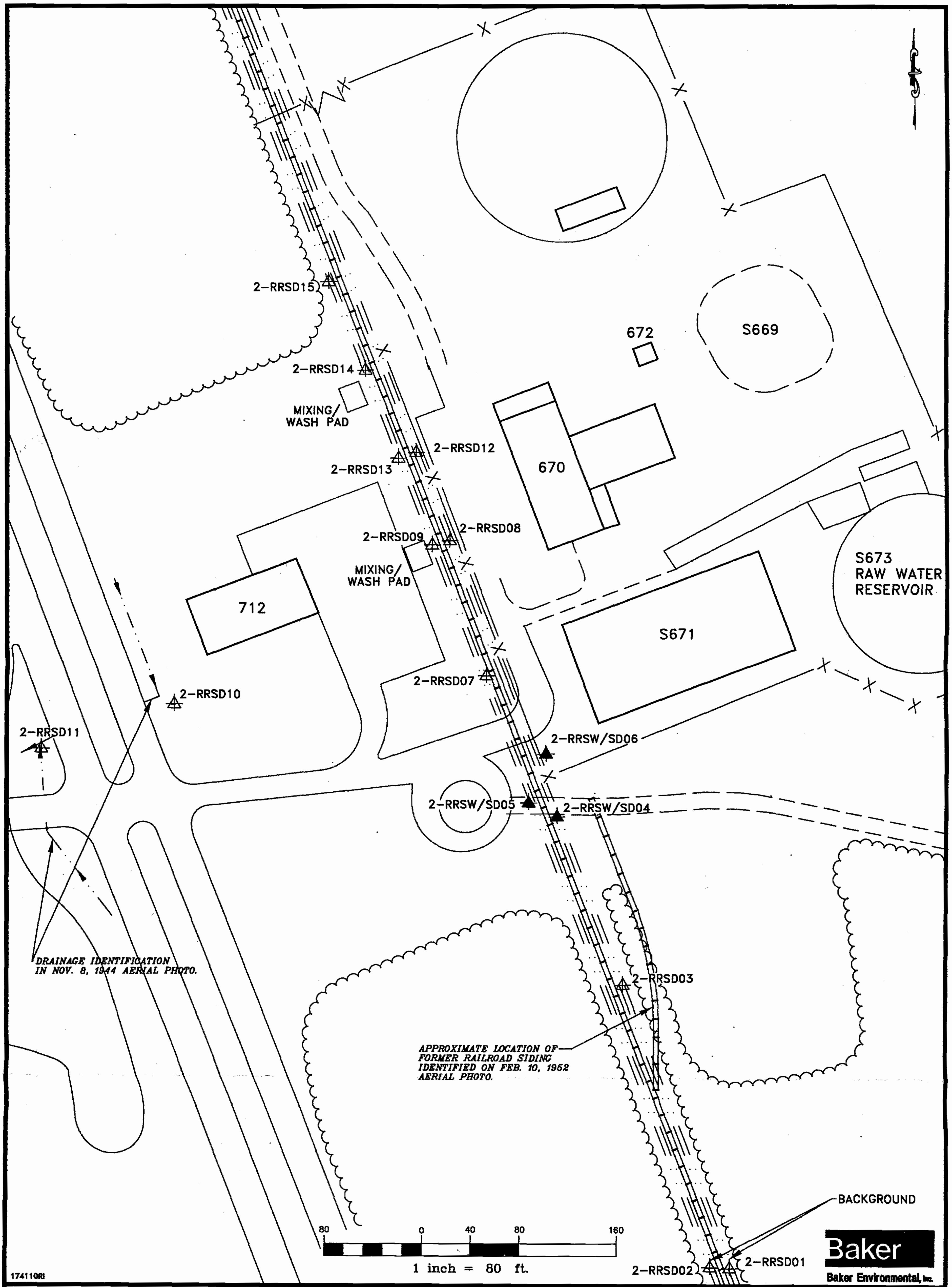
FIGURE 2–7
TYPICAL DEEP GROUNDWATER
MONITORING WELL CONSTRUCTION DIAGRAM
REMEDIAL INVESTIGATION CTO–0174

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA



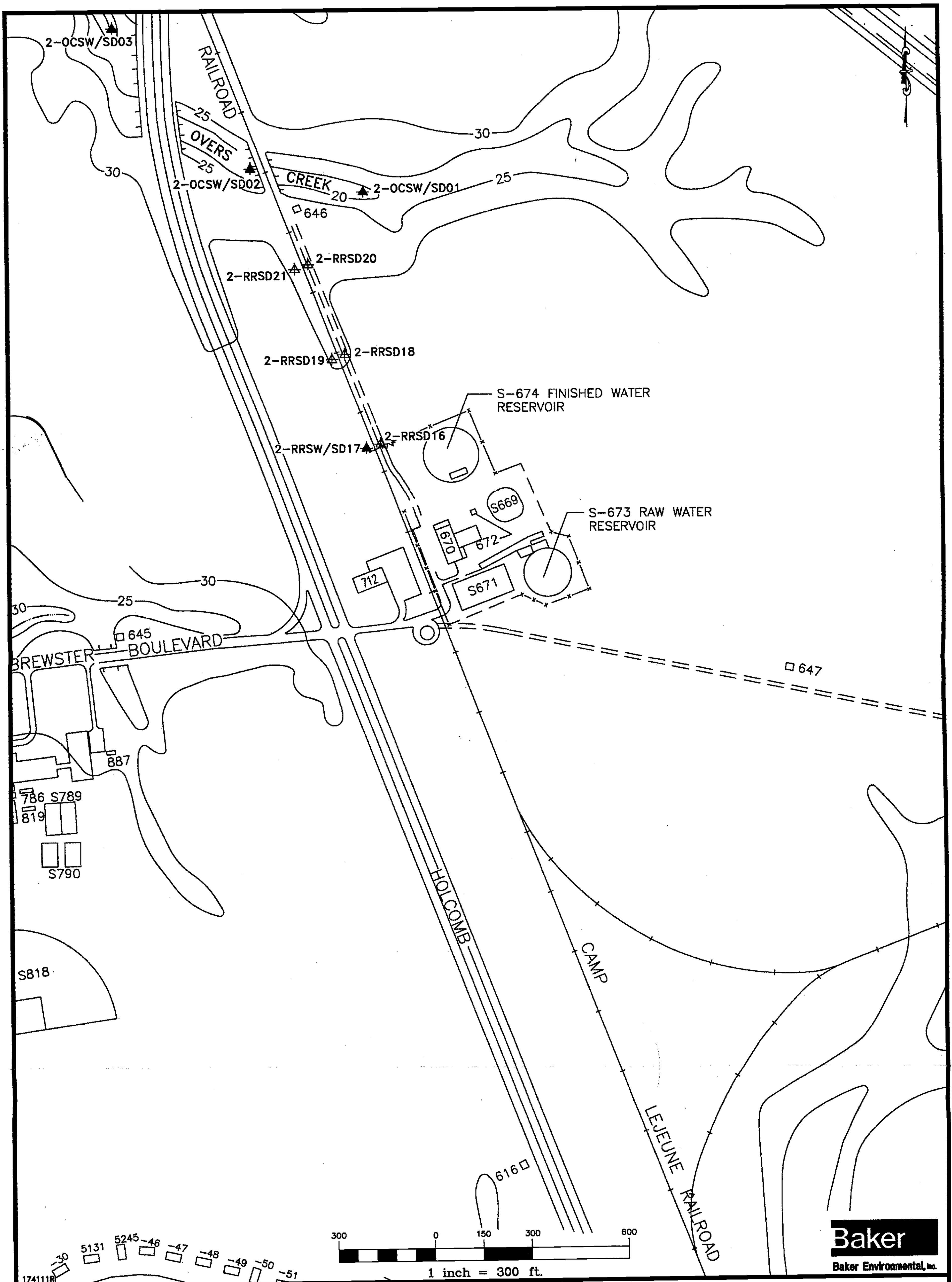
LEGEND

2-RRSW/SD04 ▲ SURFACE WATER AND SEDIMENT SAMPLING STATION

2-RRSW/SD04 △ SEDIMENT SAMPLING STATION ONLY

SOURCE: LANTDIV, FEB. 1992

FIGURE 2-8
SURFACE WATER/SEDIMENT
SAMPLING LOCATIONS
SITE 2
REMEDIAL INVESTIGATION CTO-0174
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA



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LEGEND

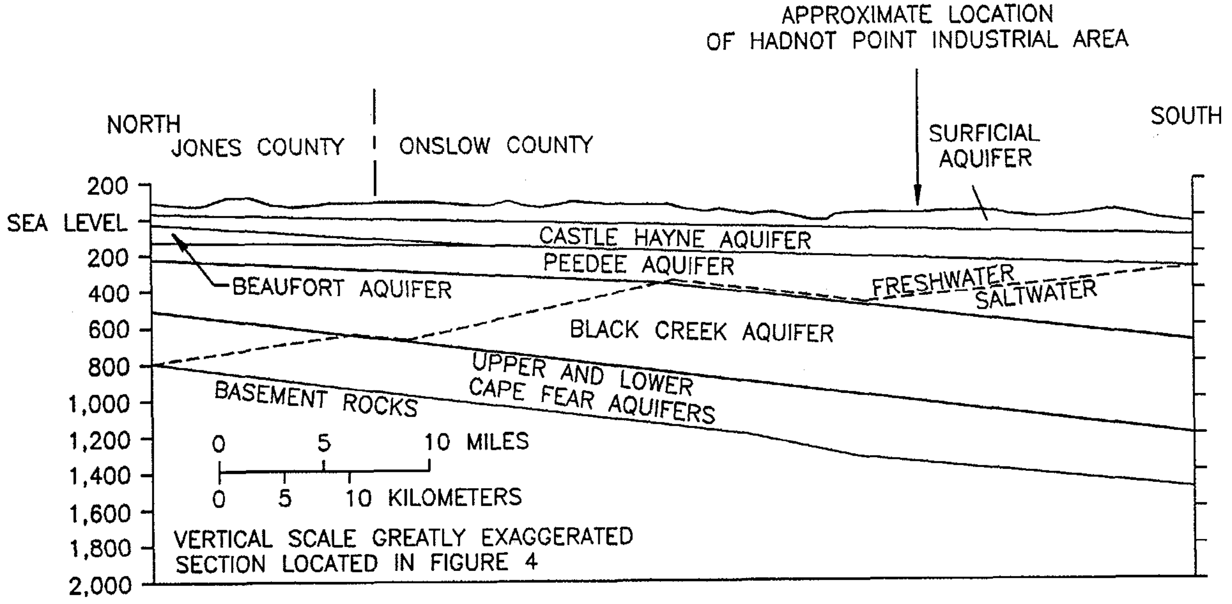
2-RRSW/SD17 ▲ SURFACE WATER AND SEDIMENT SAMPLING STATION

2-RRSD17 △ SEDIMENT SAMPLING STATION ONLY

SOURCE: LANTDIV, FEBRUARY 1992

FIGURE 2-9
SURFACE WATER/SEDIMENT
SAMPLING LOCATIONS
NORTH OF SITE 2
REMEDIAL INVESTIGATION CTO-0174
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

01273R10Z



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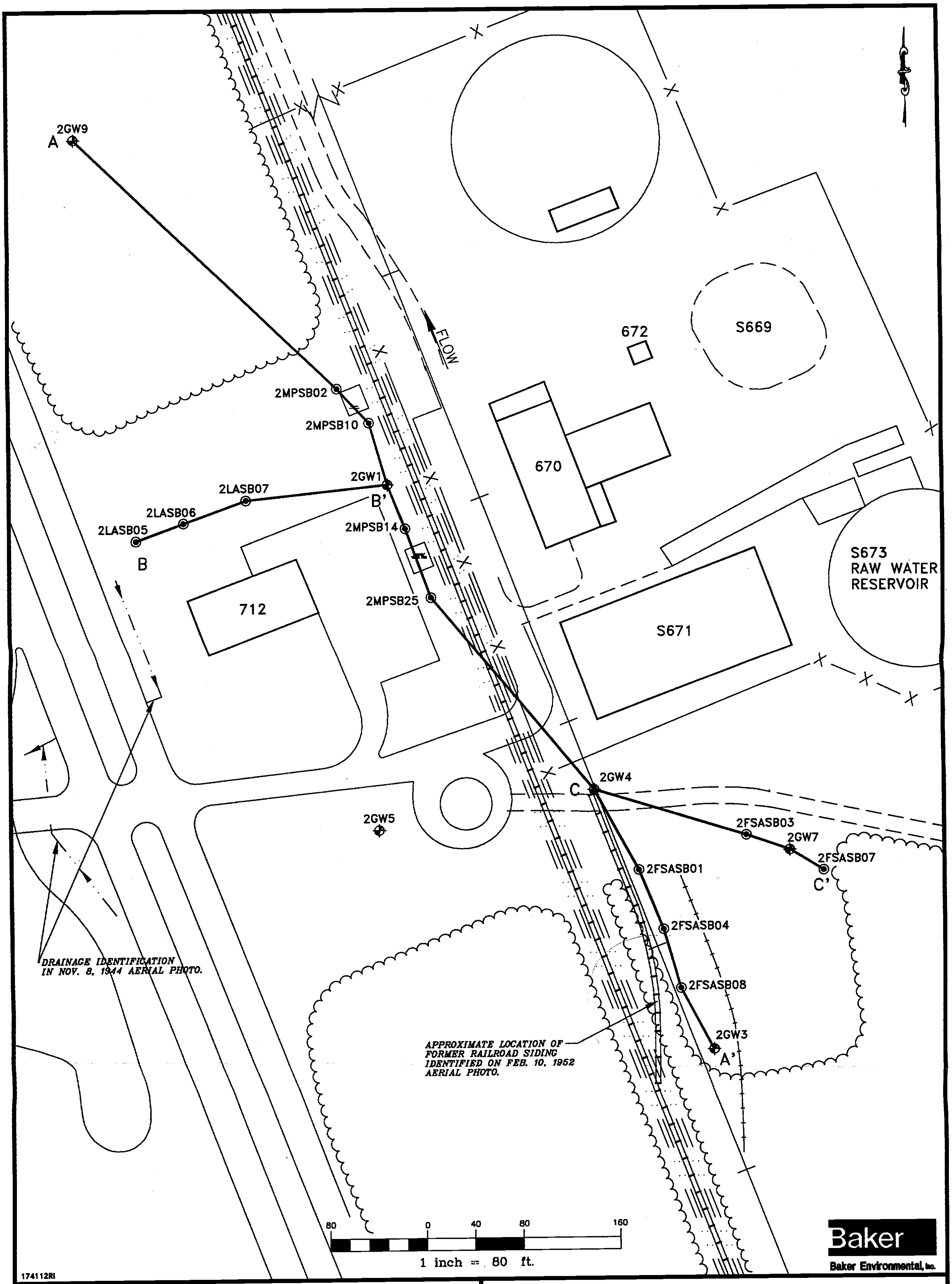
174138RI

FIGURE 3-1
GENERALIZED HYDROGEOLOGIC CROSS-SECTION JONES AND ONSLOW COUNTIES, NORTH CAROLINA
REMEDIAL INVESTIGATION CTO-0174

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

SOURCE: HARNED, et. al., 1989



LEGEND

2LASB05 ◉ SOIL BORING LOCATION

2GW1 ⊕ MONITORING WELL LOCATION

A—A' CROSS-SECTION TRAVERSE

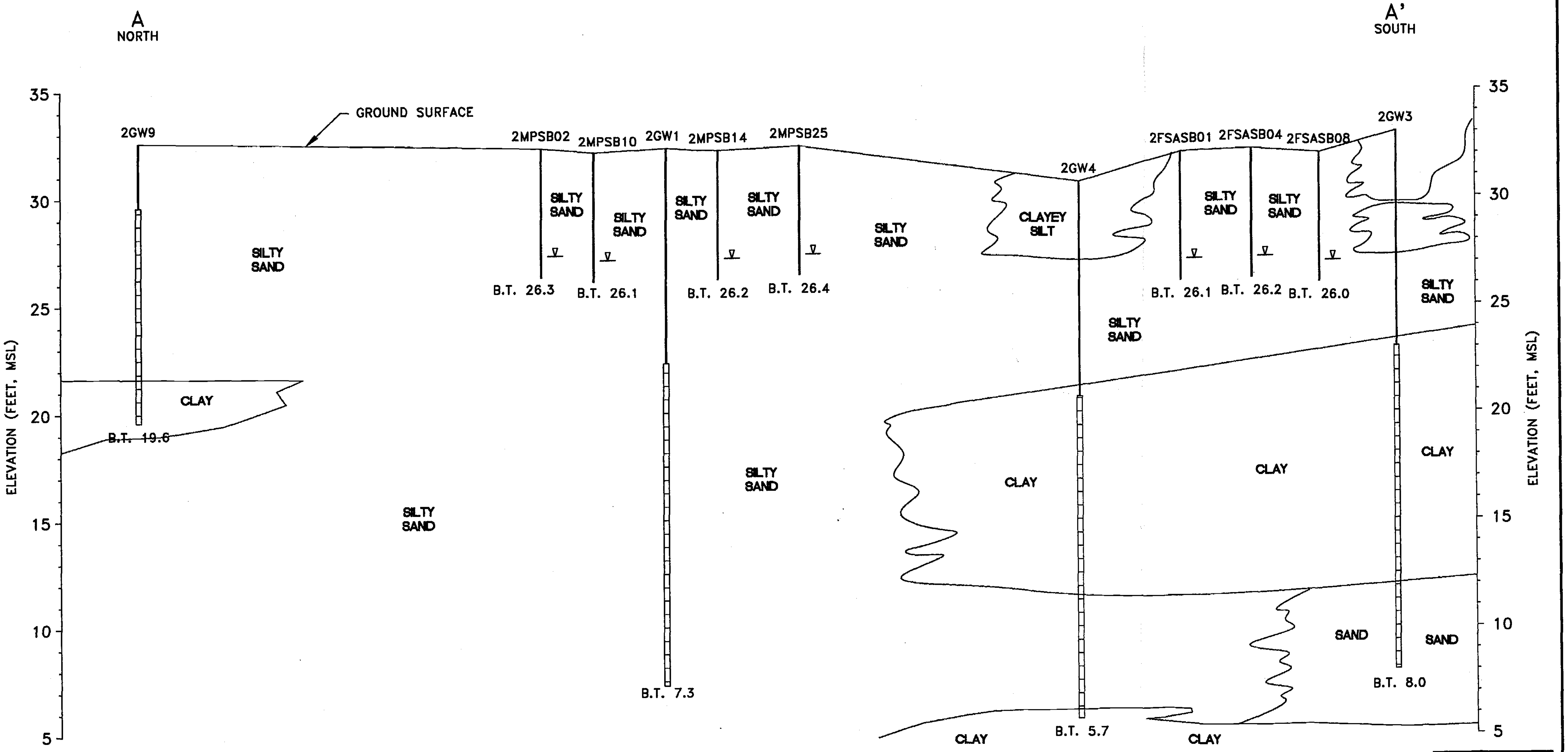
SOURCE: LANTDIV, FEB. 1992

FIGURE 3-2
HYDROGEOLOGIC CROSS-SECTON
LOCATION MAP
REMEDIAL INVESTIGATION CTO-0174

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

01273R112

174113RI



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LEGEND

▽	GROUNDWATER ENCOUNTERED DURING DRILLING
B.T. 7.3'	BORING TERMINATED, ELEVATION MSL
▯	WELL SCREEN INTERVAL
——	ESTIMATED

80 0 40 80 160
Horizontal Scale: 1 inch = 80 ft.

