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FINAL

FEASIBILITY STUDY
OPERABLE UNIT NO. 6
SITES 36, 43, 44, AND 54

MARINE CORPS BASE
CAMP LEJEUNE, NORTH CAROLINA

CONTRACT TASK ORDER 0219

July 2002

Prepared for:

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QC Review Page

Feasibility Study

Operable Unit No. 6

MCB Camp Lejeune

Jacksonville, North Carolina

Contract Task Order Number - 0219
Contract Number N62470-95-D-6007
Navy CLEAN II Program

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July 2002

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LIST OF ACRONYMS AND ABBREVIATIONS

ARAR	Applicable or Relevant and Appropriate Requirement
Baker	Baker Environmental, Inc.
bgs	below ground surface
CDI	Chronic Daily Intake
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CFR	Code of Federal Regulations
CLEAN	Comprehensive Long-Term Environmental Action Navy
COC	Contaminants of Concern
CTO	Contract Task Order
CWA	Clean Water Act
CY	cubic yards
1,2-DCE	1,2-dichloroethene
DDD	Dichlorodiphenyldichloroethane
DDE	Dichlorodiphenyldichloroethylene
DDT	Dichlorodiphenyltrichloroethane
DoN	Department of Navy
FFA	Federal Facilities Agreement
FS	Feasibility Study
HRC	Hydrogen Releasing Compound
IAS	Initial Assessment Study
kg	kilogram
LANTDIV	Atlantic Division, Naval Facilities Engineering Command
LTM	Long-Term Monitoring
MCAS	Marine Corps Air Station
MCB	Marine Corps Base
MCL	Maximum Contaminant Level
mg	milligram
mg/kg	milligrams per kilogram
MNA	Monitored Natural Attenuation
MW	Monitoring Well
NA	Natural Attenuation
NC	North Carolina
NCAC	North Carolina Administrative Code
NCDENR	North Carolina Department of Environment and Natural Resources
NCDOT	North Carolina Department of Transportation
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NCSSL	North Carolina Soil Screening Level
NCWQS	North Carolina Water Quality Standards
ND	Not Detected

LIST OF ACRONYMS AND ABBREVIATIONS
(Continued)

NE	No Criteria Published
NFESC	Naval Facilities Engineering Service Center
NOAA	National Oceanic and Atmospheric Administration
NPL	National Priorities List
NPW	Net Present Worth
O&M	Operations and Maintenance
ORP	Oxygen Reduction Potential
OSWER	Office of Solid Waste and Emergency Response
OU	Operable Unit
PAH	Polynuclear Aromatic Hydrocarbon
PCB	Polychlorinated Biphenyl
PCE	Tetrachloroethene
POL	Petroleum-oil-lubricant
ppm	parts per million
PRAP	Proposed Remedial Action Plan
PRG	Preliminary Remediation Goal
QI	Quotient Indices
RA	Risk Assessment (Human Health)
RAA	Remedial Action Alternative
RAB	Restoration Activity Board
RAC	Remedial Action Contractor
RCRA	Resource Conservation Recovery Act
RI	Remedial Investigation
RI/FS	Remedial Investigation/Feasibility Study
ROD	Record of Decision
SARA	Superfund Amendments and Reauthorization Act
SB	Soil Boring
SDWA	Safe Drinking Water Act
SI	Site Inspection
SSLs	Soil Screening Levels
SSSV	Surface Soil Screening Value
SVOC	Semivolatile Organic Compound
SWSV	Surface Water Screening Value
TBC	To Be Considered
TCE	Trichloroethene
TCL	Target Compound List
TCLP	Toxicity Characteristic Leachate Procedure
TCRA	Time Critical Removal Action
TOC	Total Organic Carbon
TRV	Terrestrial Reference Value

LIST OF ACRONYMS AND ABBREVIATIONS
(Continued)

µg/kg	micrograms per kilogram
µg/L	micrograms per Liter
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
UST	Underground Storage Tank
VOC	Volatile Organic Compound

EXECUTIVE SUMMARY

The objectives of this Feasibility Study (FS) are to identify and evaluate a set of remedial action alternatives (RAAs) to address environmental concerns at Operable Unit (OU) No. 6. Operable Unit No. 6 consists of four distinct sites including Site 36, Site 43, Site 44 and Site 54. The RAAs developed and evaluated for OU No. 6 are effective in protecting human health and the environment and in attaining federal and state requirements that are applicable or relevant and appropriate (ARARs). A wide range of potential RAAs are presented and evaluated that represent various levels of cleanup, land use controls and cost.

Site 36 (Camp Geiger Area Dump)

Site 36 Location

- 20 acres on the southern limits of Brinson Creek
- 1,000 feet east of Camp Geiger, 500 feet west of the New River
- Gravel roads provide access to Jack's Point Recreation Area (¼ mile east of Site 36)

Site 36 History

- Former dump active from late 1940s to late 1950s
  - Disposal of municipal wastes and mixed industrial wastes including trash, waste oils and hydraulic fluids
  - Disposed material was usually burned then buried, however, some unburned material was also disposed at Site 36
- North Carolina Department of Transportation (NCDOT) Route 17 bypass construction has affected Site 36
  - Several of the gravel roads which ran through site have been widened and the elevation raised, serving as the subgrade for the Route 17 bypass

Previous Investigations and Remedial Actions

- The Remedial Investigation (RI) for Site 36 was completed from February to July of 1995
  - A majority of the semivolatile organic compounds (SVOCs) detected in soil at Site 36 were polynuclear aromatic hydrocarbons (PAHs)
  - No volatile organic compounds (VOCs) detected in surface or subsurface soil exceeded the United States Environmental Protection Agency (USEPA) Region IX Preliminary Remediation Goals (PRGs)
  - Three surface soil and eight subsurface soil samples exceed the USEPA directive of 400 parts per million (ppm) for lead
  - VOCs (primarily trichloroethene [TCE]) were detected in groundwater in the northern portion of the site above North Carolina Water Quality Standards (NCWQS)

- In July 1997 a time critical removal action (TCRA) was performed by the remedial action contractor (RAC).
  - Excavation of 92 tons of regulated polychlorinated biphenal (PCB) contaminated soil and 148 tons of unregulated soil
  - Disposal of the soil in an appropriate treatment /disposal facility
  - Confirmatory sampling to show that concentrations of PCBs were below the action level (10 milligrams per kilogram [mg/kg])
  - Field activities were completed on September 24, 1997

- A groundwater monitoring program began in October 1998 to determine if natural attenuation (NA) would be a viable remedial alternative for the site
  - Quarterly collection of both groundwater and surface water samples
  - TCE exceeds the NCWQS of 2.8 micrograms per liter (µg/L) in 6 of 11 wells, with the highest detected concentration being 54 µg/L (April 2002 sampling data)
  - 1,1,2,2-tetrachloroethane exceeds the NCWQS interim standard of 17 µg/L in 2 wells, based on April 2002 sampling data. The highest detected concentration based on this sampling data was 34 J µg/L.

Summary of Human Health Risk Assessment

- For the current exposure scenario, only fishermen exhibited a potential risk for ingestion of fish and crab tissue from Brinson Creek. Although a potential risk resulted, additional data collection and analyses indicated that the source generating the risk was not from Site 36.

- Future child and adult residents may be exposed to unacceptable noncarcinogenic risks posed by iron in groundwater

- There is also an unacceptable noncarcinogenic risk for future child residents exposed to iron in subsurface soil

Soil Contaminants of Concern and Remediation Goals

The remediation goals for soil at Site 36 were selected based on regulatory requirements, standards and guidance, for Site 36. Although surface soil does not generate an unacceptable risk at Site 36, localized areas of surface soil exhibit elevated levels of organic compounds when compared to site-wide concentrations. Addressing these localized areas of contamination is not necessary under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) because they do not pose a site-wide human health risk, however, cleanup would demonstrate responsible stewardship of the environment. Also, risks posed by lead in surface and subsurface soil were not evaluated in the Remedial Investigation (RI) human health risk assessment because health-based criteria were not available for evaluating either the noncarcinogenic or carcinogenic effects of lead exposure. Selected remediation goals for future residential land use for Site 36 are provided below.

Contaminant	Location	Basis for Remedial Goal
PAHs	Western portions of the site	USEPA Region IX Residential PRGs
Pesticides	Western portions of the site	USEPA Region IX Residential PRGs
Lead	Eastern portion of the site	USEPA Directive for lead (400 ppm)

Groundwater Contaminants of Concern and Remediation Goals

The remediation goals for groundwater at Site 36 were selected based on regulatory requirements, standards, and guidance. Selected remediation goals for Site 36 and the basis for each remedial goal are provided below. The following VOCs were detected above the NCWQS during the April 2002 sampling event:

Contaminant	Remedial Goal	Basis for Remedial Goal
Trichloroethene	2.8 µg/L	NCWQS
1,1,2,2-Tetrachloroethane	0.17 µg/L *	NCWQS
Vinyl Chloride	0.015 µg/L	NCWQS

* Interim Standard

Remedial Action Objectives

- Remove or mitigate potential exposure to contaminated surface and subsurface soils on the site that contain contaminants in excess of the selected remediation goals for *residential land use*, AND

- Protect human health by mitigating the potential for exposure to the contaminated aquifer.

Remedial Action Alternatives (RAAs)

A wide range of potential RAAs are available that represent various levels of response actions, remediation goals, land use controls, and remediation costs. Although surface soil at Site 36 does not generate a risk, it is recommended that alternatives be selected to address localized areas of higher PAH and pesticide concentrations in soil, and lead in soil above the EPA action level of 400 ppm. Alternatives are also presented to address contaminants in groundwater exceeding the NCWQS. The RAAs for soil (S) and groundwater (GW) at Site 36 are:

	TOTAL COST
36S RAA 1: No Action • No remedial actions taken	$0
36S RAA 2: Capping and Institutional Controls for Lead Contaminated Areas • Localized impacted PAH and pesticide soil areas capped • Site is graded and revegetated • Areas exceeding USEPA residential action level for lead (400 ppm) are surveyed and delineated • Land use controls for intrusive activity within the capped areas and future use restrictions for lead contaminated areas are imposed at Site 36	$188,000
36S RAA 3: Excavation and Off-Site Disposal and Institutional Controls for Lead Contaminated Areas • Localized impacted PAH and pesticide soil areas excavated • Excavated soil is disposed in the Base landfill • Site restored to pre-excavation conditions • Areas exceeding USEPA residential action level for lead (400 ppm) are surveyed and delineated • Land use controls for intrusive activity within the capped areas and future use restrictions for lead contaminated areas are imposed at Site 36	$201,000
36GW RAA 1: No Action • No physical remedial actions implemented for groundwater	$0
36GW RAA 2: Enhanced Natural Attenuation • A hydrogen releasing compound (HRC) is injected into the surficial aquifer via Geoprobe points • HRC enhances natural attenuation for expedited cleanup • Monitoring tracks progress towards NCWQS cleanup goals • Aquifer use restrictions (until remedial cleanup goals are achieved) • Land use controls for intrusive activities within plume boundary	$691,000

36GW RAA 3: Monitored Natural Attenuation $410,000

- Monitoring until groundwater reaches NCWQS cleanup goals
- Aquifer use restrictions (until remedial cleanup goals are achieved)
- Land use control for intrusive activities within plume boundary

Site 43 (Agan Street Dump)

Site 43 Location

- Located at the northern terminus of Agan Street, adjacent to the abandoned sewage disposal facility
- 11 acres bordered to the east and south by Strawhorn Creek and to the north by Edwards Creek
- Site is heavily vegetated, and areas along Edwards and Strawhorn Creek are prone to flooding
- Site 43 is traversed by an improved gravel road and unimproved paths

Site 43 History

- Construction debris (mostly fiberglass and lumber) were disposed at the site
- Sludge from the former treatment facility was also dumped at Site 43, however, the years in which this took place are unknown

Previous Investigations and Remedial Actions

- A TCRA was performed at Site 43 in 1995 by the RAC due to the findings of the Site Inspection (SI)
  - TCRA activities involved the removal of all surficial metallic debris, including empty drums, various scrap metals and an old tank vehicle
  - OHM collected, sampled and shipped off-site four drums (1,400 lbs.) of hazardous materials for disposal

- From February through May of 1995 an RI was conducted at Site 43
  - SVOCs (predominantly PAHs) were detected in surface and subsurface soil samples almost exclusively in a cleared area along the site access road
  - VOCs were not detected in surface or subsurface soil samples
  - No inorganics detected in surface or subsurface soils exceeded USEPA Region IX Residential PRGs
  - Iron and manganese were detected at levels above the NCWQS in groundwater

Summary of Human Health Risk Assessment

- There are no unacceptable human health risks for current receptors at Site 43
- No carcinogenic risks were identified for future adult and child residents or construction workers
- Ingestion of iron in groundwater contributed to unacceptable noncarcinogenic risks under a future land use scenario

Soil Contaminants of Concern and Remediation Goals

The remediation goals for soil at Site 43 were selected based on regulatory requirements, standards and guidance. Although soil at Site 43 does not generate a human health risk, a localized area of surface and subsurface soil exhibited elevated levels of organic compounds when compared to site-wide concentrations. In addition, the site is located adjacent to a Base housing area and potentially could be used for future residential land use. Selected remediation goals for residential land use for Site 43 are provided below.

Contaminant	Location	Remedial Goal
PAHs	Western portion of the site	USEPA Region IX Residential PRGs

Groundwater Contaminants of Concern and Remediation Goals

In groundwater, VOCs, pesticides and PCBs were not detected during the RI. The detected inorganics (iron and manganese) are naturally occurring and not related to past disposal practices. One SVOC (4-methylphenol) was detected at a concentration of 2 µg/L from a temporary monitoring well which does not exceed the NCWQS of 3.5 µg/L. No other organic compounds were detected. Accordingly, groundwater will not be retained as a media of concern at this site.

Remedial Action Objectives

- Remove or mitigate potential exposure to contaminated surface and subsurface soils on the site that contain contaminants in excess of the selected remediation goals (cleanup levels) for *residential land use*

Remedial Action Alternatives

Although soil at Site 43 does not generate a risk, a range of potential RAAs is available to address localized areas of higher PAH concentrations in soil. The residential land use RAAs for Site 43 include four scenarios:

	TOTAL COST
43S RAA 1: No Action	$0
• No physical remedial actions implemented	
43S RAA 2: Capping	$169,000
• Localized impacted PAH areas capped	
• Site is graded and revegetated	
• Intrusive activity restrictions	
43S RAA 3: Excavation and Off-Site Disposal	$119,000
• Localized impacted PAH areas excavated	
• Excavated soil is disposed in the Base landfill	
• Site restored to pre-excavation conditions	
• Intrusive activity restrictions	
43GW RAA 1: No Action	$0
• No physical remedial actions implemented	

Site 44 (Jones Street Dump)

Site 44 Location

- Encompasses 5 acres behind the Base housing on Jones Street
- Vehicle access is possible via Baxter Street, from Curtis Road
- Site is partially surrounded by a 6-foot chainlink fence, however, a portion of the site lies to the east of the fenced area
- Bordered to the north by Edwards Creek and to the east by a wooded area and a tributary to Edwards Creek
- Site is comprised of open fields, high grass, and small pine trees

Site 44 History

- The Site 44 Jones Street Dump was in operation during the 1950s
- Debris, cloth, lumber and paint cans were reportedly disposed
- Minor quantities of potentially hazardous waste may have been disposed

Previous Investigations and Remedial Actions

- An RI was conducted at Site 44 from February through July 1995
  - Organic contaminants were not detected in surface or subsurface soil samples
  - Detected inorganics in soil do not exceed USEPA Region IX Residential PRGs
  - Iron and manganese are the only detected constituents in groundwater that exceed the NCWQS

Summary of Human Health Risk Assessment

- There are currently no unacceptable human health risks at Site 44
- Only groundwater presented a potential future risk at Site 44 due to the ingestion of iron detected in groundwater

Soil Contaminants of Concern and Remediation Goals

Soil sampling results from the RI show that inorganics are the most prevalent constituents and are evenly dispersed throughout the site. Most of the detected inorganics are below the base background levels in both surface soils and subsurface soils at Site 44. Because the inorganics did not generate unacceptable risk or exceed screening criteria, surface soil and subsurface soil were not retained as media of concern for Site 44. In addition, the concentrations in soil were not elevated enough to leach from the soil and impact groundwater.