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

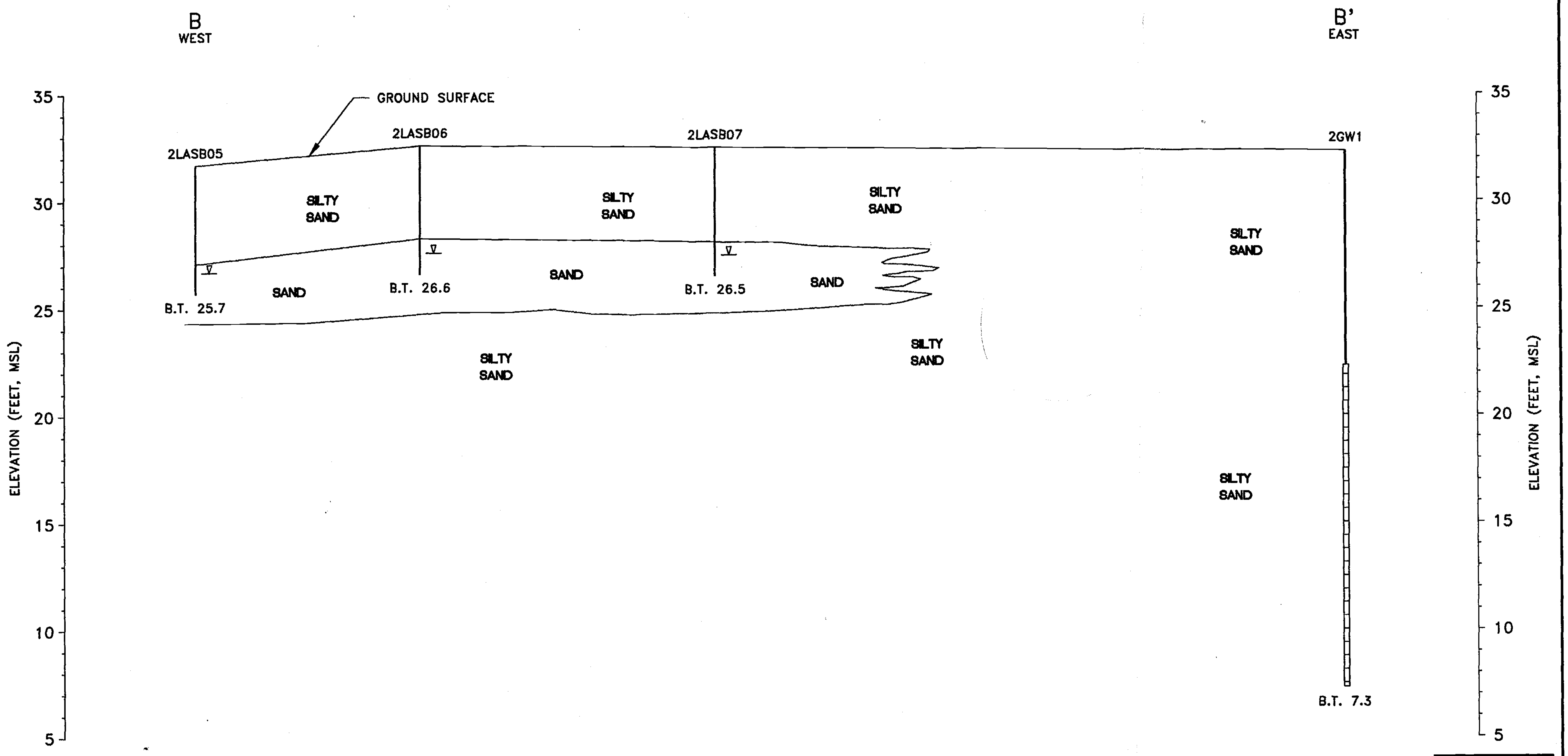
THE SOIL BORING INFORMATION IS CONSIDERED TO BE REPRESENTATIVE OF SUBSURFACE CONDITIONS AT THE RESPECTIVE BORING LOCATIONS. SUBSURFACE CONDITIONS INTERPOLATED BETWEEN BORINGS ARE ESTIMATED BASED ON ACCEPTED SOIL ENGINEERING PRINCIPLES AND GEOLOGIC JUDGEMENT.

FIGURE 3-3
HYDROGEOLOGIC CROSS-SECTION A-A'
REMEDIAL INVESTIGATION CTO-0174
SITE 2

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

01273R12Z

174114RI



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LEGEND

▽	GROUNDWATER ENCOUNTERED DURING DRILLING
B.T. 25.7'	BORING TERMINATED, ELEVATION MSL
▯	WELL SCREEN INTERVAL
———	ESTIMATED

20 0 10 20 40

Horizontal Scale: 1 inch = 20 ft.

5 0 2.5 5 10

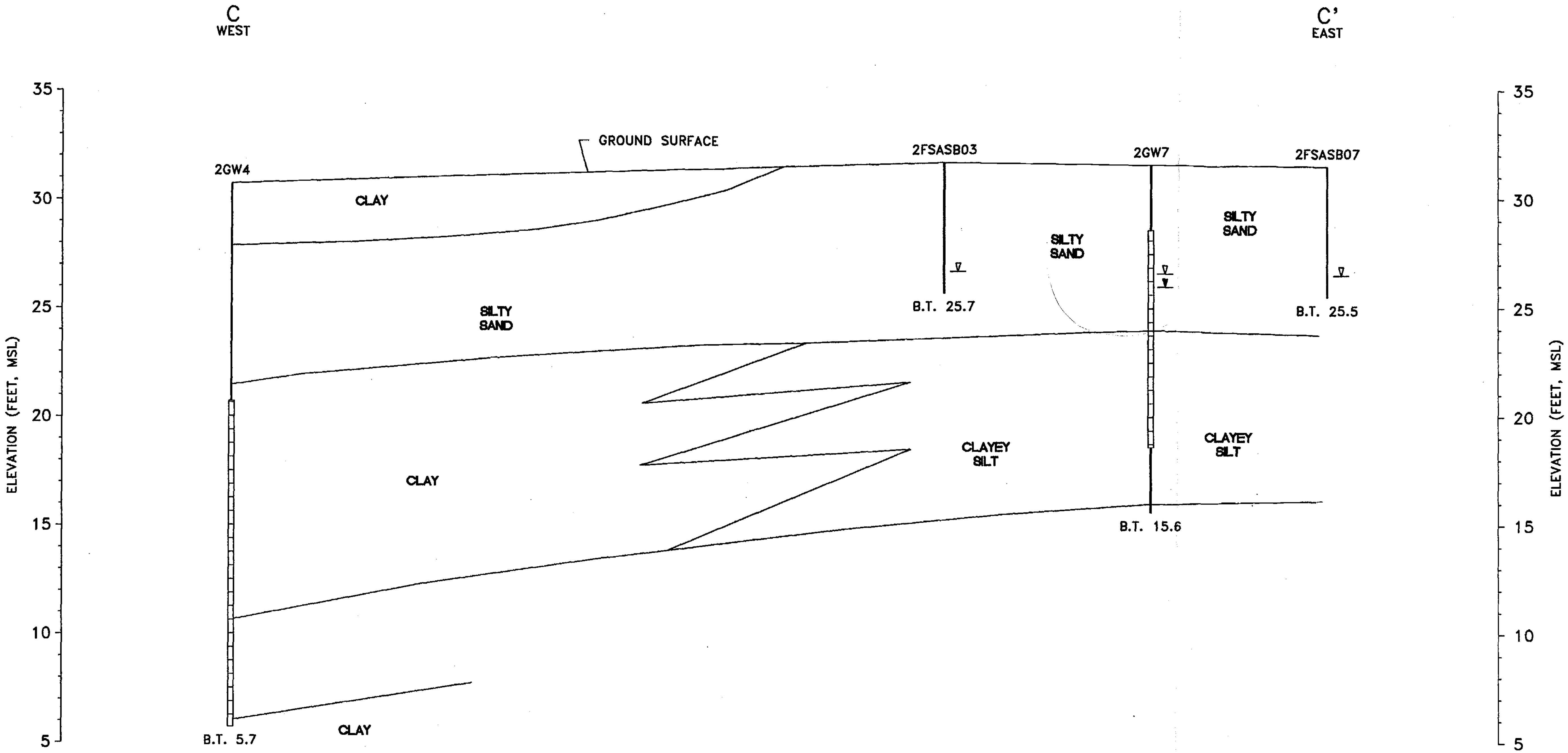
Vertical Scale: 1 inch = 5 ft.

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

FIGURE 3-4
HYDROGEOLOGIC CROSS-SECTION B-B'
REMEDIAL INVESTIGATION CTO-0174
SITE 2

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

174115RI



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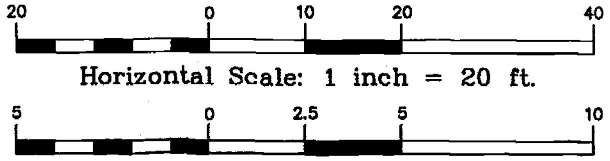
LEGEND

▼ GROUNDWATER ELEVATION (X)
▽ GROUNDWATER ENCOUNTERED DURING DRILLING
B.T. 5.7' BORING TERMINATED, ELEVATION MSL
▯ WELL SCREEN INTERVAL
—— ESTIMATED



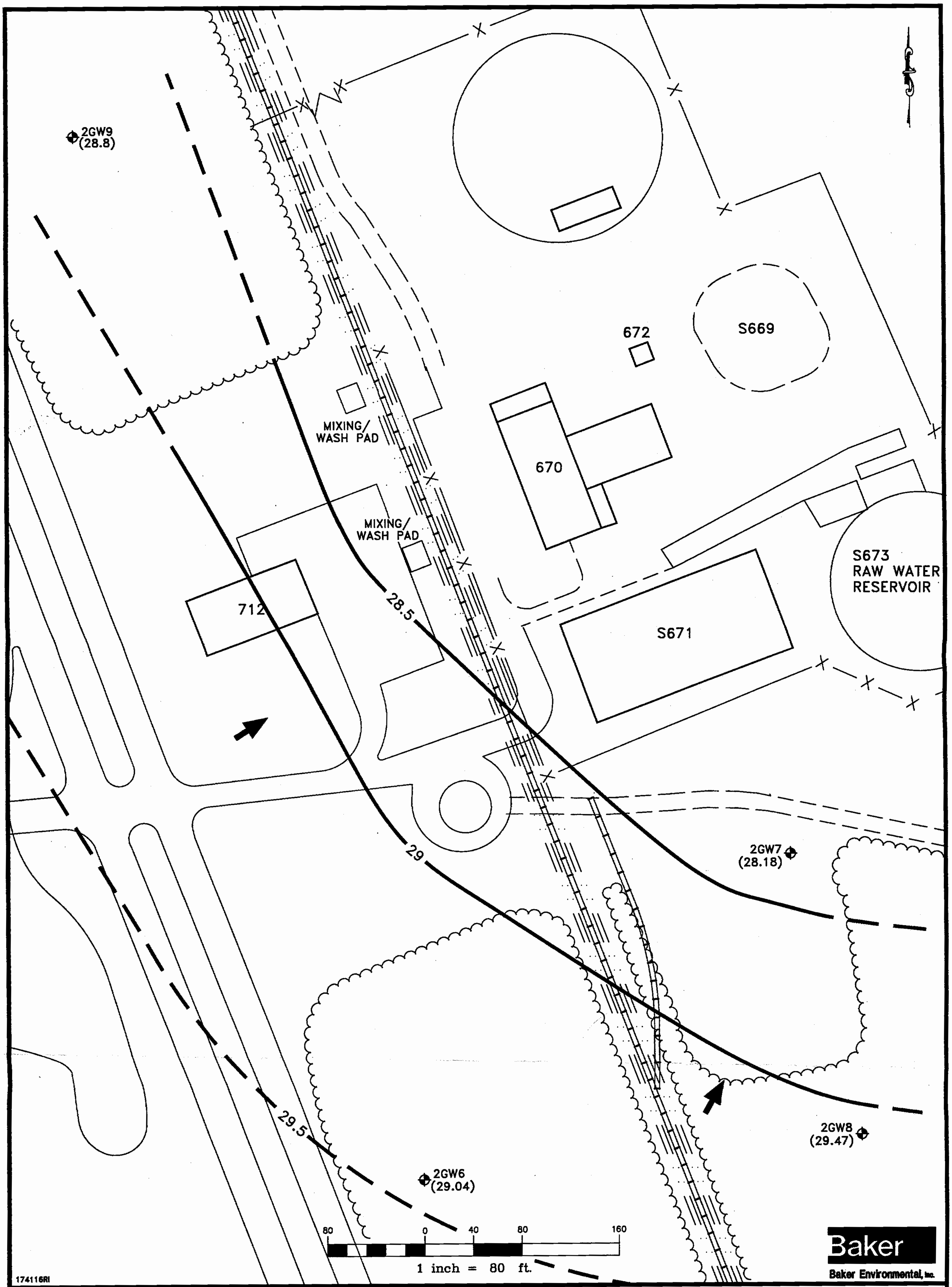
Horizontal Scale: 1 inch = 20 ft.

Vertical Scale: 1 inch = 5 ft.

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

FIGURE 3-5
HYDROGEOLOGIC CROSS-SECTION C-C'
REMEDIAL INVESTIGATION CTO-0174
SITE 2

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA



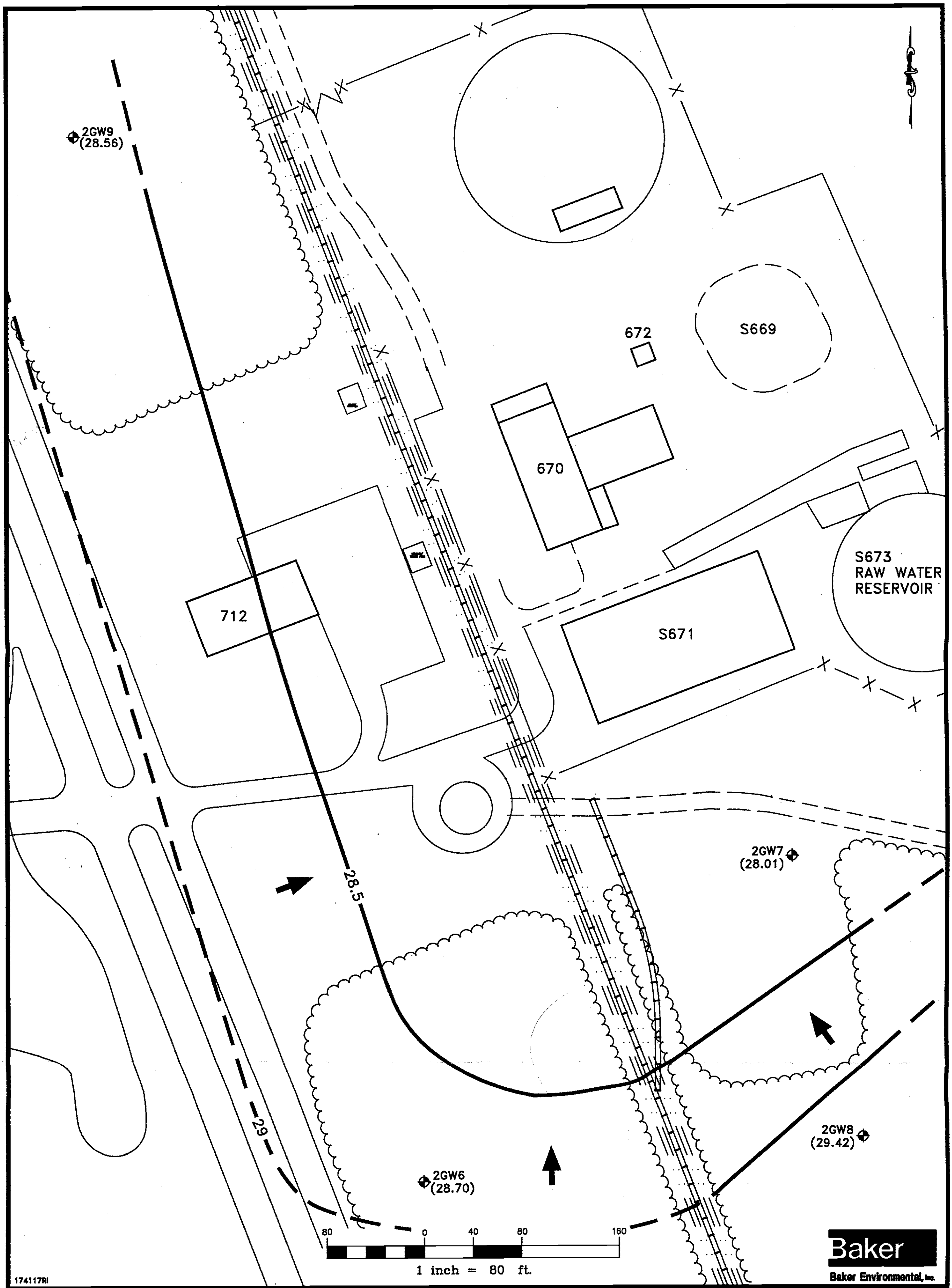
LEGEND

2GW6 ⊕	GROUNDWATER MONITORING WELL
(29.04)	GROUNDWATER ELEVATION (MSL)
—29—	GROUNDWATER CONTOUR (MSL)
- -29- -	ESTIMATED GROUNDWATER CONTOUR (MSL)
➔	ESTIMATED DIRECTION OF GROUNDWATER FLOW

SOURCE: LANTDIV, FEB. 1992

FIGURE 3-6
GROUNDWATER ELEVATION CONTOUR MAP
SURFICIAL AQUIFER
MAY 17, 1993
SITE 2
REMEDIAL INVESTIGATION CTO-0174
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