Groundwater Contaminants of Concern and Remediation Goals

Groundwater sampling results from the RI showed that detections of VOCs were limited to the surficial aquifer and were detected at low concentrations. Tetrachloroethene was detected at an estimated concentration of 1 µg/L in a groundwater sample from monitoring well 44-GW03. The lack of VOC detections in other monitoring wells that are located hydraulically downgradient from this well indicates that the extent of organic contamination is limited to that general location. Moreover, the relatively low VOC concentration suggests that its presence may be the result of unintentional spillage or limited disposal rather than long-term disposal or buried containers. Iron and manganese detected at levels above the NCWQS are naturally occurring. A Base background study is currently being conducted, and it is likely that these inorganics fall within the naturally occurring range for Marine Corps Base (MCB), Camp Lejeune. Therefore, due to limited impact, groundwater is not retained as a medium of concern at Site 44.

Remedial Action Objectives

- There are no media of concern addressed for Site 44, therefore no remedial action is warranted at this site.

Remedial Action Alternatives

The No Action alternatives for soil and groundwater are presented for Site 44:

	TOTAL COST
44S RAA 1: No Action	$0
• No physical remedial actions implemented	
44GW RAA 1: No Action	$0
• No physical remedial actions implemented	

Site 54 (Crash Crew Fire Training Burn Pit)

Site 54 Location

- Site 54 is approximately 1.5 acres, located near the southwest end of runway 5-23
- Two drainage ditches direct surface water runoff away from the burn pit in a southerly direction

Site 54 History

- Fire training exercises were conducted beginning in the mid-1950s within the former burn pit
- Waste fuels, oils and solvents were used as fuels to simulate fire conditions
- In 1975, a lined burn pit was constructed at Site 54 and remained in operation until August 2000
- A new fire training facility was put into operation in 2001

Previous Investigations and Remedial Actions

- An RI was conducted in February through April 1995
  - A number of VOCs and SVOCs were detected in soil at Site 54, but did not exceed USEPA Region IX Residential PRGs
  - Iron and lead were detected in groundwater at levels above the NCWQS

- A groundwater monitoring program at Site 54 began in July 1998
  - The 14th quarterly monitoring event was completed in April 2002
  - Groundwater monitoring was implemented at this site to determine the effectiveness of NA, and to assess if NA could be a viable remedial alternative for the site

- In April 2001, the RAC concluded remediation and construction services at Site 54 that included:
  - Removal of the underground storage tank (UST) and construction debris from the former burn pit
  - Soil excavation roughly oval in shape with a length of 128 feet, a width of 96.5 feet and extending 9 feet below grade to the surface of groundwater
  - Installation of a new, concrete-lined fire training area
  - Installation of two new aboveground propane tanks
  - Removal of petroleum-oil-lubricant (POL) contaminated soils at Site 54

Summary of Human Health Risk Assessment

- There are no human health risks for current receptors at Site 54
- Potential future noncarcinogenic risks from ingestion of groundwater were calculated for potential future child and adult residents as a result of iron in groundwater
- The future adult resident scenario also generated potential carcinogenic risk from iron in groundwater

Soil Contaminants of Concern and Remediation Goals

Due to the removal action completed in April 2001, soil contamination has already been removed from the site. Soil samples taken during the RI showed SVOC contamination, mostly from PAH compounds. Following the excavation, eight confirmatory samples were taken for PAHs, and no contaminants remained on site above cleanup goals (NC SSLs). Therefore, surface or subsurface soil is not retained as a medium of concern at Site 54.

Groundwater Contaminants of Concern and Remediation Goals

There have been no detections of VOCs in the past 11 sampling quarters that exceed the NCWQS (Baker 2001). Only one SVOC has been detected in three sampling quarters (July 2000, October 2000 and January 2001) at a concentration slightly above the NCWQS. In the October 2001 sampling event, three SVOCs were detected in one monitoring well (54-GW11) above the NCWQS. It was suspected that these detections were the result of the construction and remediation activities that occurred at Site 54 which impacted the integrity of this well. A Geoprobe sample collected adjacent to this well in January 2002 verified that the SVOCs detected in October 2001 were not present in the groundwater. During the removal action, one groundwater sample was taken at the center of the excavation. There were no detections of PAHs in this groundwater sample.

During the RI, there were five detections of lead out of 13 samples. One detection (39.7 µg/L) exceeded the NCWQS of 15 µg/L. This well is upgradient from the former burn pit. Therefore, groundwater is retained as a medium of concern at Site 54 since lead is present in the groundwater above standards. The contaminant source was potentially removed during the April 2001 removal action. Therefore, it is expected that physical processes such as diffusion and dispersion should decrease the concentration of lead in the aquifer over time.

Contaminant	Remedial Goal
Lead	15 µg/L (NCWQS)

Remedial Action Objectives

- Properly address lead in groundwater at Site 54

Remedial Action Alternatives

Although the site does not generate a risk for groundwater, a two RAAs are available to address contaminants that exceed NCWQS. The no action alternative is also presented for soil:

	TOTAL COST
54S RAA 1: No Action • No physical remedial actions implemented	$0
54GW RAA 1: No Action • No physical remedial actions implemented	$0
54GW RAA 2: Institutional Controls With Monitoring • Monitoring until groundwater reaches NCWQS for lead in four consecutive sampling events • Aquifer use restrictions (until remedial cleanup goals are achieved) • Land use control for intrusive activities within plume boundary	$44,000

1.0 INTRODUCTION

Marine Corps Base (MCB) Camp Lejeune was placed on the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) National Priorities List (NPL) effective November 4, 1989 (54 Federal Register 41015, October 4, 1989). Subsequent to this listing, in March 1991, the United States Environmental Protection Agency (USEPA) Region IV, the North Carolina Department of Environment and Natural Resources (NC DENR), the Department of Navy (DoN) and the Marine Corps entered into a Federal Facilities Agreement (FFA) for MCB, Camp Lejeune. The primary purpose of the FFA was to ensure that environmental impacts associated with past and present activities at the Base were thoroughly investigated and that appropriate CERCLA response and Resource Conservation Recovery Act (RCRA) corrective action alternatives were developed and implemented, as necessary, to protect public health and welfare, and the environment (MCB, Camp Lejeune FFA, 1991).

The Fiscal Year 2002 Site Management Plan for MCB, Camp Lejeune, a primary document referenced in the FFA, identifies 42 sites that require Remedial Investigation/Feasibility Study (RI/FS) activities. These 42 sites have been divided into 21 Operable Units (OUs). Operable units are formed as an incremental step toward addressing individual site concerns and to simplify the specific problems associated with a site or group of sites. This report describes the Feasibility Study (FS) conducted for OU No. 6, which is comprised of Sites 36, 43, 44 and 54. The location of these sites is shown on Figure 1-1. FS reports have previously been completed for Sites 36 and 54; however, this FS will readdress Sites 36 and 54 in light of recent site investigations and remedial actions. Site 86 had formerly been addressed as part of OU No. 6, but it was removed in July 2000 and placed in OU No. 20. Therefore, Site 86 will not be covered in this FS.

This FS has been prepared by Baker Environmental, Inc. (Baker) for the DoN, Atlantic Division Naval Facilities Engineering Command (LANTDIV), Comprehensive Long-Term Environmental Action Navy (CLEAN) Program. Activities associated with this FS for OU No. 6 have been conducted in accordance with the requirements contained in the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) [40 Code of Federal Regulations (CFR) 300.430]. The NCP guidelines dictating the FS process were promulgated under CERCLA, commonly referred to as Superfund, and amended by the Superfund Amendments and Reauthorization Act (SARA). The USEPA document entitled Conducting Remedial Investigations and Feasibility Studies Under CERCLA (USEPA, 1988) provided guidance during the preparation of this report.

1.1 Report Purpose and Organization

The subsections that follow describe the purpose and organization of this FS report.

1.1.1 Purpose of the Feasibility Study

The primary purpose of the FS report for OU No. 6 is to identify the remedial alternatives that are protective of human health and the environment, and that cost-effectively attain Federal and State requirements that are applicable or relevant and appropriate (ARARs). In general, the FS process under CERCLA serves to ensure appropriate remedial alternatives are developed and evaluated, such that pertinent information concerning the remedial action options can be presented and an appropriate remedy selected. The FS involves two major functions:

1. Development and screening of remedial action alternatives, and
2. Detailed analysis of remedial action alternatives.

The first phase of the FS process includes the following activities:

- Developing remedial action objectives and remediation levels
- Developing general response actions
- Identifying volumes or areas of affected media
- Identifying and screening potential technologies and process options
- Evaluating process options
- Assembling alternatives
- Defining alternatives
- Screening and evaluating alternatives

Section 121(b)(1) of CERCLA requires that an assessment be conducted to investigate possible solutions and alternative treatment technologies or resource recovery technologies that, in whole or in part, will result in a permanent and significant decrease in the toxicity, mobility, or volume of the hazardous substance, pollutant, or contaminant. In addition, according to CERCLA, treatment alternatives should be developed ranging from an alternative that, to the degree possible, would eliminate the need for long-term management to alternatives that involve treatment that would reduce toxicity, mobility, or volume as their principal element. A containment option involving little or no treatment and a no-action alternative should also be developed.

The second phase of the FS process consists of:

- Evaluating the potential alternatives in detail with respect to nine evaluation criteria that address statutory requirements and preferences of CERCLA

- Performing a comparison analysis of the evaluated alternatives.

1.1.2 Report Organization

This FS is organized into five sections. The Introduction (Section 1.0) presents the purpose of the report, a brief discussion of the FS process, and pertinent site background information including a summary of the nature and extent of contamination and risk assessments at OU No. 6. Section 2.0 contains the remedial action objectives and remediation goals that have been established for OU No. 6. Section 3.0 contains the identification of general response actions, and the identification and preliminary screening of the remedial action technologies and process options. Sections 4.0 and 5.0 contain the development, detailed analysis, and comparison of remedial action alternatives for the individual sites of OU No. 6. The detailed analysis is based on a set of nine criteria including short-term and long-term effectiveness, implementability, cost, acceptance, compliance with applicable regulations, and overall protection of human health and the environment. Reference sources are provided in Section 6.0.

1.2 Background Information

This section presents background information pertaining to OU No. 6. The following subsections include information such as site location and setting, geology, hydrogeology and site history. Further information of this type for OU No. 6 can be found in the Final Feasibility Study Report, Operable Unit No. 6, Site 54 (Baker 1998a), Final Feasibility Study Report, Operable Unit No. 6, Site 36 (Baker 1998b), and the Prefinal Record of Decision, Version 2, Operable Unit No. 6, Sites 36, 43, 44, 54, and 86 (Baker 2000).

1.2.1 Site Location and History

Site 36

Site 36 is located approximately 1,000 feet east of Camp Geiger and 500 feet west of the New River, adjacent to the Camp Geiger Sewage Treatment Plant. Camp Geiger is situated directly north of Marine Corps Air Station (MCAS), New River, and approximately 3 miles southwest of Jacksonville, North Carolina.

Figure 1-2 shows the features of Site 36. The site encompasses nearly 20 acres and is comprised primarily of open fields and wooded areas. A gravel road bisects the site and provides access to Jack's Point Recreation Area, located approximately one-quarter mile to the east. The site is bordered to the north and east by Brinson Creek and a wooded area, to the south by an unnamed tributary to Brinson Creek, and to the west by an improved (i.e., coarse gravel) road. Further to the west of the improved road lies an abandoned railroad right-of-way, once part of the Seaboard Coastline Railroad.

Site 36 reportedly has been used for the disposal of municipal wastes and mixed industrial wastes including trash, waste oils, solvents, and hydraulic fluids that were generated at MCAS, New River. The dump was active from the late 1940s to the late 1950s. Most of the material was burned and buried; however, some unburned material was also buried. Reportedly, less than five percent of all waste hydrocarbon material generated at MCAS, New River was disposed at Site 36. The remaining waste oil was reportedly used for dust control on roads or discharged directly to storm drains.

Parts of the site have been changed due to the construction of the North Carolina Department of Transportation (NCDOT) Route 17 bypass project. Several of the gravel roads that ran through the site have been widened and the elevation raised, serving as the subgrade for the Route 17 bypass. The Route 17 bypass construction extends outside the boundaries of the Site 36 study area and lies to the west of the site.

Site 43

Site 43 is comprised of approximately 11 acres and is located within the operations area of MCAS, New River, two miles west of the New River. Vehicle access to the site is via Agan Street from Curtis Road.

Figure 1-3 shows the site features for Site 43. The site is located at the northern terminus of Agan Street, adjacent to an abandoned wastewater treatment plant. The site is bordered to the north by Edwards Creek, to the east and south by Strawhorn Creek, and to the west by Agan Street and the former sewage disposal facility. Strawhorn Creek discharges into Edwards Creek at Site 43. Edwards Creek then discharges into the New River approximately 2,000 feet north of the study area, near Site 36.

Much of this site is heavily vegetated with dense shrubs and trees greater than three inches in diameter. Marsh areas prone to flooding surround both the Strawhorn and Edwards Creeks. An improved gravel loop road provides access to the main portion of the study area; other, smaller unimproved paths extend outward from the gravel loop road.

The Agan Street Dump reportedly received mainly inert material such as construction debris (i.e., fiberglass and lumber) and trash. Sludge from the former sewage disposal facility, located adjacent to the study area, was also dumped at Site 43. The time period during which disposal activities occurred, however, is not known.

Site 44

The Jones Street Dump (Site 44) encompasses approximately 5 acres and is situated within the operations area of MCAS New River. Figure 1-4 shows the site features of Site 44. Vehicle access to the site is via Baxter Street, from Curtis Road. Site 44 is located at the northern terminus of Baxter Street, behind Base housing units situated along Jones Street.

The site is partially surrounded by a six-foot chainlink fence constructed in 1995 to limit access/exposure to housing residents, but a portion of the site lies to the east of the fenced area. The site is bordered to the north and west by Edwards Creek, to the east by woods, a marsh area and an unnamed tributary to Edwards Creek. Edwards Creek flows east from the study area toward Site 43, which is located about 2,000 feet east of Site 44.

A majority of the site is comprised of a gently dipping open field that slopes toward Edwards Creek. The field is covered with high grass, weeds, and small pine trees that are less than two inches in diameter. Surrounding the open field is a mature wooded area with a dense brush.

Site 44 was reportedly in operation during the late 1950s. Although the quantity of waste is not known, debris, cloth, lumber and paint cans were reportedly disposed at the site. It was also reported that minor quantities of potentially hazardous waste may have been disposed at Site 44; however, background information does not indicate the exact nature of hazardous waste disposed.