01273R152



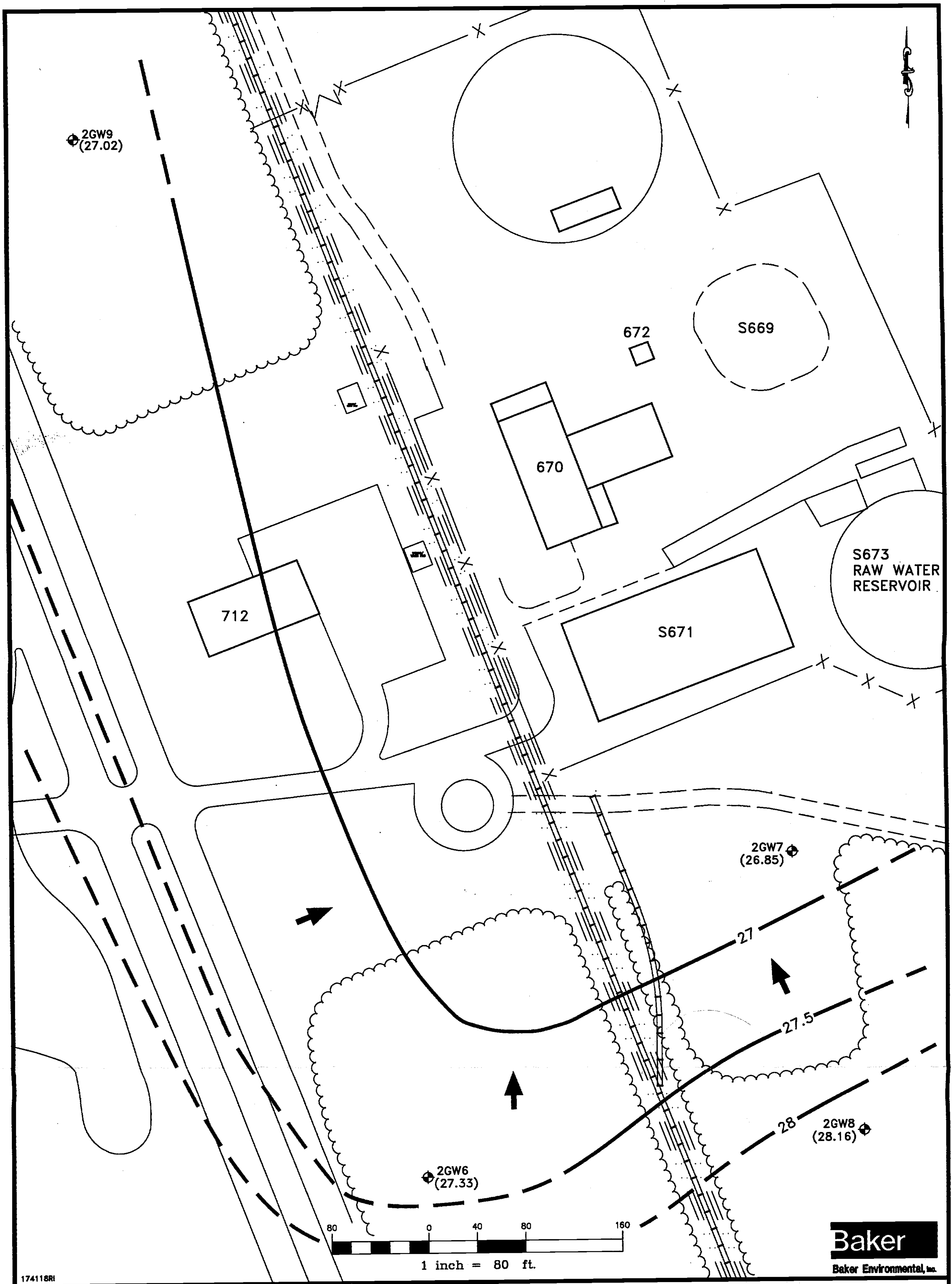
LEGEND

2GW6 ⊕	GROUNDWATER MONITORING WELL
(28.70)	GROUNDWATER ELEVATION (MSL)
—29—	GROUNDWATER CONTOUR (MSL)
- -29- -	ESTIMATED GROUNDWATER CONTOUR (MSL)
➔	ESTIMATED DIRECTION OF GROUNDWATER FLOW

SOURCE: LANTDIV, FEB. 1992

FIGURE 3-7
GROUNDWATER ELEVATION CONTOUR MAP
SURFICIAL AQUIFER
MAY 20, 1993
SITE 2
REMEDIAL INVESTIGATION CTO-0174
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

01273R16Z

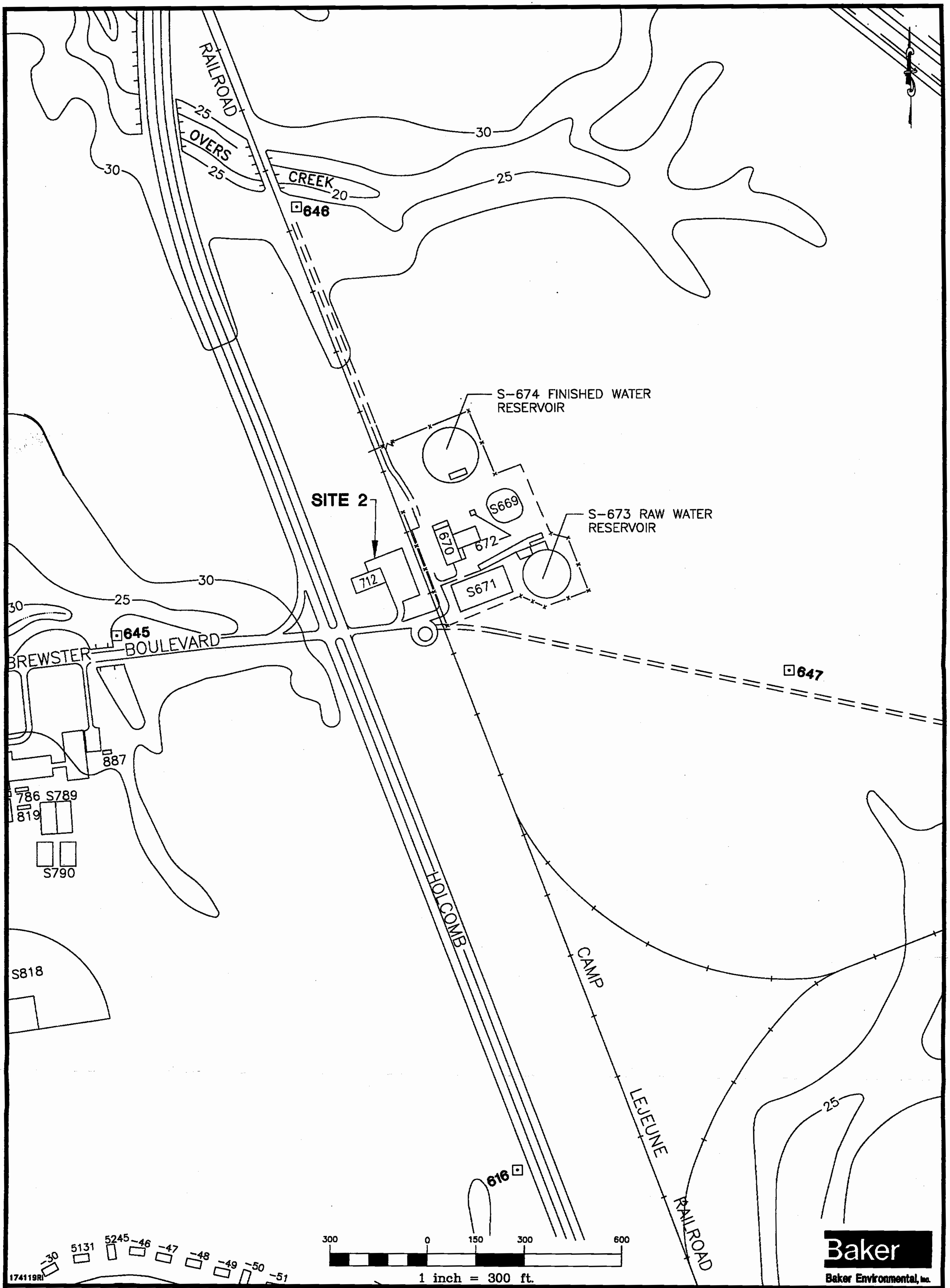


LEGEND	
2GW6 ⊕	GROUNDWATER MONITORING WELL
(28.70)	GROUNDWATER ELEVATION (MSL)
—27—	GROUNDWATER CONTOUR (MSL)
--27--	ESTIMATED GROUNDWATER CONTOUR (MSL)
→	ESTIMATED DIRECTION OF GROUNDWATER FLOW

SOURCE: LANTDIV, FEB. 1992

FIGURE 3-8
GROUNDWATER ELEVATION CONTOUR MAP
SURFICIAL AQUIFER
JUNE 5, 1993
SITE 2
REMEDIAL INVESTIGATION CTO-0174
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

01273R172



LEGEND

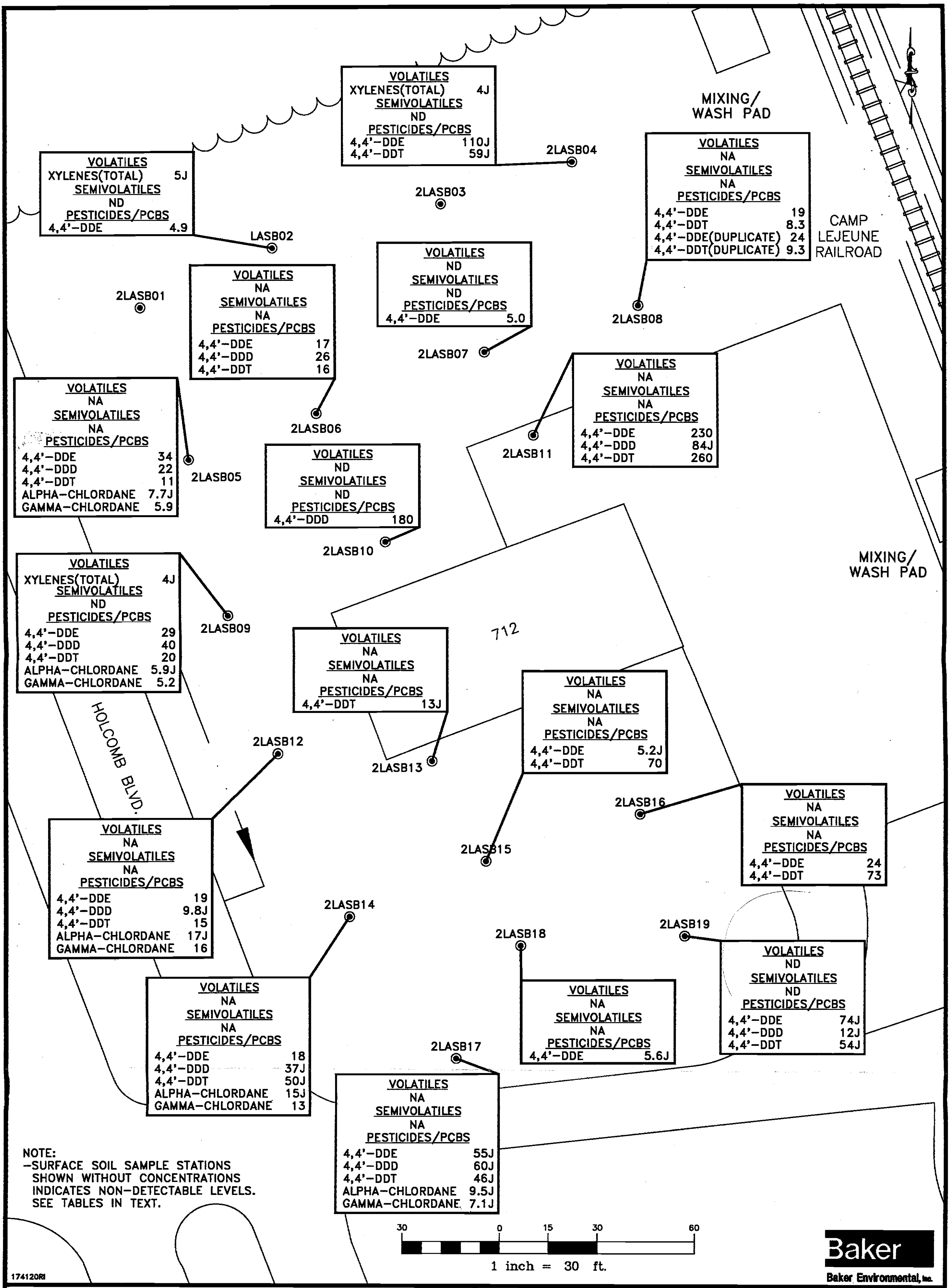
616 ⊡ WATER SUPPLY WELL

SOURCE: LANTDIV, FEB. 1992

FIGURE 3-9
SUPPLY WELLS IN THE VICINITY
OF SITE 2
REMEDIAL INVESTIGATION CTO-0174

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

01273R182



NOTE:
-SURFACE SOIL SAMPLE STATIONS SHOWN WITHOUT CONCENTRATIONS INDICATES NON-DETECTABLE LEVELS. SEE TABLES IN TEXT.

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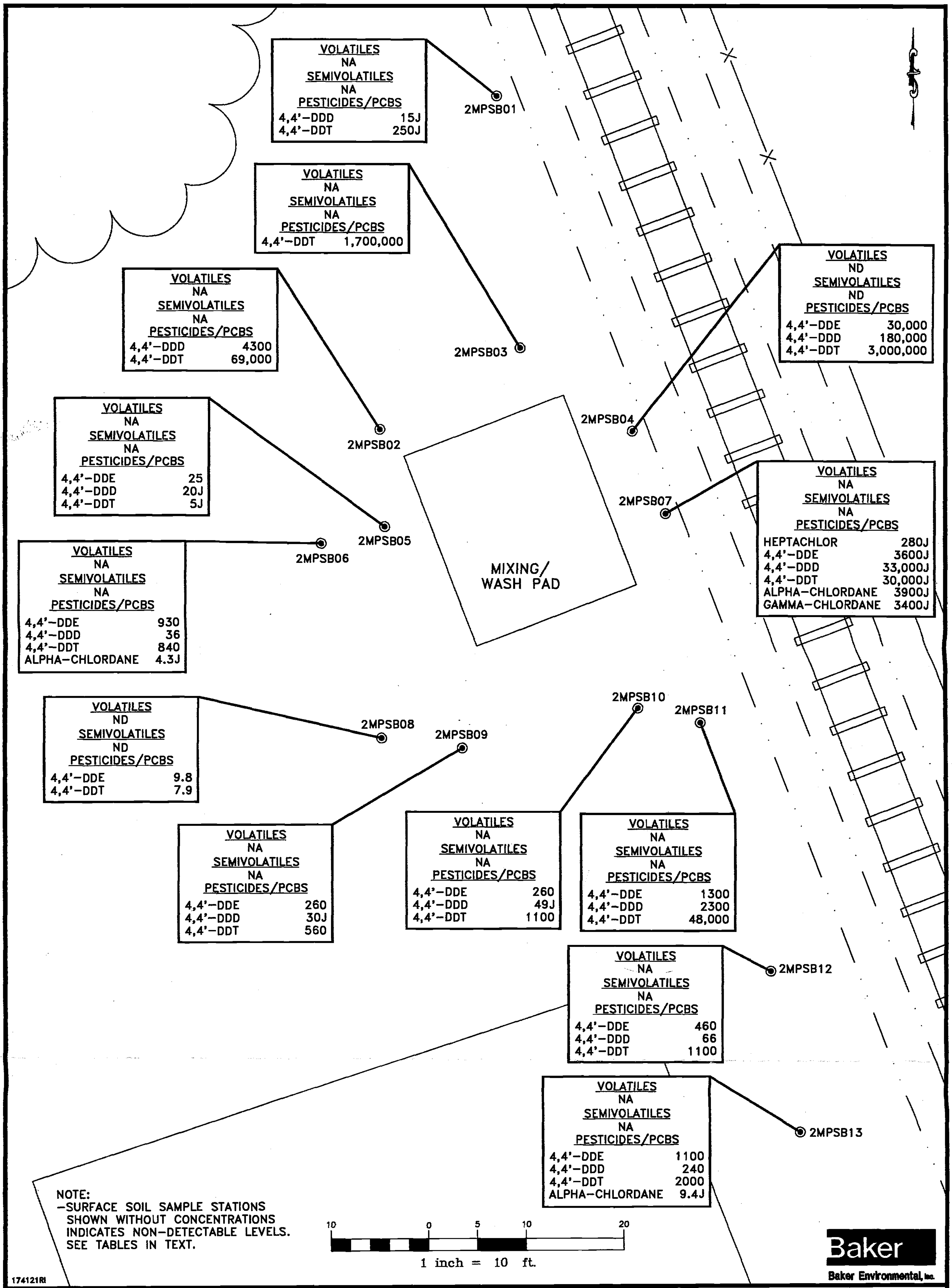
LEGEND

2LASB01 ●	SOIL BORING
ND	NOT DETECTED
NA	NOT ANALYZED
J	ESTIMATED CONCENTRATION

COMPOUND CONCENTRATIONS EXPRESSED IN ug/kg(ppb)
SOURCE: LANTDIV, FEB. 1992

FIGURE 4-1
POSITIVE DETECTIONS OF ORGANIC COMPOUNDS IN SURFACE SOILS
SITE 2, LAWN AREA
REMEDIAL INVESTIGATION CTO-0174
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

01273R192



NOTE:
-SURFACE SOIL SAMPLE STATIONS SHOWN WITHOUT CONCENTRATIONS INDICATES NON-DETECTABLE LEVELS. SEE TABLES IN TEXT.