Site 54

Site 54 is the former Crash Crew Fire Training Burn Pit. The site is located near the southwest end of runway 5-23, within the operations area of MCAS, New River. Figure 1-5 shows the site features of Site 54. The former burn pit was approximately 90 feet in diameter and was situated at the center of this 1.5 acre site. An 8,000-gallon underground storage tank (UST) was located to the northwest of the burn pit. Fire training exercises were conducted within the burn pit using JP-type fuel, which was stored in the nearby UST. An oil and water separator, located approximately 100 feet southeast of the burn pit, was used for temporary storage and collection of the spent fuel.

An improved gravel surface surrounds the burn pit, while the remaining portion of the site is comprised of a maintained lawn area. The ground surface slopes away from the central portion of the study area toward the south, southwest and southeast. Two drainage ditches lead away from the burn pit area toward the south, on either side of an improved road. During periods of heavy precipitation, the ditches serve as channels for surface water runoff.

Site 54 has served as a fire training burn pit since the mid-1950s. Excess fuels, oils and solvents were used as fuel to simulate fire conditions that would result from aircraft crashes. Fire training at Site 54 was originally conducted on the ground surface, within a bermed area. In 1975, a concrete-lined burn pit was constructed. In April 2001, construction and remedial activities at Site 54 were completed by the Remedial Action Contractor (RAC). The UST was removed and excavated contaminated soils from the burn pit and construction debris were taken to the Base landfill. Construction activities included a new concrete basin fire training area and two propane tanks (OHM 2001).

1.2.2 Geology

Site 36

A depositional sequence, consistent with the generalized North Carolina coastal plain sequence, was observed in borings throughout Site 36. The uppermost beds are undifferentiated. The surficial aquifer lies within the sediments of this undifferentiated formation. Less permeable sediments below the undifferentiated formation comprise the Belgrade Formation, also called the Castle Hayne confining unit. According to Cardinell et al., 1993, the Belgrade Formation constitutes part of the surficial aquifer and Castle Hayne confining unit. In this report for the purpose of simplicity, the less permeable sediments below the undifferentiated formation will be referred to as the Belgrade Formation (Castle Hayne confining unit). The River Bend Formation lies below the Belgrade Formation and is primarily characterized by beds of partially cemented shell fragments. The upper portion of the Castle Hayne aquifer lies within sediments of the River Bend Formation. The generalized sequence shows that the Yorktown, Eastover, and Pungo River Formations lie between the undifferentiated and Belgrade Formation. However, the Yorktown, Eastover, and Pungo River Formations have not been identified at Camp Lejeune.

Much of the surface soil at the site has been disturbed by human activity, as evidenced by the mounds, ridges, roads, and cleared areas observed throughout the site. Debris and soil have been disposed on portions of the site that resulted in the ridge and mound areas. Generally, regraded soil and debris were encountered in borings in the southern portion of Site 36. The soil was observed to be predominantly sand, silt and clay, with a lesser amount of debris. The debris included rocks, glass, metal, bricks and wood.

The uppermost formation at Site 36, the undifferentiated formation, is comprised of several units of Holocene and Pleistocene ages. This formation typically extends to a depth between 30 and 40 feet below ground surface (bgs). Fine sand, with lesser amounts of silt and clay occupies the uppermost portion of the formation. This sand unit is typically 5 feet thick. Below the sand is a clay layer with lesser amounts of fine sand and silt, approximately 2 to 5 feet thick. A second fine sand layer is below the clay. Zones of medium and coarse sand are present within this second sand unit. This sand unit also contains a lesser amount of silt and clay, and is approximately 5 to 15 feet thick. Additionally, laminae features are distinct in some portions of the unit. A unit composed of predominantly shell fragments lies below the second sand. This

unit also contains of a lesser amount of fine sand, silt, and clay. This unit occupies the lower portion of the formation, and is 15 to 20 feet thick. The sands of the undifferentiated formation tend to be loose to medium dense, the clays are soft to medium stiff, and the shell fragment layer is dense to very dense.

The Belgrade Formation is comprised of fine sand with lesser amounts of shell fragments, silt, and clay of the Miocene age. The top of this formation lies 30 to 40 feet bgs, is 15 to 20 feet thick, and has a distinct green or greenish-gray color. The sediments of this formation are medium dense to dense.

The River Bend Formation is comprised of fine to medium sand, with lesser amounts of shell fragments, silt, and clay of the Oligocene age. This formation lies approximately 60 feet bgs at Site 36. The sediments of this formation are very dense.

Site 43

A depositional sequence was observed in the deep well borings at Site 43 that matches the sequence discussed in the U.S. Geological Survey's hydrogeologic assessment of Camp Lejeune (Cardinell, et al., 1993). The uppermost formation at Site 43 is called the undifferentiated formation. The Belgrade Formation lies below, with the River Bend Formation below that.

The uppermost formation at Site 43, the undifferentiated formation, is comprised of two units of Holocene and Pleistocene ages. This formation extends to a depth between 33 and 38 feet bgs. The upper unit consists of fine sand with lesser amounts of medium and coarse sand, silt and clay. This unit is approximately 20 feet thick, and tends to be loose to medium dense. A fine to medium sand with a lesser amount of shell fragments and silt lies below the upper sand. This fine to medium sand unit is 12 to 18 feet thick, and tends to be medium dense to dense. Lenses of silts and clays were sporadically encountered in the undifferentiated formation.

The Belgrade Formation, is comprised of fine sand, with lesser amounts of silt and clay of the Miocene age. The top of this Formation lies 33 to 38 feet bgs, is approximately 16 feet thick, and has a distinct green or greenish-gray color. The sediments of this formation are medium dense to dense.

The River Bend Formation is comprised of fine sand, with lesser amounts of shell fragments and silt of the Oligocene age. This Formation lies 50 to 55 feet bgs at Site 43, and tends to be very dense.

Site 44

A depositional sequence was observed in the deep well borings at Site 44 that matches the sequence discussed in the U.S. Geological Survey's hydrogeologic assessment of Camp Lejeune (Cardinell, et al., 1993). The uppermost formation at Site 44 is the undifferentiated formation. The Belgrade Formation lies below, with the River Bend Formation below that.

The undifferentiated formation typically consists of three units of Holocene and Pleistocene ages. The upper unit is 3 to 8 feet thick and predominantly consists of silt and clay layers that are medium stiff to very stiff. The middle unit is predominantly fine sand with lesser amounts of silt and clay, and is loose to medium dense. This unit is approximately 12 to 14 feet thick. The lower unit is generally a fine to medium sand and shell fragments with lesser amounts of silt, or a clayey silt and shell fragments. These sediments are typically medium dense to very dense, and are approximately 30 feet thick. The undifferentiated formation typically extends to a depth between 45 and 50 feet bgs.

The Belgrade Formation, is predominantly a fine sand and clayey silt of the Miocene age. The top of this Formation lies 45 to 50 feet bgs, is approximately 5 feet thick, and has a distinct green or greenish-gray color. These sediments are typically medium dense to dense.

The River Bend Formation is predominantly a fine to medium sand with lesser amounts of silt and clay of the Oligocene age. This Formation lies 52 to 57 feet bgs at Site 44. The sediments of this formation are typically medium dense to dense.

Site 54

A generally consistent depositional sequence was observed in borings throughout Site 54. The exception is a thin, discontinuous fine-grained layer, called the Belgrade Formation. The uppermost beds are undifferentiated. The surficial aquifer lies within the sediments of this undifferentiated formation. Less permeable, fine-grained sediments below the undifferentiated

formation comprise the Belgrade Formation, also called the Castle Hayne confining unit. According to Cardinell, et. al., 1993, the Belgrade Formation constitutes part of the surficial aquifer and Castle Hayne confining unit. In this report, for the purpose of simplicity, the less permeable sediments below the undifferentiated formation will be referred to as the Belgrade Formation (Castle Hayne confining unit). The River Bend Formation lies below the Belgrade Formation and is primarily characterized by beds of partially cemented shell fragments. The upper portion of the Castle Hayne aquifer lies within sediments of the River Bend Formation.