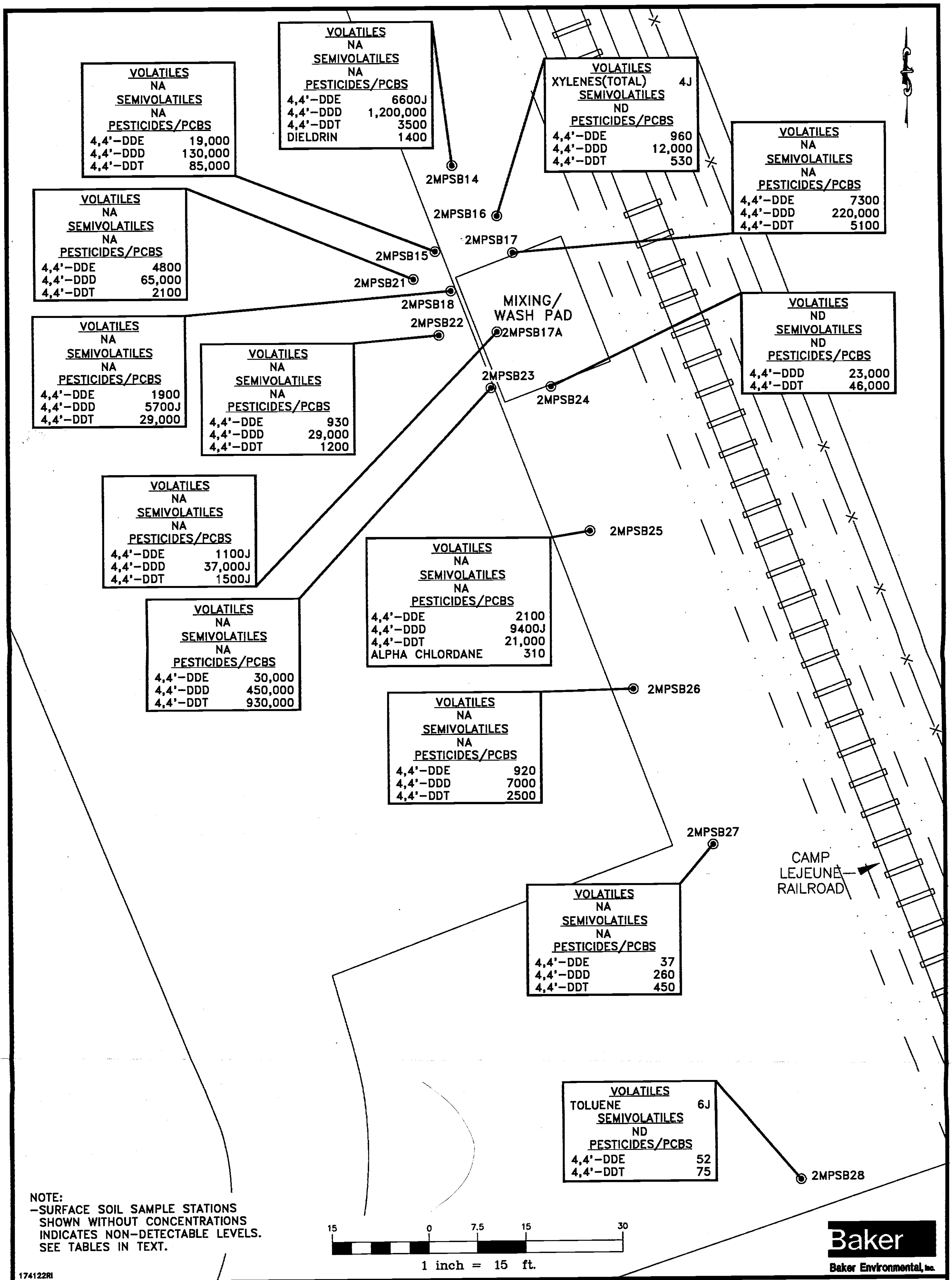
Baker
Baker Environmental, Inc.

LEGEND

2MPSB01 ● SOIL BORING
ND NOT DETECTED
NA NOT ANALYZED
J ESTIMATED CONCENTRATION
COMPOUND CONCENTRATIONS EXPRESSED IN ug/kg(ppb)
SOURCE: LANTDIV, FEB. 1992

FIGURE 4-2
POSITIVE DETECTIONS OF ORGANIC COMPOUNDS IN SURFACE SOILS
SITE 2, NORTH MIXING PAD AREA
REMEDIAL INVESTIGATION CTO-0174
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

01273R202



VOLATILES
NA
SEMIVOLATILES
NA
PESTICIDES/PCBS
4,4'–DDE 19,000
4,4'–DDD 130,000
4,4'–DDT 85,000

VOLATILES
NA
SEMIVOLATILES
NA
PESTICIDES/PCBS
4,4'–DDE 6600J
4,4'–DDD 1,200,000
4,4'–DDT 3500
DIELDRIN 1400

VOLATILES
XYLENES(TOTAL) 4J
SEMIVOLATILES
ND
PESTICIDES/PCBS
4,4'–DDE 960
4,4'–DDD 12,000
4,4'–DDT 530

VOLATILES
NA
SEMIVOLATILES
NA
PESTICIDES/PCBS
4,4'–DDE 7300
4,4'–DDD 220,000
4,4'–DDT 5100

VOLATILES
NA
SEMIVOLATILES
NA
PESTICIDES/PCBS
4,4'–DDE 4800
4,4'–DDD 65,000
4,4'–DDT 2100

VOLATILES
NA
SEMIVOLATILES
NA
PESTICIDES/PCBS
4,4'–DDE 1900
4,4'–DDD 5700J
4,4'–DDT 29,000

VOLATILES
NA
SEMIVOLATILES
NA
PESTICIDES/PCBS
4,4'–DDE 930
4,4'–DDD 29,000
4,4'–DDT 1200

VOLATILES
ND
SEMIVOLATILES
ND
PESTICIDES/PCBS
4,4'–DDD 23,000
4,4'–DDT 46,000

VOLATILES
NA
SEMIVOLATILES
NA
PESTICIDES/PCBS
4,4'–DDE 1100J
4,4'–DDD 37,000J
4,4'–DDT 1500J

VOLATILES
NA
SEMIVOLATILES
NA
PESTICIDES/PCBS
4,4'–DDE 2100
4,4'–DDD 9400J
4,4'–DDT 21,000
ALPHA CHLORDANE 310

VOLATILES
NA
SEMIVOLATILES
NA
PESTICIDES/PCBS
4,4'–DDE 30,000
4,4'–DDD 450,000
4,4'–DDT 930,000

VOLATILES
NA
SEMIVOLATILES
NA
PESTICIDES/PCBS
4,4'–DDE 920
4,4'–DDD 7000
4,4'–DDT 2500

VOLATILES
NA
SEMIVOLATILES
NA
PESTICIDES/PCBS
4,4'–DDE 37
4,4'–DDD 260
4,4'–DDT 450

VOLATILES
TOLUENE 6J
SEMIVOLATILES
ND
PESTICIDES/PCBS
4,4'–DDE 52
4,4'–DDT 75

NOTE:
–SURFACE SOIL SAMPLE STATIONS SHOWN WITHOUT CONCENTRATIONS INDICATES NON-DETECTABLE LEVELS. SEE TABLES IN TEXT.

174122RI

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Baker Environmental, Inc.

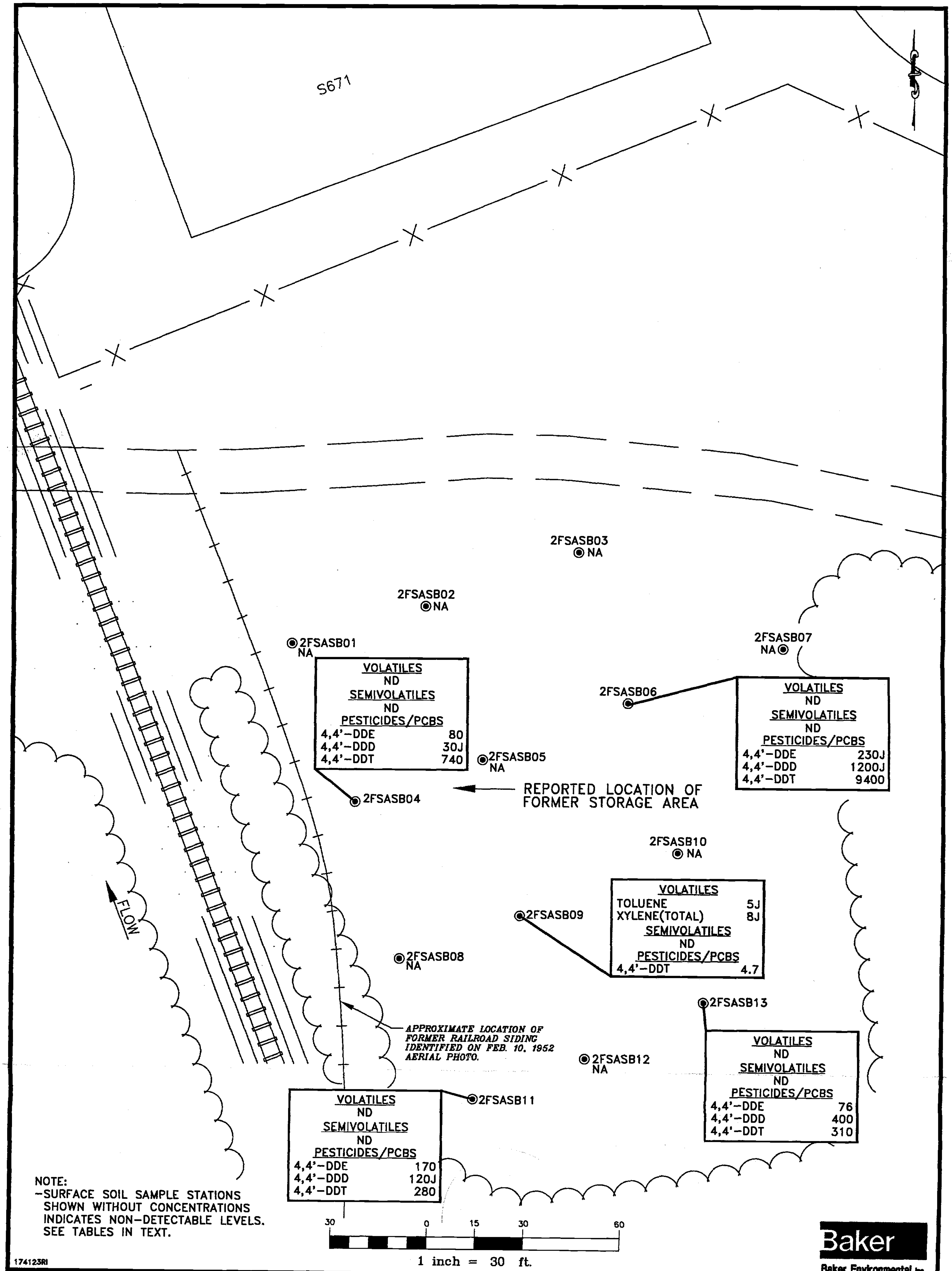
LEGEND

2MPSB14 ◉	SOIL BORING
ND	NOT DETECTED
NA	NOT ANALYZED
J	ESTIMATED CONCENTRATIONS

COMPOUND CONCENTRATIONS EXPRESSED IN ug/kg(ppb)
SOURCE: LANTDIV, FEB. 1992

FIGURE 4–3
POSITIVE DETECTIONS OF ORGANIC COMPOUNDS IN SURFACE SOILS
SITE 2, SOUTH MIXING PAD AREA
REMEDIAL INVESTIGATION CTO–0174
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

01273R212



NOTE:
-SURFACE SOIL SAMPLE STATIONS SHOWN WITHOUT CONCENTRATIONS INDICATES NON-DETECTABLE LEVELS. SEE TABLES IN TEXT.

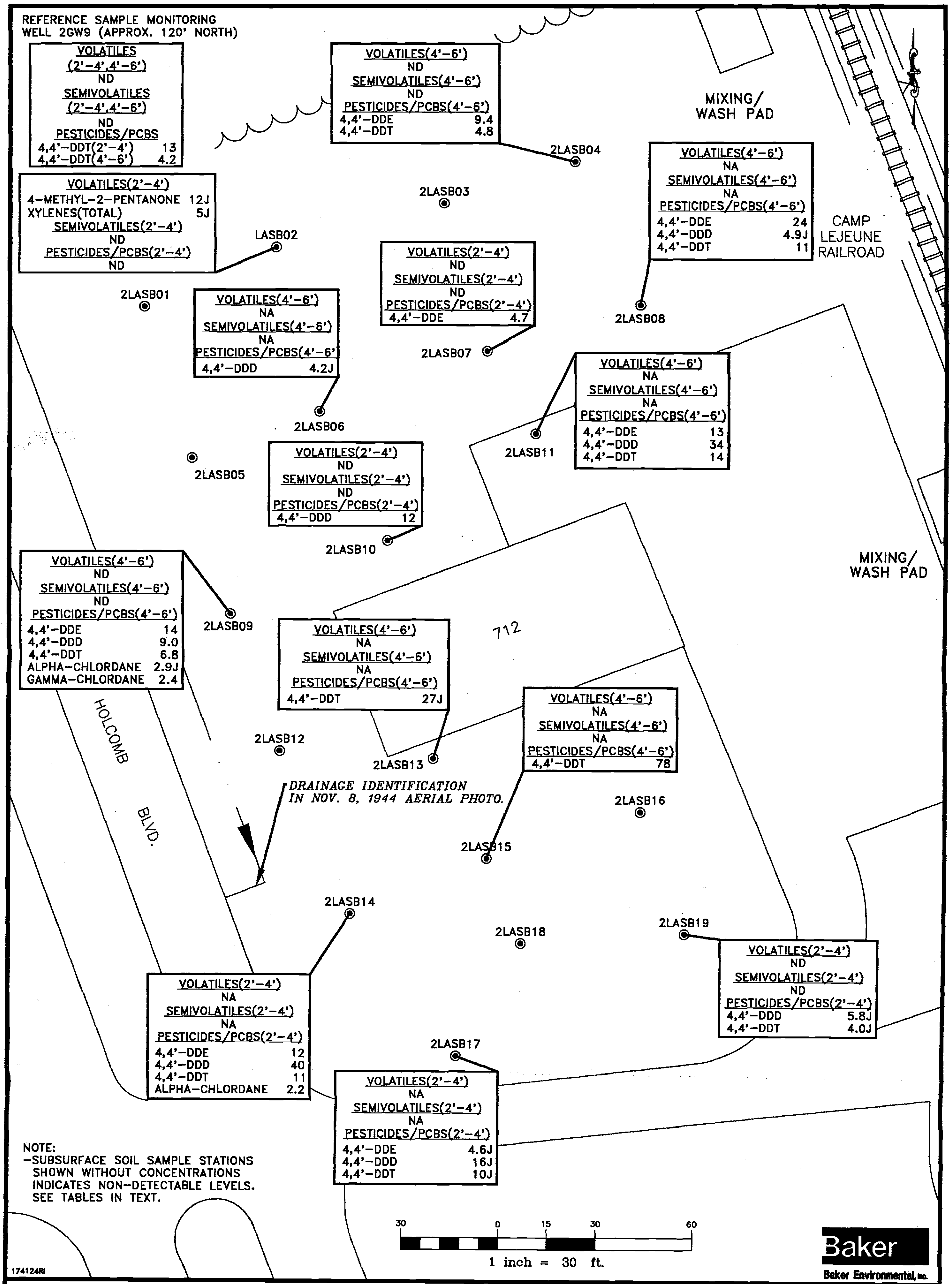
LEGEND

2FSASB01 ◉	SOIL BORING
ND	NOT DETECTED
NA	NOT ANALYZED
J	ESTIMATED CONCENTRATION

COMPOUND CONCENTRATIONS EXPRESSED IN ug/kg(ppb)

SOURCE: LANTDIV, FEB. 1992

FIGURE 4-4
POSITIVE DETECTIONS OF ORGANIC COMPOUNDS IN SURFACE SOILS
SITE 2, FORMER STORAGE AREA
REMEDIAL INVESTIGATION CTO-0174
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA



NOTE:
-SUBSURFACE SOIL SAMPLE STATIONS SHOWN WITHOUT CONCENTRATIONS INDICATES NON-DETECTABLE LEVELS. SEE TABLES IN TEXT.

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LEGEND

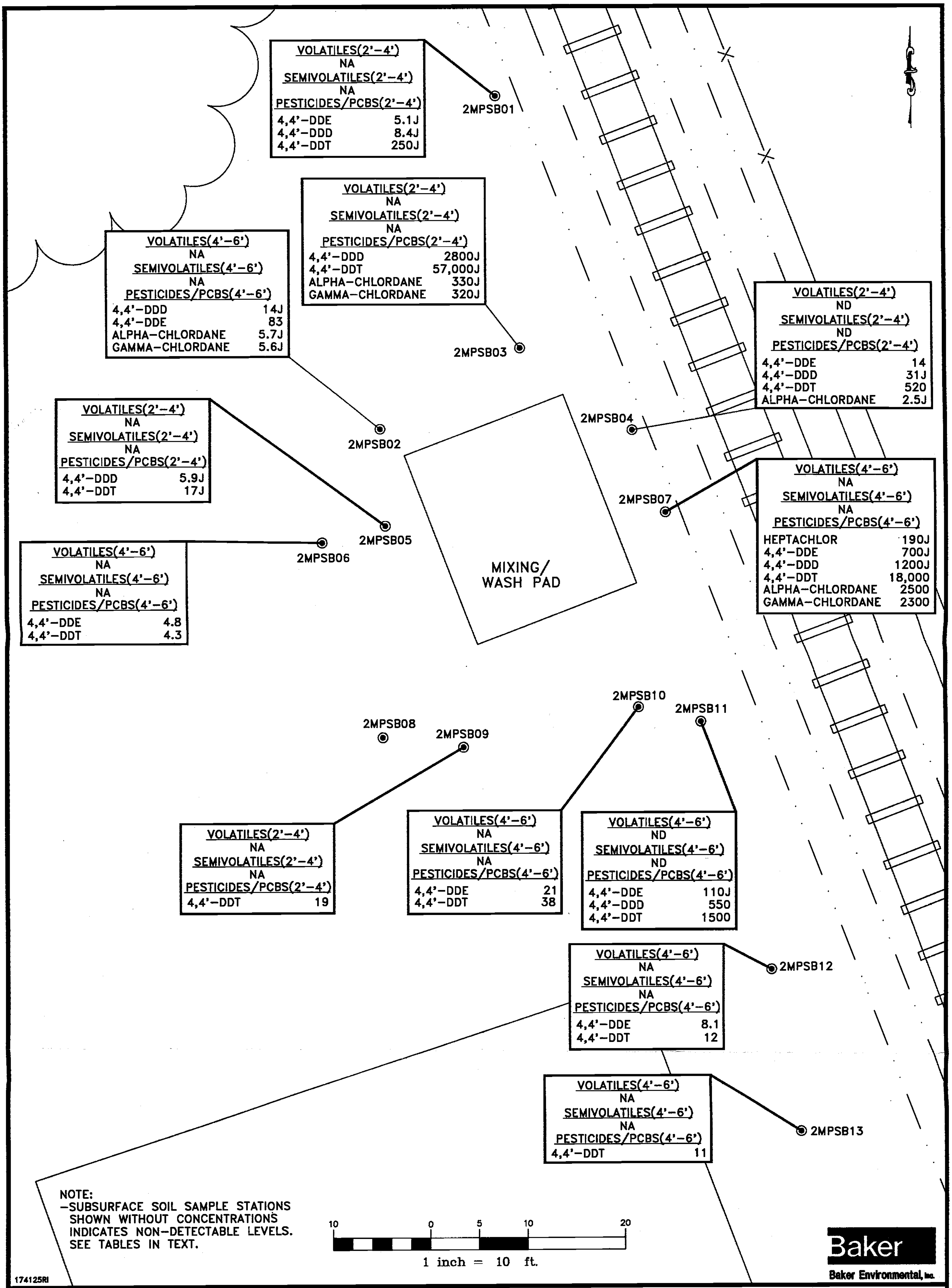
2LASB01 ◉	SOIL BORING
ND	NOT DETECTED
NA	NOT ANALYZED
J	ESTIMATED CONCENTRATION

COMPOUND CONCENTRATIONS EXPRESSED IN ug/kg(ppb)

SOURCE: LANTDIV, FEB. 1992

FIGURE 4-5
POSITIVE DETECTIONS OF ORGANIC COMPOUNDS IN SUBSURFACE SOILS
SITE 2, LAWN AREA
REMEDIAL INVESTIGATION CTO-0174
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

01273R232



NOTE:
-SUBSURFACE SOIL SAMPLE STATIONS SHOWN WITHOUT CONCENTRATIONS INDICATES NON-DETECTABLE LEVELS. SEE TABLES IN TEXT.

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LEGEND

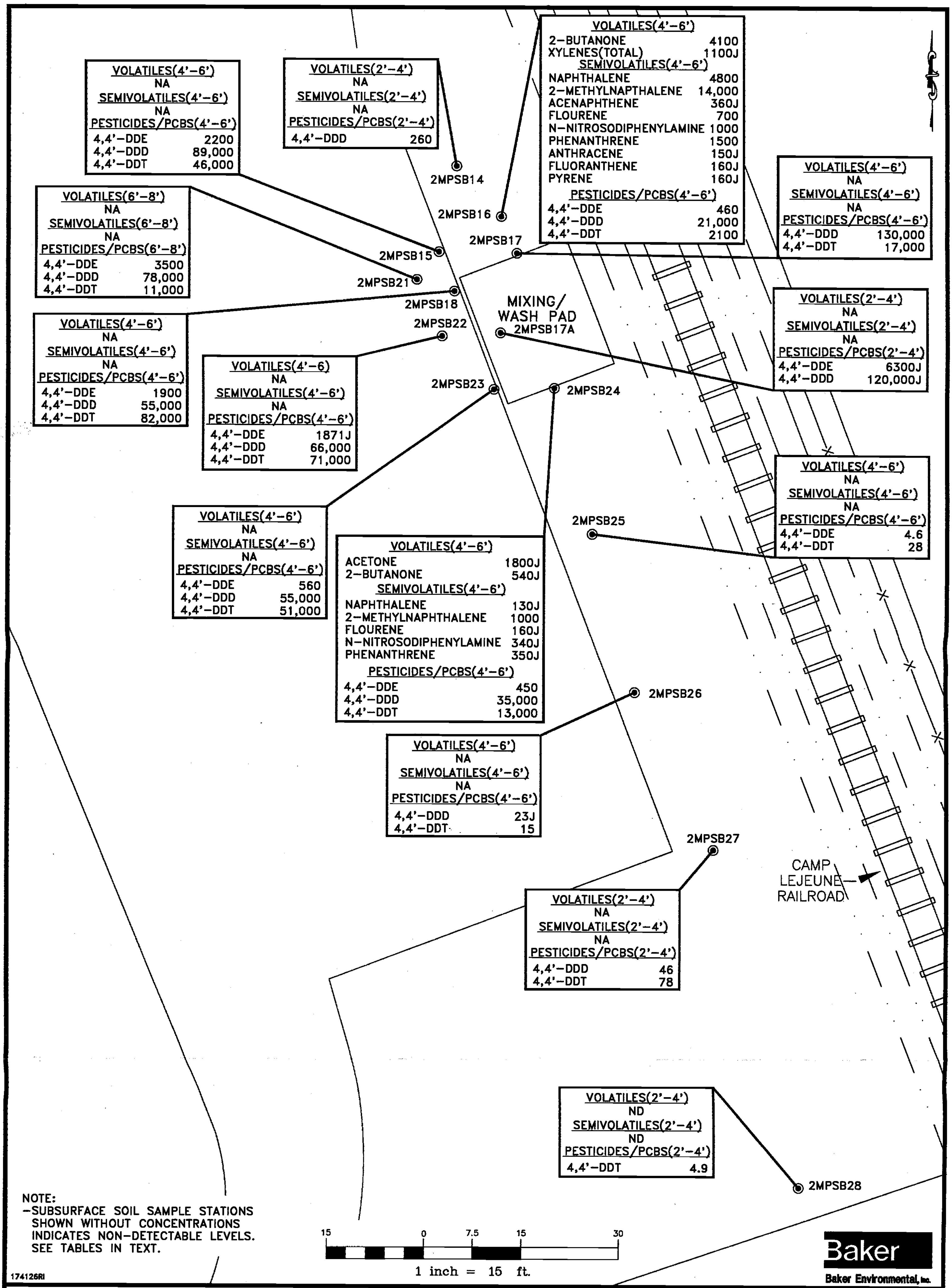
2MPSB01 ◉	SOIL BORING
ND	NOT DETECTED
NA	NOT ANALYZED
J	ESTIMATED CONCENTRATION

COMPOUND CONCENTRATIONS EXPRESSED IN ug/kg(ppb)

SOURCE: LANTDIV, FEB. 1992

FIGURE 4-6
POSITIVE DETECTIONS OF ORGANIC COMPOUNDS IN SUBSURFACE SOILS
SITE 2, NORTH MIXING PAD AREA
REMEDIAL INVESTIGATION CTO-0174
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

01273 R242



VOLATILES(4'-6')	
NA	
SEMIVOLATILES(4'-6')	
NA	
PESTICIDES/PCBS(4'-6')	
4,4'-DDE	2200
4,4'-DDD	89,000
4,4'-DDT	46,000

VOLATILES(2'-4')	
NA	
SEMIVOLATILES(2'-4')	
NA	
PESTICIDES/PCBS(2'-4')	
4,4'-DDD	260

VOLATILES(4'-6')	
2-BUTANONE	4100
XYLENES(TOTAL)	1100J
SEMIVOLATILES(4'-6')	
NAPHTHALENE	4800
2-METHYLNAPTHALENE	14,000
ACENAPHTHENE	360J
FLOURENE	700
N-NITROSODIPHENYLAMINE	1000
PHENANTHRENE	1500
ANTHRACENE	150J
FLUORANTHENE	160J
PYRENE	160J
PESTICIDES/PCBS(4'-6')	
4,4'-DDE	460
4,4'-DDD	21,000
4,4'-DDT	2100

VOLATILES(4'-6')	
NA	
SEMIVOLATILES(4'-6')	
NA	
PESTICIDES/PCBS(4'-6')	
4,4'-DDD	130,000
4,4'-DDT	17,000

VOLATILES(6'-8')	
NA	
SEMIVOLATILES(6'-8')	
NA	
PESTICIDES/PCBS(6'-8')	
4,4'-DDE	3500
4,4'-DDD	78,000
4,4'-DDT	11,000

VOLATILES(2'-4')	
NA	
SEMIVOLATILES(2'-4')	
NA	
PESTICIDES/PCBS(2'-4')	
4,4'-DDE	6300J
4,4'-DDD	120,000J

VOLATILES(4'-6')	
NA	
SEMIVOLATILES(4'-6')	
NA	
PESTICIDES/PCBS(4'-6')	
4,4'-DDE	1900
4,4'-DDD	55,000
4,4'-DDT	82,000

VOLATILES(4'-6)	
NA	
SEMIVOLATILES(4'-6')	
NA	
PESTICIDES/PCBS(4'-6')	
4,4'-DDE	1871J
4,4'-DDD	66,000
4,4'-DDT	71,000

VOLATILES(4'-6')	
NA	
SEMIVOLATILES(4'-6')	
NA	
PESTICIDES/PCBS(4'-6')	
4,4'-DDE	4.6
4,4'-DDT	28

VOLATILES(4'-6')	
NA	
SEMIVOLATILES(4'-6')	
NA	
PESTICIDES/PCBS(4'-6')	
4,4'-DDE	560
4,4'-DDD	55,000
4,4'-DDT	51,000

VOLATILES(4'-6')	
ACETONE	1800J
2-BUTANONE	540J
SEMIVOLATILES(4'-6')	
NAPHTHALENE	130J
2-METHYLNAPHTHALENE	1000
FLOURENE	160J
N-NITROSODIPHENYLAMINE	340J
PHENANTHRENE	350J
PESTICIDES/PCBS(4'-6')	
4,4'-DDE	450
4,4'-DDD	35,000
4,4'-DDT	13,000

VOLATILES(4'-6')	
NA	
SEMIVOLATILES(4'-6')	
NA	
PESTICIDES/PCBS(4'-6')	
4,4'-DDD	23J
4,4'-DDT	15

VOLATILES(2'-4')	
NA	
SEMIVOLATILES(2'-4')	
NA	
PESTICIDES/PCBS(2'-4')	
4,4'-DDD	46
4,4'-DDT	78

VOLATILES(2'-4')	
ND	
SEMIVOLATILES(2'-4')	
ND	
PESTICIDES/PCBS(2'-4')	
4,4'-DDT	4.9

NOTE:
-SUBSURFACE SOIL SAMPLE STATIONS SHOWN WITHOUT CONCENTRATIONS INDICATES NON-DETECTABLE LEVELS. SEE TABLES IN TEXT.

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LEGEND

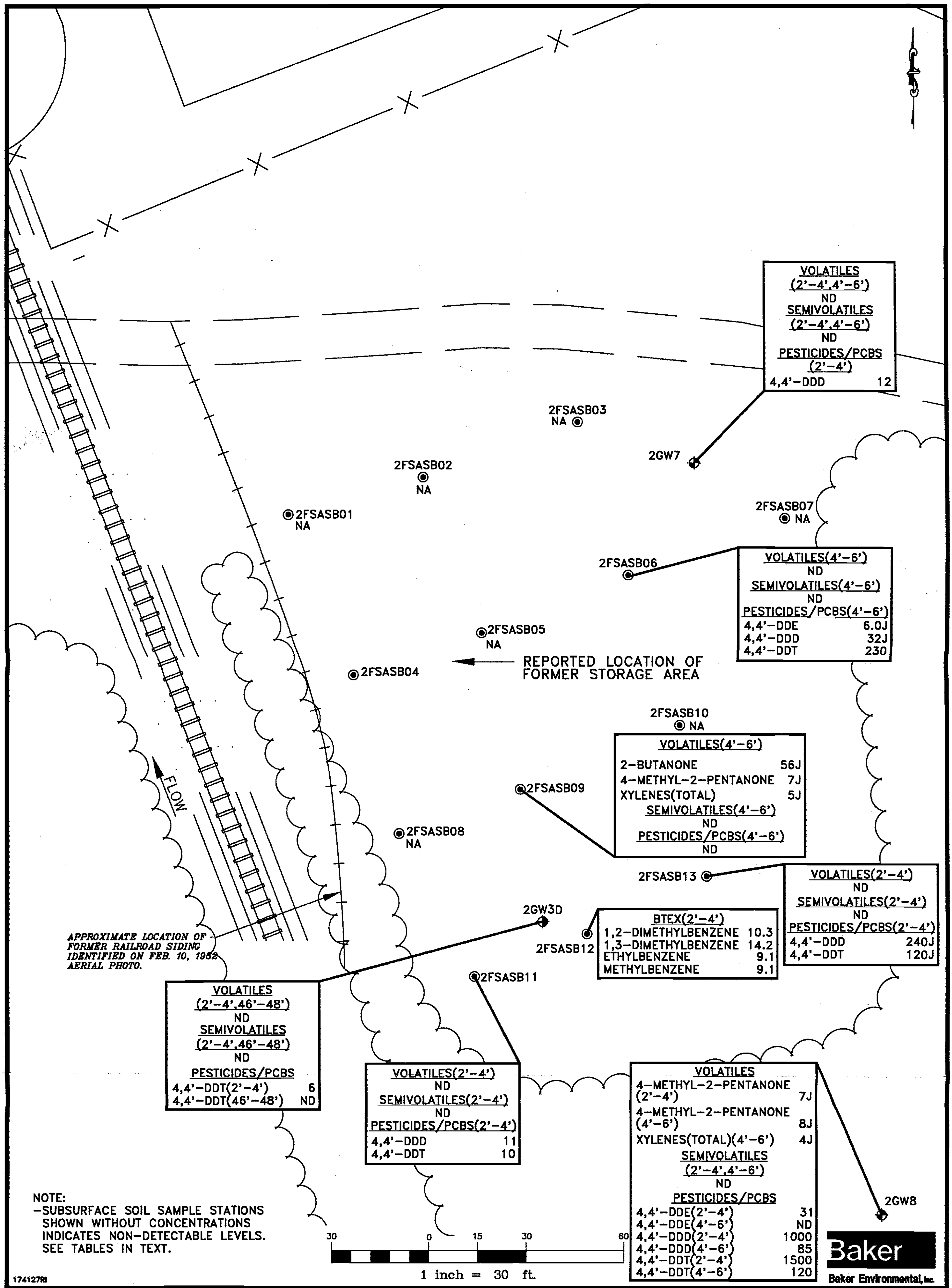
2MPSB14 ◉	SOIL BORING
ND	NOT DETECTED
NA	NOT ANALYZED
J	ESTIMATED CONCENTRATION

COMPOUND CONCENTRATIONS EXPRESSED IN ug/kg(ppb)

SOURCE: LANTDIV, FEB. 1002

FIGURE 4-7
POSITIVE DETECTIONS OF ORGANIC COMPOUNDS IN SUBSURFACE SOILS
SITE 2, SOUTH MIXING PAD AREA
REMEDIAL INVESTIGATION CTO-0174
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

01273R252



NOTE:
-SUBSURFACE SOIL SAMPLE STATIONS SHOWN WITHOUT CONCENTRATIONS INDICATES NON-DETECTABLE LEVELS. SEE TABLES IN TEXT.

Baker
Baker Environmental, Inc.

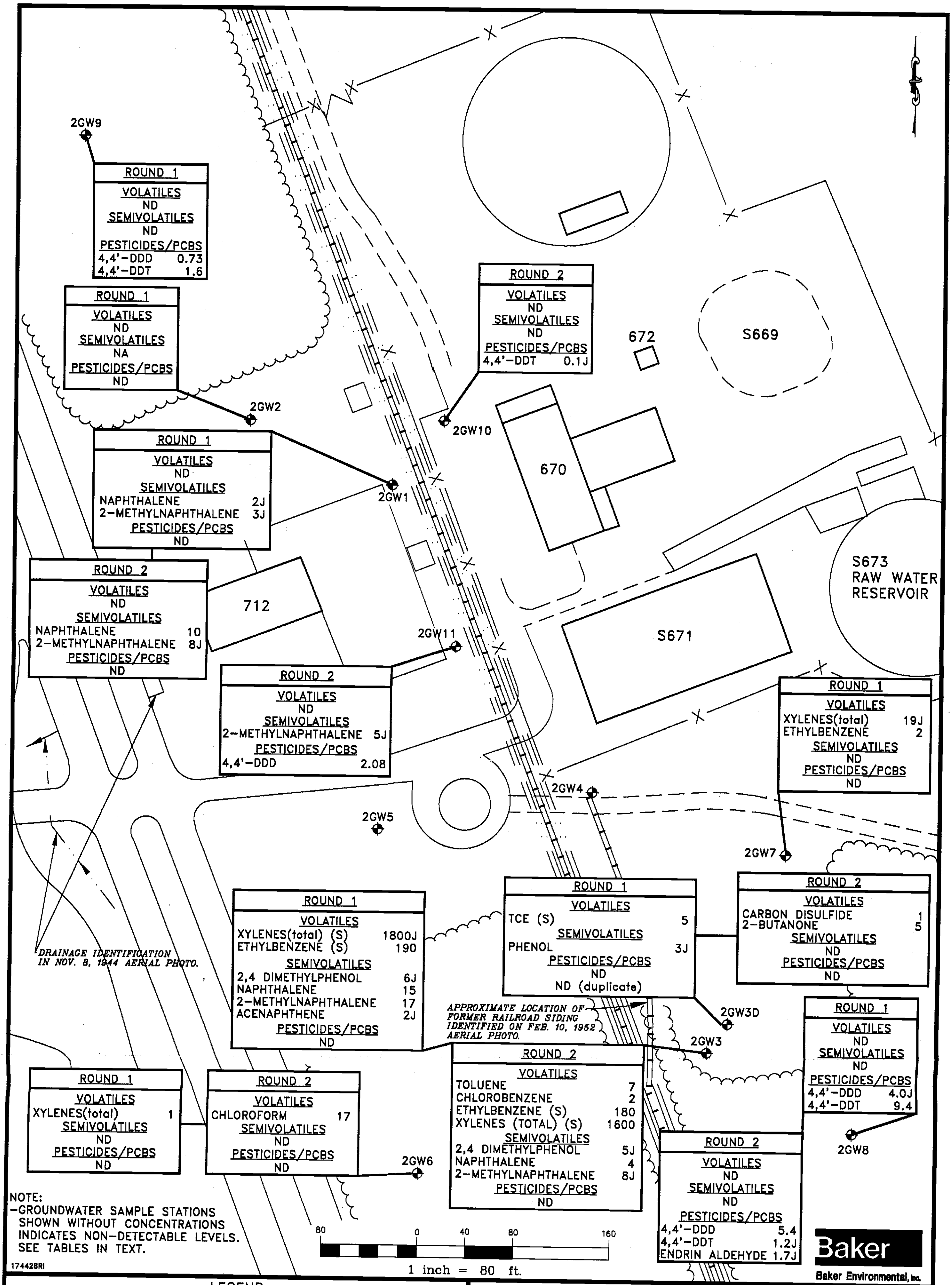
LEGEND

2GW7 ⊕	SHALLOW MONITORING WELL
2GW3D ⊕	DEEP MONITORING WELL
2FSASB01 ◉	SOIL BORING
ND	NOT DETECTED
NA	NOT ANALYZED
J	ESTIMATED CONCENTRATION

COMPOUND CONCENTRATIONS EXPRESSED IN ug/kg(ppb)
SOURCE: LANTDIV, FEB. 1992

FIGURE 4-8
POSITIVE DETECTIONS OF ORGANIC COMPOUNDS IN SUBSURFACE SOILS
SITE 2, FORMER STORAGE AREA
REMEDIAL INVESTIGATION CTO-0174
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

01273 R262



NOTE:
-GROUNDWATER SAMPLE STATIONS SHOWN WITHOUT CONCENTRATIONS INDICATES NON-DETECTABLE LEVELS. SEE TABLES IN TEXT.