The uppermost formation at Site 54, the undifferentiated formation, consists of several units of Holocene and Pleistocene ages. This formation typically extends to a depth between 15 to 20 feet bgs. The upper 2 feet of soil appear to be fill or reworked soil, particularly in the area around the burn pit. Compacted layers of gravel, sand, silt, and/or clay were observed. Otherwise, a predominantly silty fine sand or silt is present at the surface. Sediments of the undifferentiated formation tend to coarsen with depth, and are generally medium dense. Thin, discontinuous lenses of clay and silt are scattered throughout the undifferentiated formation.

The Belgrade Formation, which is usually a well-defined and fine-grained unit, was observed to be thin and discontinuous under Site 54. These units are identified as the "possible Castle Hayne confining unit" on the cross sections, and the formation contact is projected in places because of the discontinuous nature. However, these fine-grained units are at elevations consistent with elevations described by Cardinell, and generally match the description of the confining unit as less permeable sediments. These fine-grained units generally contain clay with lesser amounts of fine sand and silt of the Miocene age. This formation is typically 12 to 16 feet bgs, and can be less than 2 feet thick in places. The sediments of this formation are very soft to soft.

The River Bend Formation lies under the Belgrade Formation where present, but is generally in direct contact with the undifferentiated formation. The River Bend Formation consists of several units of the Oligocene age. This formation lies 12 to 22 feet bgs at Site 54. The formation predominantly consists of fine to medium sand south of the burn pit, and predominantly silty fine sand to fine sand east of the burn pit. Sediments in this formation are generally medium dense. Cemented and partially cemented shell fragments, typical of the River Bend Formation at other OU 6 sites, were observed only at monitoring well 54-GW07 (Figure 1-9).

1.2.3 Hydrogeology

Site 36

There are several aquifers beneath Site 36 and vicinity. The upper two aquifers were investigated in this study: the surficial and Castle Hayne. The surficial aquifer occurs within the sediments of the undifferentiated formation within 10 feet of the surface. It is approximately 25 to 30 feet thick in the vicinity of Site 36 and is under unconfined conditions (i.e., water table aquifer). The upper portion of the Castle Hayne aquifer occurs within the sediments of the River Bend Formation. The Castle Hayne aquifer occurs approximately 60 feet bgs and is approximately 200 feet thick in the vicinity of Camp Geiger and the Air Station (Cardinell et al., 1993). The Belgrade Formation, situated between the undifferentiated and River Bend Formations is also known as the Castle Hayne confining unit. The Castle Hayne confining unit is approximately 17 to 23 feet thick at Site 36.

The surficial aquifer hydraulic conductivity values are an order of magnitude lower than the value presented in the Cardinell's report. The average hydraulic conductivity at Site 36, based on RI slug tests is 2.4 feet/day, compared to 50 feet/day presented by Cardinell. Cardinell provided an estimated hydraulic conductivity value of 50 feet/day based on a general composition of fine sand, mixed with some silt and clay. The average hydraulic conductivity and transmissivity for the Castle Hayne aquifer at Site 36 is 5.7 feet/day and 1,248 $feet^2$/day, respectively. Cardinell's report presents hydraulic conductivities and transmissivities from several studies. Hydraulic conductivities range from 14 to 91 feet/day and transmissivities range from 820 to 26,000 $feet^2$/day. The hydraulic conductivity results for Site 36 are comparable to other sites throughout Camp Lejeune.

Groundwater flow in the surficial aquifer at Site 36 is to the northeast, toward Brinson Creek, with an average velocity of 0.1 feet/day. Groundwater flow in the upper Castle Hayne aquifer is to the northeast, with an average velocity of 0.3 feet/day. Because the hydraulic conductivity varies, groundwater may exhibit preferential flow paths following the relatively highly conductive medium and coarse sands. There appears to be some degree of connection between the surficial and Castle Hayne aquifers.

Brinson Creek and the unnamed tributary, represent a groundwater flow boundary for the surficial aquifer at Site 36. It appears that groundwater in the surficial aquifer discharges to Brinson Creek based on the elevation of the creek relative to groundwater elevations and groundwater flow direction.

Groundwater flow in the upper 10 to 15 feet of the surficial aquifer is complicated by the presence of a clayey layer under much of the site. The position of the clay layer roughly corresponds to the water table. During drilling, water was observed in sands and silts above the clay in the western portion of the site. It appears that water infiltrating the sands and silts is slow to infiltrate around/through the clay layer, creating a thin, perched groundwater zone. This perched zone may be seasonal. Baker personnel observed a significant amount of rain prior to the start of field activities. Many low-lying areas of the site contained ponded water or saturated soils. Additionally, the perched zone was typically less than 1 foot thick, and limited in extent. No perched zone was evident during drilling in the eastern portion of the site. There, the depth to groundwater tended to be within or below the clay unit.

Site 43

There are several aquifers beneath Site 43 and vicinity. The upper two aquifers were investigated in this study, namely the surficial and Castle Hayne. The surficial aquifer, which is under unconfined conditions (i.e., water table aquifer), occurs within the sediments of the undifferentiated formation. The surficial aquifer typically lies within 5 feet of the surface and is 30 to 37 feet thick in the vicinity of Site 43. The upper portion of the Castle Hayne aquifer lies within the sediments of the River Bend Formation. The Castle Hayne aquifer lies 50 to 55 feet bgs, and is approximately 200 feet thick in the vicinity of Camp Geiger and the Air Station (Cardinell et al., 1993). The Belgrade Formation, situated between the undifferentiated and River Bend Formations is also known as the Castle Hayne confining unit. The Castle Hayne confining unit is approximately 16 feet thick in the vicinity of Site 43.

The surficial aquifer hydraulic conductivity values are on the same order of magnitude as the value presented in the Cardinell (1993) report. The average hydraulic conductivity at Site 43, based on RI slug tests, is 16.1 feet/day, compared to 50 feet/day presented by Cardinell. Cardinell provided an estimated hydraulic conductivity value of 50 feet/day based on a general composition of fine sand, mixed with some silt and clay. The average hydraulic conductivity and

transmissivity for the Castle Hayne at Site 43 is 34.1 feet/day and 6,810 feet^2/day, respectively. Cardinell's report presents hydraulic conductivities and transmissivities from several studies. Hydraulic conductivities range from 14 to 91 feet^2/day and transmissivities range from 820 to 26,000 feet^2/day. The hydraulic conductivity results for Site 43 are comparable with other sites throughout Camp Lejeune.

The calculated groundwater flow velocities of the surficial aquifer varied by an order of magnitude across the site, ranging from 0.03 feet/day to 0.33 feet/day. The highest velocity observed is at monitoring well 43-GW04 (Figure 1-7). This is directly related to a hydraulic conductivity that is nearly an order of magnitude higher than the other wells.

The calculated groundwater flow velocities for the Castle Hayne were 1.19 feet/day at monitoring well 43-GW01DW and 0.18 feet/day at monitoring well 43-GW04DW. This order of magnitude difference is directly related to hydraulic conductivity. Note that these velocities are an estimate due to the fact that only two points were used to calculate the groundwater gradient. Three points are desirable for determining the gradient.

Groundwater flow in the surficial aquifer at Site 43 is toward Strawhorn Creek and the marshland to the east, with an average velocity of 0.13 feet/day. Groundwater flow in the upper Castle Hayne aquifer is also to the east, with an average velocity of 0.69 feet/day. Because the hydraulic conductivity varies, groundwater may exhibit preferential flow paths following the relatively highly conductive medium and coarse sands.

The surficial and Castle Hayne aquifers underlying Site 43 are separated by the Castle Hayne confining unit. This confining unit consists of fine sand with lesser amounts of silt and clay, and is approximately 16 feet thick. There appears to be some degree of hydraulic connection between the two aquifers. A vertical hydraulic conductivity of 0.0004 feet/day was measured in a sample from the Castle Hayne confining unit from monitoring well 43-GW01DW. This rate suggests slow vertical infiltration through the confining unit at this particular location.