174428RI

Baker

Baker Environmental, Inc.

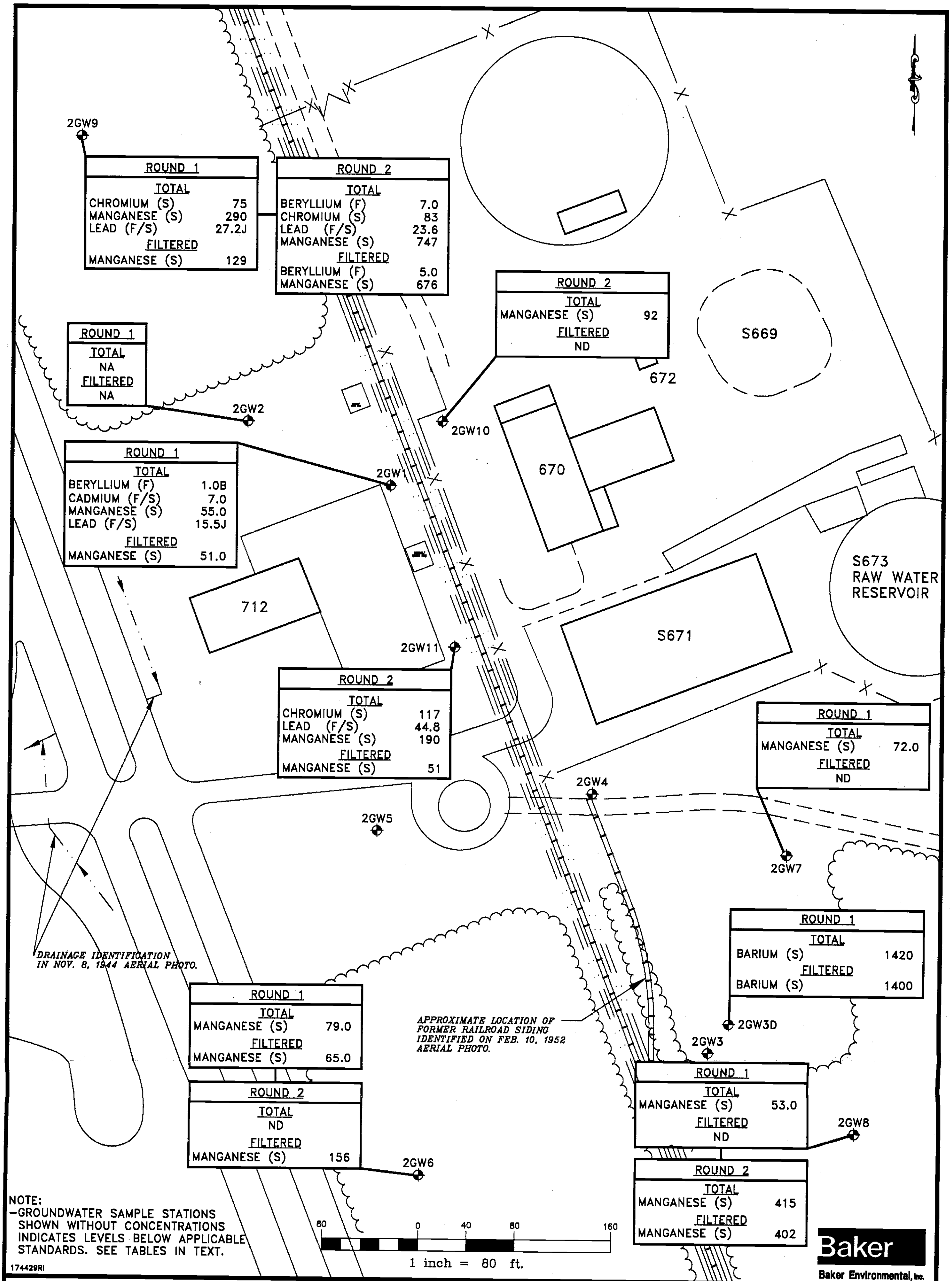
LEGEND

2GW1 ⊕	GROUNDWATER WELL
(S)	EXCEEDS NORTH CAROLINA GROUNDWATER STANDARD
ND	NOT DETECTED
NA	NOT ANALYZED
J	ESTIMATED CONCENTRATION

COMPOUND CONCENTRATIONS EXPRESSED IN ug/l(ppb)
SOURCE: LANTDIV, FEB. 1992

FIGURE 4-9
POSITIVE DETECTIONS OF ORGANIC
COMPOUNDS IN GROUNDWATER
SITE 2
REMEDIAL INVESTIGATION CTO-0174
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

01273 R 272



NOTE:
-GROUNDWATER SAMPLE STATIONS
SHOWN WITHOUT CONCENTRATIONS
INDICATES LEVELS BELOW APPLICABLE
STANDARDS. SEE TABLES IN TEXT.

174429RI

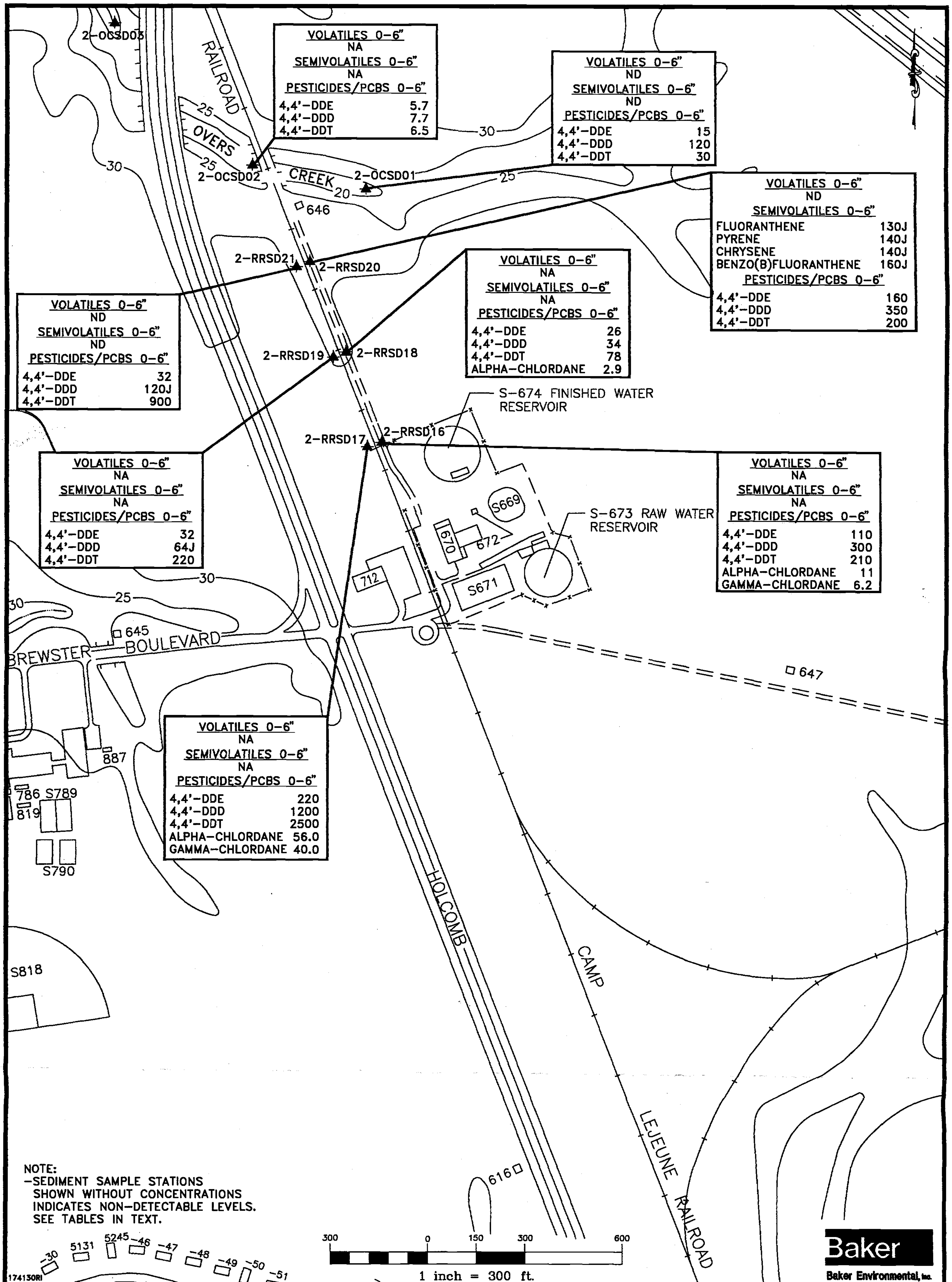
Baker
Baker Environmental, Inc.

LEGEND

2GW1 ⊕	GROUNDWATER WELL
(F)	EXCEEDS FEDERAL STANDARD
(S)	EXCEEDS STATE STANDARD
(FAL)	FEDERAL ACTION LEVEL
ND	NOT DETECTED ABOVE APPLICABLE STANDARDS
NA	NOT ANALYZED
J	ESTIMATED CONCENTRATIONS

CONCENTRATIONS EXPRESSED IN ug/l(ppb)
SOURCE: LANTDIV, FEB. 1992

FIGURE 4-10
POSITIVE DETECTIONS ABOVE APPLICABLE FEDERAL
AND STATE STANDARDS FOR TOTAL AND FILTERED
INORGANIC ANALYTES IN GROUNDWATER
SITE 2
REMEDIAL INVESTIGATION CTO-0174
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA



NOTE:
-SEDIMENT SAMPLE STATIONS SHOWN WITHOUT CONCENTRATIONS INDICATES NON-DETECTABLE LEVELS. SEE TABLES IN TEXT.

Baker
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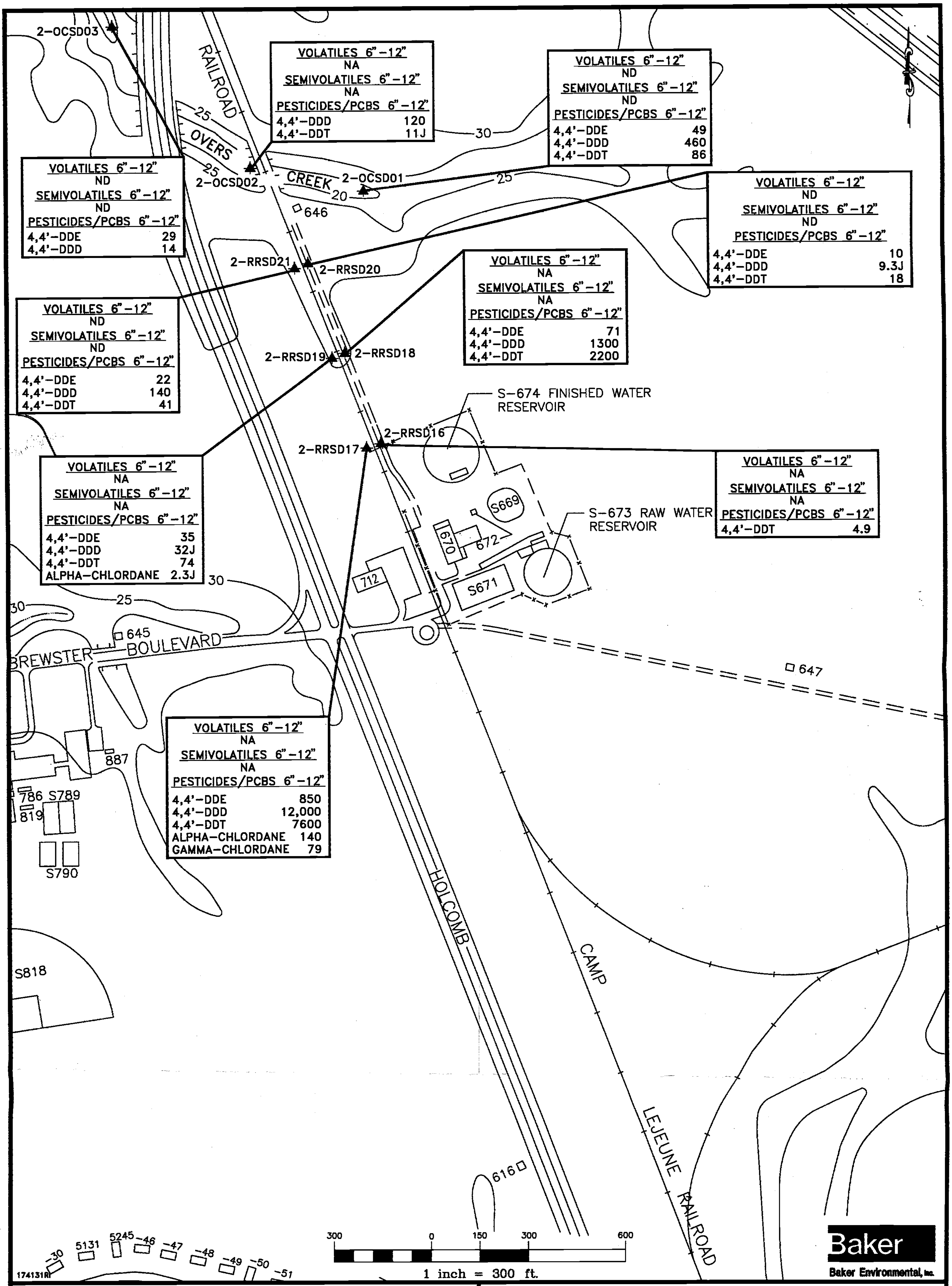
LEGEND

2-OCSD01 ▲ SEDIMENT SAMPLING STATION
ND NOT DETECTED
NA NOT ANALYZED
J ESTIMATED CONCENTRATION
CONCENTRATIONS EXPRESSED IN ug/kg (ppb)

SOURCE: LANTDIV, FEBRUARY 1992

FIGURE 4-11
POSITIVE DETECTIONS OF ORGANIC COMPOUNDS IN SEDIMENT (0-6")
NORTH OF SITE 2
REMEDIAL INVESTIGATION CTO-0174
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

01273 R 292



VOLATILES 6"-12"
NA
SEMIVOLATILES 6"-12"
NA
PESTICIDES/PCBS 6"-12"

4,4'-DDD	120
4,4'-DDT	11J

VOLATILES 6"-12"
ND
SEMIVOLATILES 6"-12"
ND
PESTICIDES/PCBS 6"-12"

4,4'-DDE	49
4,4'-DDD	460
4,4'-DDT	86

VOLATILES 6"-12"
ND
SEMIVOLATILES 6"-12"
ND
PESTICIDES/PCBS 6"-12"

4,4'-DDE	29
4,4'-DDD	14

VOLATILES 6"-12"
ND
SEMIVOLATILES 6"-12"
ND
PESTICIDES/PCBS 6"-12"

4,4'-DDE	10
4,4'-DDD	9.3J
4,4'-DDT	18

VOLATILES 6"-12"
NA
SEMIVOLATILES 6"-12"
NA
PESTICIDES/PCBS 6"-12"

4,4'-DDE	71
4,4'-DDD	1300
4,4'-DDT	2200

VOLATILES 6"-12"
ND
SEMIVOLATILES 6"-12"
ND
PESTICIDES/PCBS 6"-12"

4,4'-DDE	22
4,4'-DDD	140
4,4'-DDT	41

VOLATILES 6"-12"
NA
SEMIVOLATILES 6"-12"
NA
PESTICIDES/PCBS 6"-12"

4,4'-DDE	35
4,4'-DDD	32J
4,4'-DDT	74
ALPHA-CHLORDANE	2.3J

VOLATILES 6"-12"
NA
SEMIVOLATILES 6"-12"
NA
PESTICIDES/PCBS 6"-12"

4,4'-DDT	4.9

VOLATILES 6"-12"
NA
SEMIVOLATILES 6"-12"
NA
PESTICIDES/PCBS 6"-12"

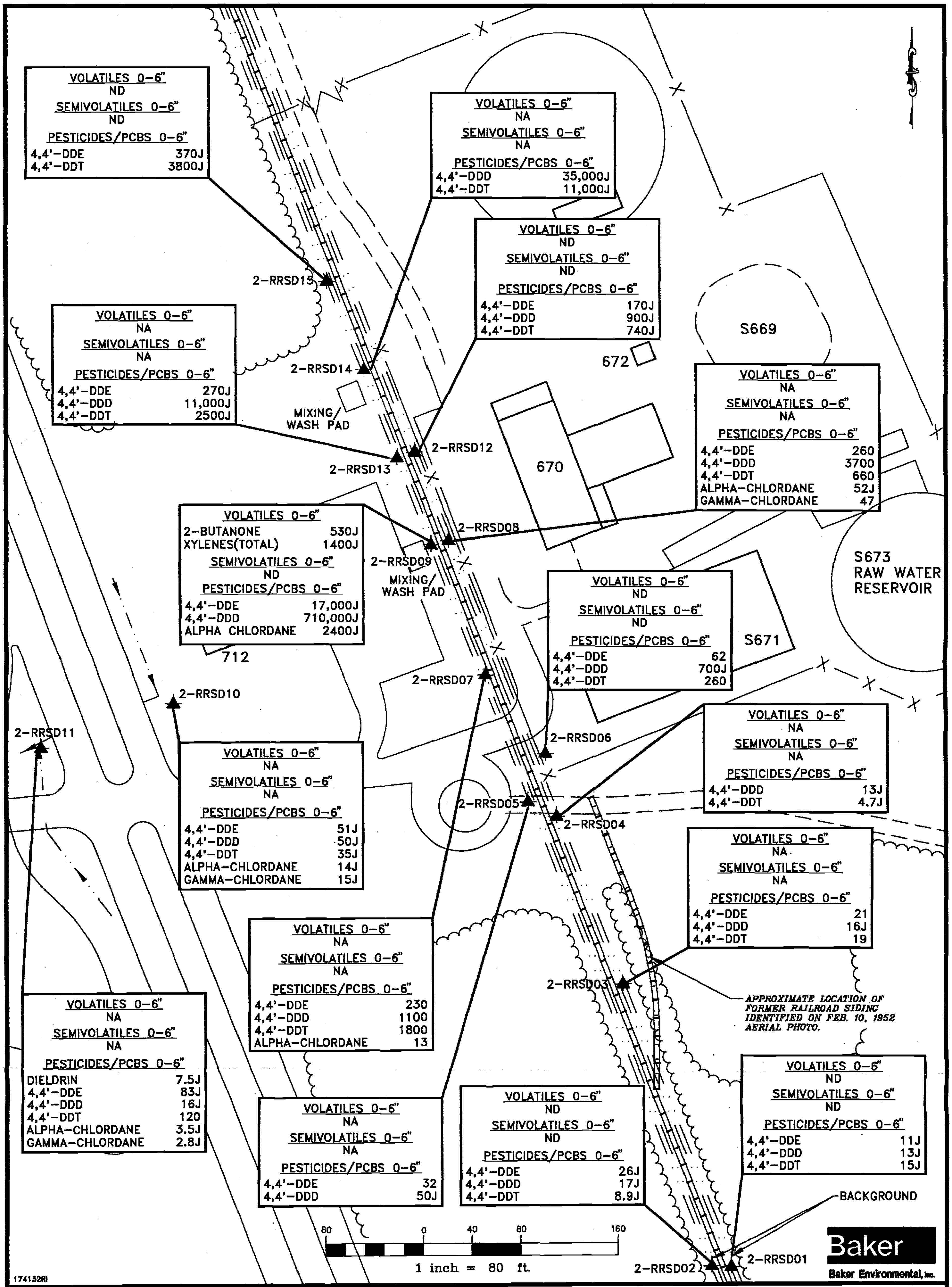
4,4'-DDE	850
4,4'-DDD	12,000
4,4'-DDT	7600
ALPHA-CHLORDANE	140
GAMMA-CHLORDANE	79