It appears that groundwater in the surficial aquifer at Site 43 discharges to Strawhorn Creek, based on the elevation of the creek relative to groundwater elevations and groundwater flow direction. It appears that groundwater in the Castle Hayne aquifer flows underneath Strawhorn Creek, and may discharge to the New River and/or the adjacent marsh area. This is based on the

groundwater flow direction and consistent gradient. Groundwater elevation data compiled and mapped by Cardinell indicate that groundwater in the Castle Hayne aquifer flows toward, and discharges to the New River and its major tributaries.

Site 44

There are several aquifers beneath Site 44 and vicinity. The upper two aquifers were investigated in this study, namely the surficial and Castle Hayne aquifers. The surficial aquifer occurs within the sediments of the undifferentiated formation. The surficial aquifer, which is under unconfined conditions (i.e., water table aquifer), typically lies within 10 feet of the surface, and is approximately 43 feet thick in the vicinity of Site 44. The upper portion of the Castle Hayne aquifer lies within the sediments of the River Bend Formation. The Castle Hayne aquifer lies 52 to 57 feet bgs and is approximately 200 feet thick in the vicinity of Camp Geiger and the Air Station (Cardinell et al., 1993). The Belgrade Formation, situated between the Undifferentiated and River Bend Formations is also known as the Castle Hayne confining unit. The Castle Hayne confining unit is approximately 5 feet thick in the vicinity of Site 44.

The surficial aquifer hydraulic conductivity values are an order of magnitude lower than the value presented in the Cardinell report. The average hydraulic conductivity at Site 44, based on hydraulic conductivity slug tests is 1.4 feet/day, compared to 50 feet/day presented by Cardinell. Cardinell provided an estimated hydraulic conductivity value of 50 feet/day based on a general composition of fine sand, mixed with some silt and clay. The average hydraulic conductivity and transmissivity for the Castle Hayne at Site 44 is 17.8 feet/day and 3,560 $feet^2$/day, respectively. Cardinell's report presents hydraulic conductivities and transmissivities from several studies. Hydraulic conductivities range from 14 to 91 feet/day and transmissivities range from 820 to 26,000 $feet^2$/day. The hydraulic conductivity results for Site 44 are comparable with other sites throughout Camp Lejeune.

The calculated groundwater flow velocities of the surficial aquifer varied within an order of magnitude across the site. The velocity values ranged from 0.01 feet/day at monitoring well 44-GW05 to 0.05 feet/day at monitoring well 44-GW04 (Figure 1-8). The variations in groundwater flow velocities across the site are likely due to the heterogeneous soil conditions at the site, which cause the hydraulic properties to change spacially.

The calculated groundwater flow velocities for the Castle Hayne were 0.36 feet/day at monitoring well 44-GW01DW and 0.35 feet/day at monitoring well 44-GW06DW. The higher velocities of the Castle Hayne aquifer as compared to the surficial aquifer are attributable to higher hydraulic conductivity values of the Castle Hayne.

Groundwater flow in the surficial aquifer at Site 44 is toward Edwards Creek and the unnamed tributary, with an average velocity of 0.03 feet/day. Based on groundwater flow direction and groundwater elevation relative to surface water elevations, the surficial aquifer discharges to Edwards Creek and the unnamed tributary.

Groundwater flow in the upper Castle Hayne aquifer is to the east with an average velocity of 0.36 feet/day. Groundwater elevation data compiled and mapped by Cardinell indicate that groundwater in the Castle Hayne aquifer flows toward and discharges to the New River and its major tributaries.

The Castle Hayne confining unit appears to be semi-confining. The groundwater elevations in the deep and shallow wells respond similarly to precipitation and/or atmospheric changes. The confining unit is relatively thin, approximately 5 feet thick, with a measured vertical permeability of 0.04 feet/day. Based on groundwater elevations in shallow and deep well clusters, there appears to be a consistent upward groundwater flow from the Castle Hayne to the surficial aquifer.

Site 54

There are several aquifers beneath Site 54 and vicinity. The upper two aquifers investigated in this study are: the surficial and Castle Hayne. The surficial aquifer occurs within the sediments of the undifferentiated formation typically within 10 feet of the surface. The surficial aquifer is 5 to 10 feet thick where the Belgrade Formation is present. The upper portion of the Castle Hayne aquifer occurs within the sediments of the River Bend Formation. According to U.S. Geological Survey report (Cardinell, et. al, 1993), the Castle Hayne aquifer is approximately 200 feet thick in the vicinity of Camp Geiger and the Air Station.

The average surficial aquifer hydraulic conductivity at Site 54 is about half of the value presented by Cardinell. The average hydraulic conductivity value at Site 54, based on slug tests, is 22.5 feet/day, compared to 50 feet/day presented in Cardinell. The Cardinell value was estimated based on a general composition of fine sand, mixed with some silt and clay. The average hydraulic conductivity and transmissivity for the Castle Hayne at Site 54 is 32.0 feet/day and 6,390 $feet^2$/day, respectively. Cardinell reported hydraulic conductivities and transmissivities from several studies.

Hydraulic conductivities ranged from 14 to 91 feet/day and transmissivities range from 820 to 26,000 $feet^2$/day. The hydraulic conductivity results at Site 54 are comparable to the results at other sites throughout MCB Camp Lejeune.

For the surficial aquifer, calculated groundwater flow velocities varied by one order of magnitude, ranging from 0.16 to 1.01 feet/day. The higher velocity at monitoring well 54-GW06 (Figure 1-9) is attributable to relatively high hydraulic conductivity of the fine to coarse sands observed at this well.

For the Castle Hayne aquifer, calculated groundwater flow velocities varied by nearly one order of magnitude, ranging from 0.46 feet/day to 1.25 feet/day. The higher velocity at monitoring well 54-GW08 is attributable to relatively high hydraulic conductivity of the fine to medium sands observed at this well.

Groundwater in the surficial aquifer at Site 54 flows toward a tributary west of the site with an average velocity of 0.45 feet/day. Groundwater flow in the upper Castle Hayne aquifer is also west toward the tributary with an average velocity of 0.86 feet/day. The unnamed tributary west of the site represents a groundwater flow boundary at Site 54. It is evident that groundwater discharges to the tributary based groundwater flow direction and on the elevation of the creek relative to groundwater elevations.

1.3 Previous Investigations

1.3.1 Site 36

Previous investigations conducted at Site 36 include an Initial Assessment Study (IAS), a Confirmation Study, a Remedial Investigation (RI) Scoping Investigation, an Aerial Photographic Investigation, and a Remedial Investigation / Feasibility Study (RI/FS), a Time Critical Removal Action (TCRA), and a Temporary Well Investigation. Post-RI groundwater monitoring is ongoing at the site. The following paragraphs briefly discuss these investigations.

Initial Assessment Study

An IAS was conducted at Site 36 in 1983. The IAS evaluated the potential hazards at various sites throughout the Base, including Site 36. The IAS was based on historical records, aerial photographs, inspections, and personnel interviews; sampling was not conducted of any media. Due to the indication that hazardous substances were disposed at Site 36, a Confirmation Study was recommended.

Confirmation Study

A two-part Confirmation Study was conducted at Site 36 from 1984 through 1987. The study consisted of a Verification Step performed in 1984 and a Confirmation Step performed in 1986 and 1987. Field activities included groundwater, surface water, and sediment investigations.

Based on the results of the Confirmation Study, it was recommended that further characterization of shallow and deep groundwater be implemented due to low levels of volatile organic compounds (VOCs) and metals. Supplemental surface water and sediment investigations were also suggested to determine possible upstream sources of contamination. In addition, a thorough characterization of unsaturated soils within the identified disposal area was recommended to assess soil quality. Following the characterization of potentially impacted environmental media, a risk assessment was recommended to evaluate potential risks to human health and the environment.