LEGEND

2-OCSD01 ▲ SEDIMENT SAMPLING STATION
ND NOT DETECTED
NA NOT ANALYZED
J ESTIMATED CONCENTRATION
CONCENTRATIONS EXPRESSED IN ug/kg (ppb)
SOURCE: LANTDIV, FEBRUARY 1992

FIGURE 4-12
POSITIVE DETECTIONS OF ORGANIC
COMPOUNDS IN SEDIMENT (6"-12")
NORTH OF SITE 2
REMEDIAL INVESTIGATION CTO-0174
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

01273 R302



LEGEND

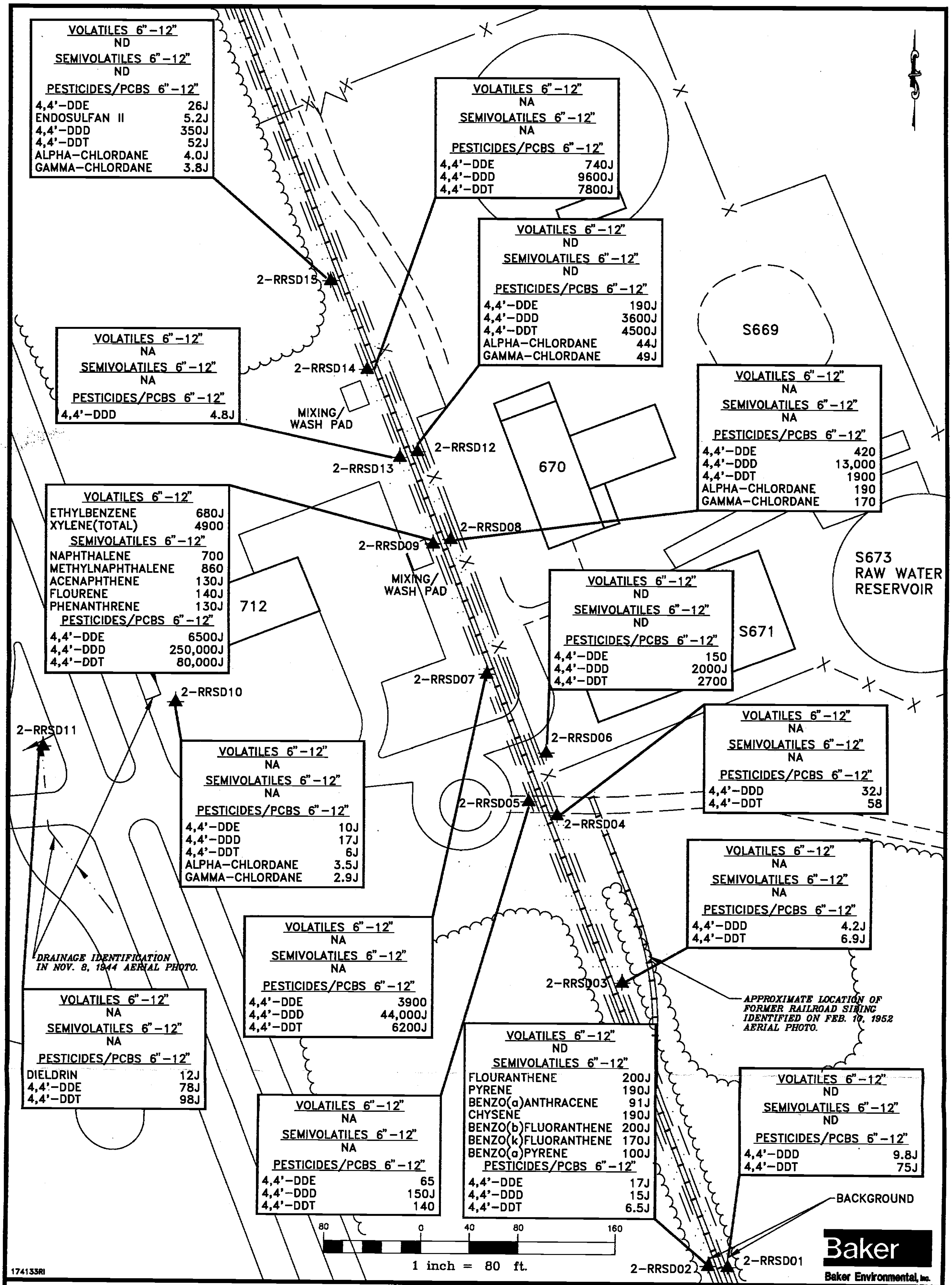
2-RRSD01 ▲	SEDIMENT SAMPLING STATION
ND	NOT DETECTED
NA	NOT ANALYZED
J	ESTIMATED CONCENTRATION

CONCENTRATIONS EXPRESSED IN ug/kg (ppb)

SOURCE: LANTDIV, FEB. 1992

FIGURE 4-13
POSITIVE DETECTIONS OF ORGANIC
COMOUNDS IN SEDIMENT (0-6")
SITE 2
REMEDIAL INVESTIGATION CTO-0174
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

01273 R 312



LEGEND

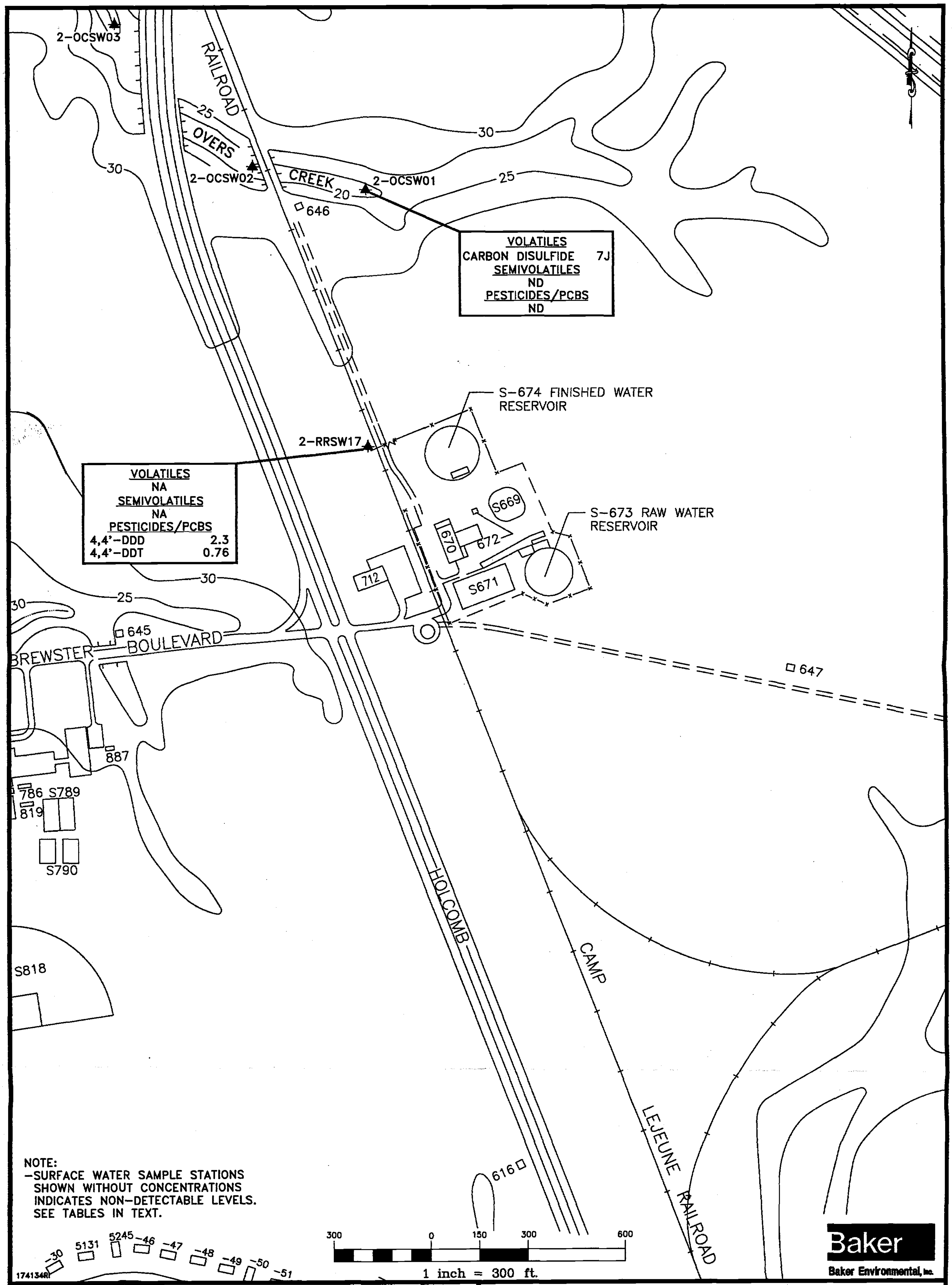
2-RRSD01 ▲ SEDIMENT SAMPLING STATION

ND NOT DETECTED
NA NOT ANALYZED
J ESTIMATED CONCENTRATION
CONCENTRATIONS EXPRESSED IN ug/kg (ppb)

SOURCE: LANTDIV, FEB. 1992

FIGURE 4-14
POSITIVE DETECTIONS OF ORGANIC COMPOUNDS IN SEDIMENT (6"-12")
SITE 2
REMEDIAL INVESTIGATION CTO-0174
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

01273R32Z



VOLATILES
CARBON DISULFIDE 7J
SEMIVOLATILES
ND
PESTICIDES/PCBS
ND

VOLATILES
NA
SEMIVOLATILES
NA
PESTICIDES/PCBS

4,4'-DDD	2.3
4,4'-DDT	0.76

NOTE:
-SURFACE WATER SAMPLE STATIONS SHOWN WITHOUT CONCENTRATIONS INDICATES NON-DETECTABLE LEVELS. SEE TABLES IN TEXT.

LEGEND

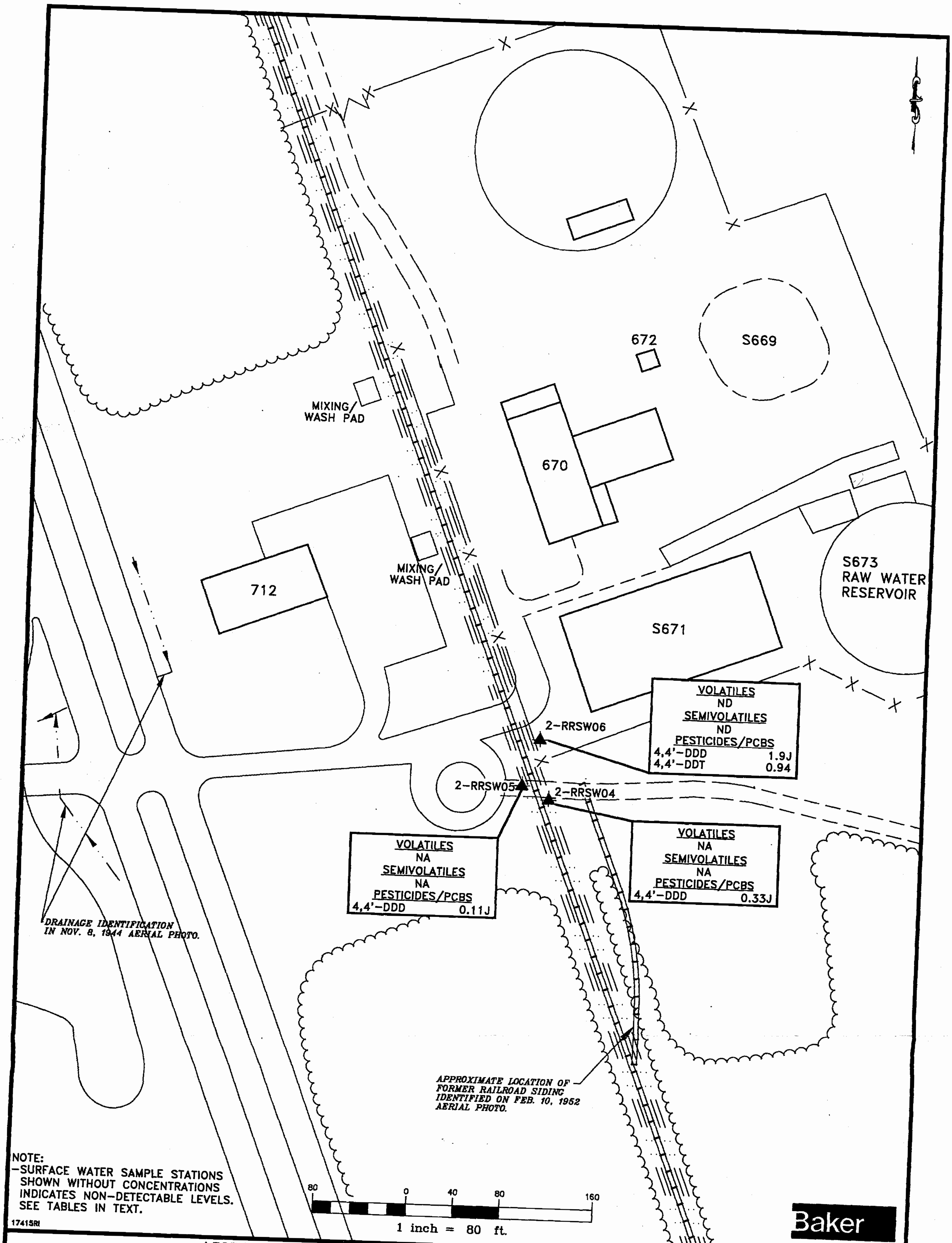
2-RRSW17 SURFACE WATER SAMPLING STATION

ND	NOT DETECTED
NA	NOT ANALYZED
J	ESTIMATED CONCENTRATION

CONCENTRATIONS EXPRESSED IN ug/l (ppb)

SOURCE: LANTDIV, FEBRUARY 1992

FIGURE 4-15
POSITIVE DETECTIONS OF ORGANIC COMPOUNDS IN SURFACE WATER
NORTH OF SITE 2
REMEDIAL INVESTIGATION CTO-0174
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA



VOLATILES
ND
SEMIVOLATILES
ND
PESTICIDES/PCBS

4,4'-DDD	1.9J
4,4'-DDT	0.94

VOLATILES
NA
SEMIVOLATILES
NA
PESTICIDES/PCBS

4,4'-DDD	0.11J

VOLATILES
NA
SEMIVOLATILES
NA
PESTICIDES/PCBS

4,4'-DDD	0.33J

DRAINAGE IDENTIFICATION IN NOV. 8, 1944 AERIAL PHOTO.

APPROXIMATE LOCATION OF FORMER RAILROAD SIDING IDENTIFIED ON FEB. 10, 1952 AERIAL PHOTO.

NOTE:
-SURFACE WATER SAMPLE STATIONS SHOWN WITHOUT CONCENTRATIONS INDICATES NON-DETECTABLE LEVELS. SEE TABLES IN TEXT.

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LEGEND

2-RRSW01
▲ SURFACE WATER SAMPLING STATION

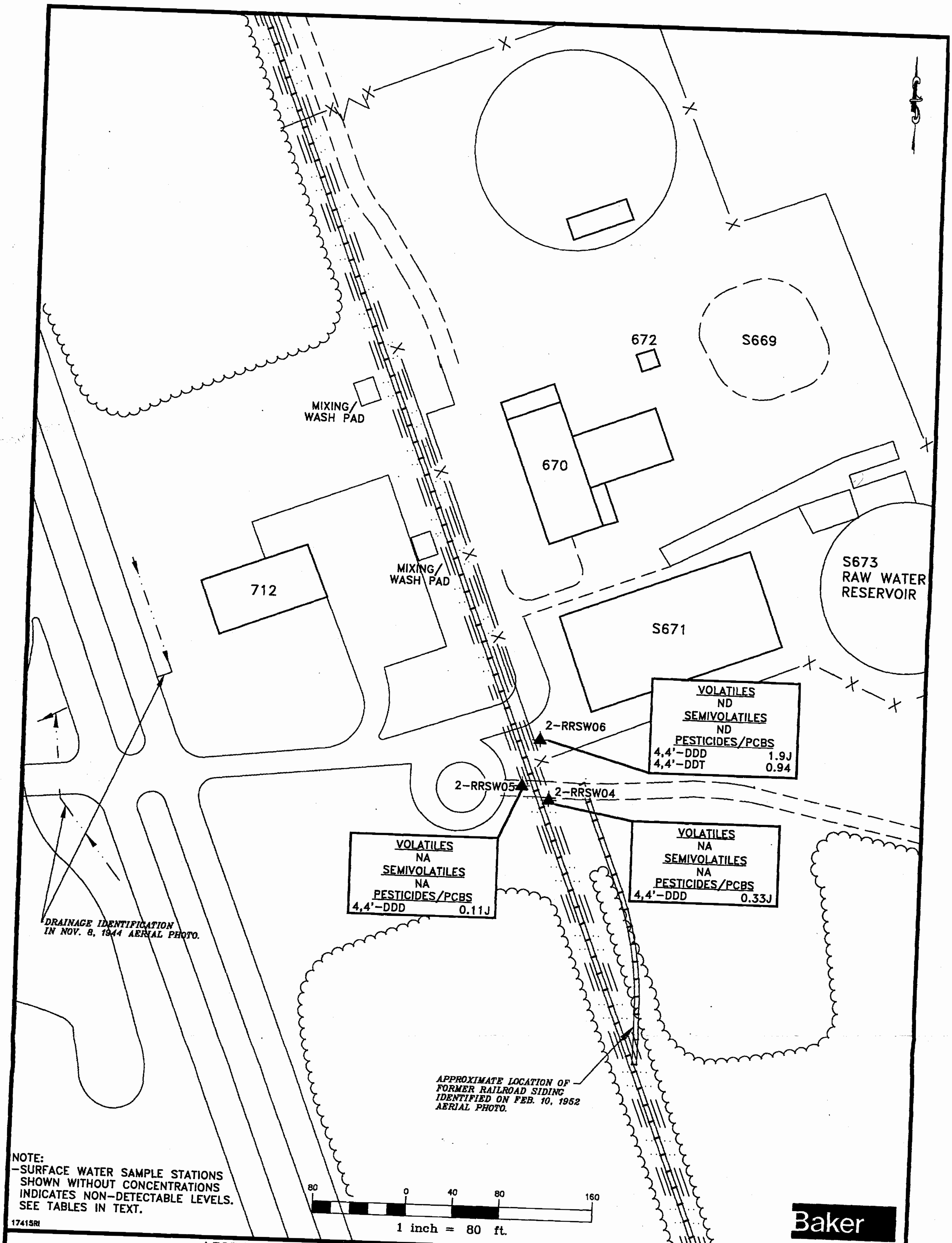
ND	NOT DETECTED
NA	NOT ANALYZED
J	ESTIMATED CONCENTRATION

CONCENTRATIONS EXPRESSED IN ug/l (ppb)

SOURCE: LANTDIV, FEB. 1992

FIGURE 4-16
POSITIVE DETECTIONS OF ORGANIC COMPOUNDS IN SURFACE WATER
SITE 2
REMEDIAL INVESTIGATION CTO-0174
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

01273R342



NOTE:
-SURFACE WATER SAMPLE STATIONS SHOWN WITHOUT CONCENTRATIONS INDICATES NON-DETECTABLE LEVELS. SEE TABLES IN TEXT.

LEGEND

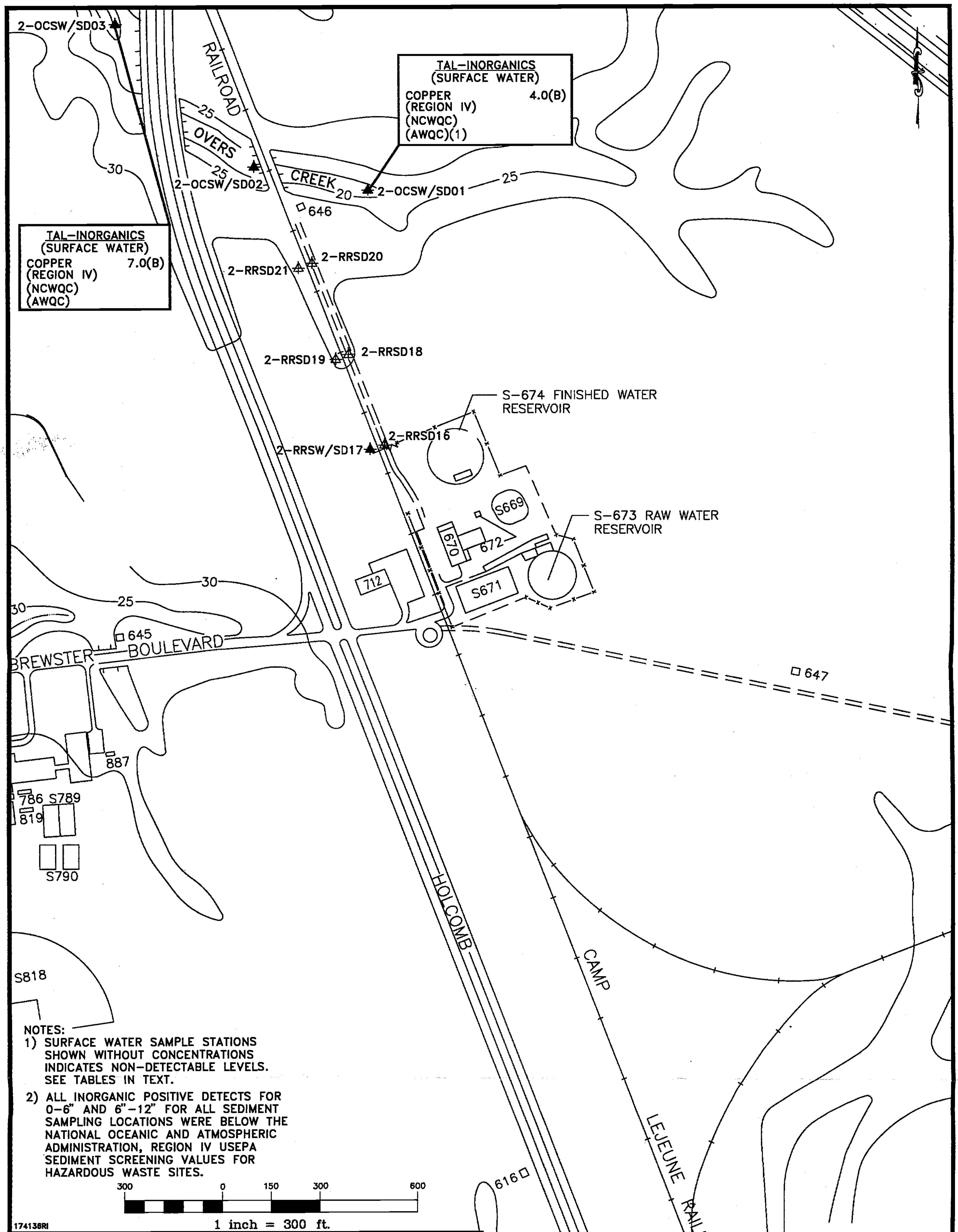
2-RRSW01 ▲	SURFACE WATER SAMPLING STATION
ND	NOT DETECTED
NA	NOT ANALYZED
J	ESTIMATED CONCENTRATION

CONCENTRATIONS EXPRESSED IN ug/l (ppb)

SOURCE: LANTDIV, FEB. 1992

FIGURE 4-16
POSITIVE DETECTIONS OF ORGANIC COMPOUNDS IN SURFACE WATER
SITE 2
REMEDIAL INVESTIGATION CTO-0174
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

D1273R342



NOTES:

1) SURFACE WATER SAMPLE STATIONS SHOWN WITHOUT CONCENTRATIONS INDICATES NON-DETECTABLE LEVELS. SEE TABLES IN TEXT.
2) ALL INORGANIC POSITIVE DETECTS FOR 0-6" AND 6"-12" FOR ALL SEDIMENT SAMPLING LOCATIONS WERE BELOW THE NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION, REGION IV USEPA SEDIMENT SCREENING VALUES FOR HAZARDOUS WASTE SITES.

1 inch = 300 ft.

174136RI

LEGEND

2-OCSW/SD01 ▲	SURFACE WATER AND SEDIMENT SAMPLING STATION
2-RRSD16 △	SEDIMENT SAMPLING STATION ONLY
REGION IV	USEPA SALTWATER WATER QUALITY SCREENING VALUES FOR HAZARDOUS WASTE SITES.
NCWQC	NORTH CAROLINA WATER QUALITY CRITERIA FOR TIDAL SALTWATER CLASSIFICATIONS
AWQC	USEPA AMBIENT WATER QUALITY CRITERIA
(1)	NOTE THE COPPER VALUE FOR AWQC IS THE ACUTE VALUE, AND NOT THE CHRONIC VALUE.
(B)	ESTIMATED CONCENTRATION

CONCENTRATIONS EXPRESSED IN ug/l (ppb)

SOURCE: LANTDIV, FEBRUARY 1992

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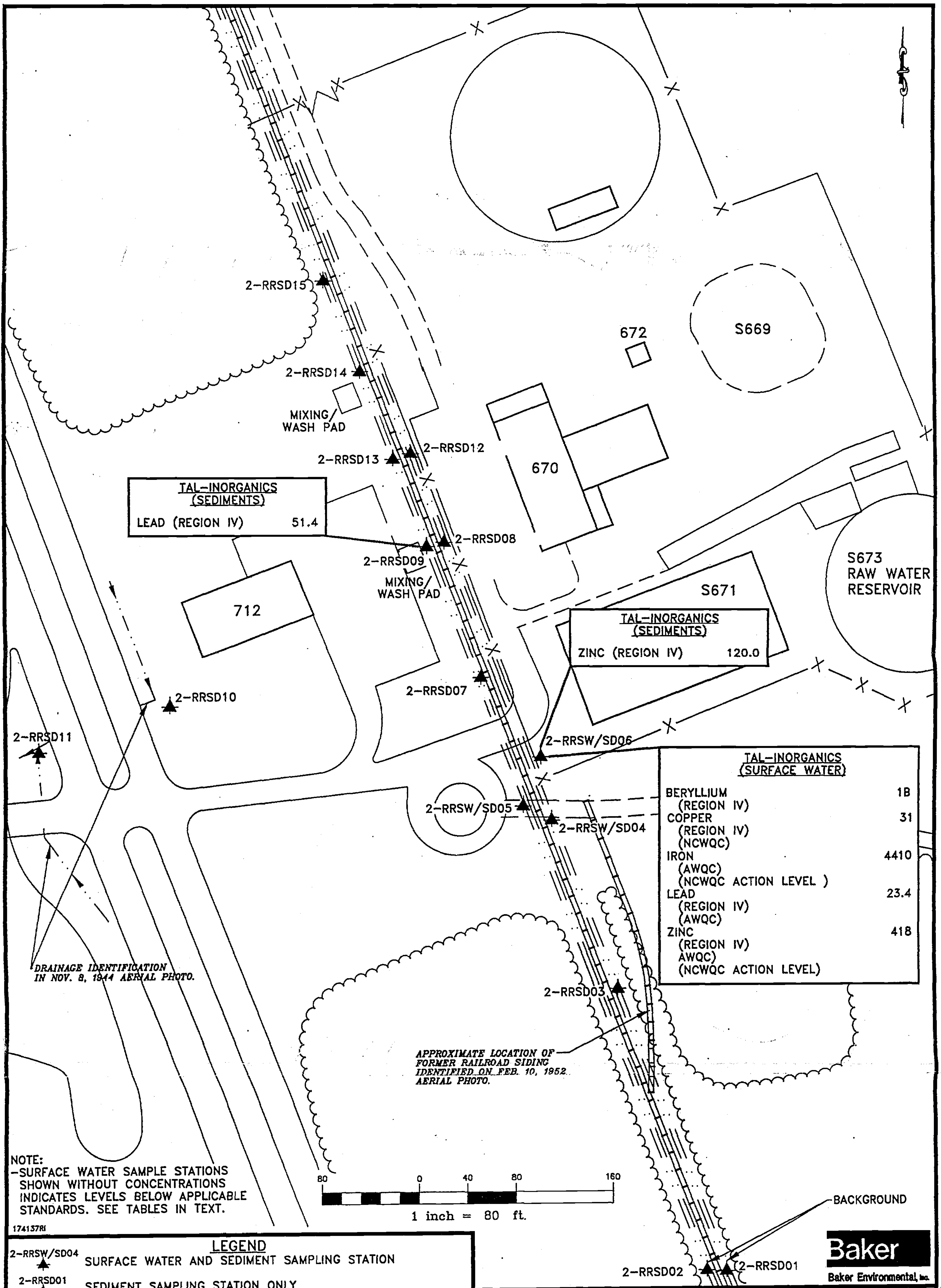
FIGURE 4-17
POSITIVE DETECTIONS OF INORGANIC ANALYTES IN SURFACE WATER AND SEDIMENT ABOVE APPLICABLE STATE AND FEDERAL STANDARDS
NORTH OF SITE 2
REMEDIAL INVESTIGATION CTO-0174
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

01273R352



DRAINAGE IDENTIFICATION IN NOV. 8, 1944 AERIAL PHOTO.

APPROXIMATE LOCATION OF FORMER RAILROAD SIDING IDENTIFIED ON FEB. 10, 1952 AERIAL PHOTO.

TAL-INORGANICS (SEDIMENTS)

LEAD (REGION IV)	51.4

TAL-INORGANICS (SEDIMENTS)

ZINC (REGION IV)	120.0

TAL-INORGANICS (SURFACE WATER)

BERYLLIUM (REGION IV)	1B
COPPER (REGION IV) (NCWQC)	31
IRON (AWQC) (NCWQC ACTION LEVEL)	4410
LEAD (REGION IV) (AWQC)	23.4
ZINC (REGION IV) AWQC) (NCWQC ACTION LEVEL)	418

NOTE:
-SURFACE WATER SAMPLE STATIONS SHOWN WITHOUT CONCENTRATIONS INDICATES LEVELS BELOW APPLICABLE STANDARDS. SEE TABLES IN TEXT.

LEGEND

2-RRSW/SD04 ▲ SURFACE WATER AND SEDIMENT SAMPLING STATION

2-RRSD01 △ SEDIMENT SAMPLING STATION ONLY

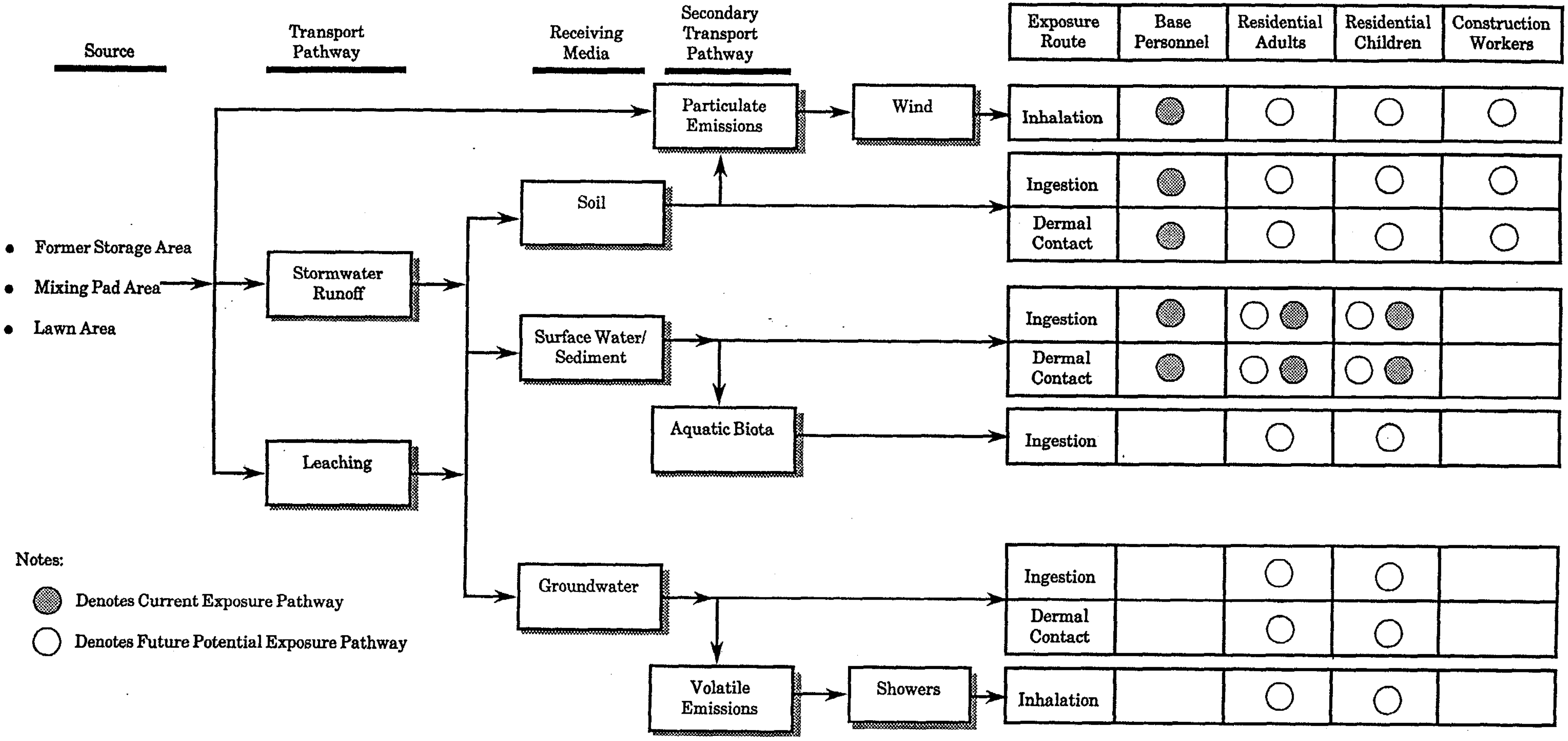
NOAA-NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION, REGION IV USEPA SEDIMENT SCREENING VALUES FOR HAZARDOUS WASTE SITES.
REGION IV-USEPA FRESHWATER WATER QUALITY SCREENING VALUES FOR HAZARDOUS WASTE SITES.
NCWQC-NORTH CAROLINA WATER QUALITY CRITERIA FOR FRESHWATER CLASSES.
AWQC-USEPA AMBIENT WATER QUALITY CRITERIA.
(B) ESTIMATED CONCENTRATION
CONCENTRATIONS EXPRESSED AS ug/l (ppb)
SOURCE: LANTDIV, FEB. 1992

FIGURE 4-18
POSITIVE DETECTIONS OF INORGANIC ANALYTES IN SURFACE WATER AND SEDIMENT ABOVE APPLICABLE STATE AND FEDERAL STANDARDS
SITE 2
REMEDIAL INVESTIGATION CTO-0174
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

01273 R 362

FIGURE 6-1

CONCEPTUAL SITE MODEL OF POTENTIAL EXPOSURE
CURRENT AND FUTURE LAND USE
OPERABLE UNIT NO. 5, SITE 2, MCB CAMP LEJEUNE, NORTH CAROLINA



Exposure Route	Base Personnel	Residential Adults	Residential Children	Construction Workers
Inhalation	●	○	○	○
Ingestion	●	○	○	○
Dermal Contact	●	○	○	○
Ingestion	●	○ ●	○ ●	
Dermal Contact	●	○ ●	○ ●	
Ingestion		○	○	
Ingestion		○	○	
Dermal Contact		○	○	
Inhalation		○	○	

Notes:

● Denotes Current Exposure Pathway

○ Denotes Future Potential Exposure Pathway