RI Scoping Investigation

A RI Scoping Investigation was conducted in 1994 at Site 36. Following the identification of 11 abandoned containers (5-gallon containers and 55-gallon drums) during the March 1994 initial site survey, a limited drum and soil sampling program was proposed to address potentially impacted media. The objective of the drum sampling program was to collect representative samples from each of the containers and determine appropriate disposal actions. During the intervening months between the initial site survey and the drum investigation a majority of the containers were removed from the study area. Accordingly, only four five-gallon containers were sampled during the investigation. These four containers were located near the south central portion of the study area.

Based upon test kit results and field observations, the containerized substance was determined to be a non-reactive flammable liquid. One composite sample representing the contents of the four containers was submitted for analysis of toxicity characteristic leachate procedure (TCLP) contaminants and hazardous waste characteristics (i.e., corrosivity, reactivity, and ignitability). Results of these analyses and visual inspections indicated that the material was a weathered paint product.

Aerial Photographic Investigation

Surface conditions at Site 36 were examined via black-and-white aerial photographs taken in 1949, 1956, 1960, 1964, and 1970. Visual data from these photographs was used to evaluate previous site operations and to identify potential source areas of contamination. Additional photographs from 1938 and 1943 were used to establish a basis of comparison, as they depicted the area prior to development of the Camp Lejeune Military Reservation.

Remedial Investigations

From February through July 1995, an RI was conducted at Site 36. The RI consisted of a soil investigation, groundwater investigation, surface water and sediment investigation, an aquatic investigation, and a habitat evaluation. Section 1.4.1 summarizes the results of the RI for Site 36. Section 1.5.1 summarizes the risk assessment completed for Site 36 during the RI. In June of 1997, a Post-RI field investigation was conducted to define the limits of VOCs detected in groundwater.

Feasibility Study

The preferred remedial action for Site 36, as introduced in the 1998 Feasibility Study (FS), was based on the nature and extent of contamination and the potential risks to human health or the environment. Monitored natural attenuation (MNA) was selected as the preferred remedial action for Site 36 to address the VOCs detected in the surficial aquifer at concentrations exceeding Federal and State water quality standards. These VOCs include trichloroethene (TCE) and tetrachloroethene (PCE). In addition, the preferred alternative for Site 36 included surface water monitoring, annual fate and transport modeling, and aquifer use controls. The annual fate and transport modeling would provide additional evidence that natural attenuation (NA) is occurring, while the aquifer use controls would prohibit use of the aquifers within 1,000 feet of the estimated groundwater plume (except for monitoring purposes).

Time Critical Removal Action

A TCRA was performed at Site 36 in 1997 based on the results of the 1995 Final RI. Results of the RI found that the surface soil may have presented an imminent threat to human health and the environment. The TCRA included excavation of the polychlorinated biphenyl (PCB) contaminated soil and disposal of the soil in an appropriate treatment /disposal facility. In July 1997, the TCRA was performed by the RAC to remove approximately 92 tons of regulated PCB-contaminated soil and approximately 148 tons of non-regulated PCB-contaminated soils from Site 36. Field activities commenced on August 25, 1997 and were completed on September 24, 1997.

Upon completion of excavation activities, confirmation sampling was performed and revealed that soils remaining on site exhibited concentrations of PCBs below the action levels specified in the work plans (10 milligrams per kilogram [mg/kg]) for PCBs. Site restoration included the placement of clean backfill from an off-site borrow pit, the replacement of gravel on the gravel road, and revegetation.

Groundwater Monitoring Program

The groundwater monitoring program at Site 36 began in October 1998 with quarterly collection of both groundwater and surface water samples. The most recent sampling initiative at Site 36 was conducted in April 2002. Groundwater monitoring was implemented at this site to determine if NA could be a viable remedial alternative for this site. Table 1-1 shows groundwater detections at Site 36 since monitoring began in 1998 and the applicable NCWQS. TCE exceeds the NCWQS of 2.8 micrograms per liter (µg/L) in 6 of 11 monitoring wells, with the highest detection being 54 µg/L, based on the April 2002 data. In addition, 1,1,2,2-tetrachloroethane also exceeded the NCWQS of 0.17 µg/L in 2 monitoring wells, with the highest detection being 34 J µg/L, based on the April 2002 data.

Temporary Well Investigation

Three temporary well clusters were installed across Brinson Creek from Site 36, for the purpose of determining if contamination related to Site 36 had migrated under Brinson Creek and for identifying groundwater flow patterns in the vicinity of Brinson Creek. The three well clusters were installed and sampled between June 12 and 14, 2000. The results support the conclusion that groundwater contamination from Site 36 has not migrated across Brinson Creek.

1.3.2 Site 43

Previous investigations conducted at Site 43 include an IAS, a Site Inspection (SI), an additional groundwater investigation, an RI, and a TCRA. The following paragraphs briefly describe these investigations.

Initial Assessment Study

In 1983, an IAS was conducted at MCB, Camp Lejeune and MCAS, New River. The IAS evaluated the potential hazardous at various sites throughout the facilities, including Site 43. The evaluation included a review of historical records, aerial photographs, inspections, and personnel interviews. Sampling was not conducted of environmental media. The IAS concluded that waste quantities at Site 43, regardless of their nature, were minor; therefore, a Confirmation Study was not recommended for the site.

Site Inspection

In 1991, an SI was conducted at Site 43. The SI consisted of the following field activities: the installation and sampling of three monitoring wells (43-GW01, 43-GW02, and 43-GW03); the collection of two soil samples from each monitoring well test boring (one near the surface and one just above the water table); the collection of two soil samples from five additional soil borings; and the collection of five surface water and five sediment samples from the adjacent creeks and marsh. Contaminants detected during the SI included polynuclear aromatic hydrocarbons (PAHs) in surface soil, carbon disulfide and inorganics in groundwater, benzoic acid and inorganics in surface water, and PAHs and pesticides in sediment. Based on the findings of the SI, an RI/FS, including a human health and ecological risk assessment (RA), was recommended to further evaluate the nature and extent of soil, sediment, surface water, and groundwater contamination. Also, further characterization of upgradient groundwater and background soil, surface water, and sediment sampling was recommended.

Additional Groundwater Investigation

In 1994, an additional groundwater investigation was performed prior to conducting the RI to determine if vandalism of the wells had impacted groundwater or the wells themselves. The additional investigation at Site 43 included groundwater sampling of the three existing monitoring wells (43-GW01, 43-GW02, 43-GW03). Results from the additional groundwater investigation indicated that vandalism had not impacted the usability of the existing monitoring wells at Site 43. Therefore, the wells could be employed during future groundwater sampling investigations. However, it was recommended that the site be secured to prevent future vandalism.

Remedial Investigation

From February through May 1995, an RI was conducted at Site 43. The RI consisted of the following field activities: a soil investigation, which included drilling and sampling; a groundwater investigation, which included monitoring well installation, groundwater sampling, and aquifer testing; a surface water and sediment investigation; a habitat evaluation; and a bioassay.

Based on the RI results and the human health and ecological RAs conducted during the RI, conditions at Site 43 did not pose a risk to human health and the environment. As a result, the only remedial action identified for Site 43 was the "no action" alternative. Section 1.4.2 summarizes the results of the RI for Site 43, and Section 1.5.2 summarizes the RA completed during the RI.

Time Critical Removal Action

During 1995, a TCRA was performed at Site 43 by the RAC to remove surficial metallic debris found on site during the SI. Project activities involved the removal of all surficial metallic debris, including empty drums, various scrap metals and an old tank vehicle. Additionally, the RAC collected, sampled and shipped off-site four drums (1,400 lbs.) of hazardous materials for disposal. Site restoration included regrading the site due to the removal of the old tank vehicle and other debris.

1.3.3 Site 44

Previous investigations conducted at Site 44 include an IAS, SI and RI. The following paragraphs briefly describe these investigations.

Initial Assessment Study

An IAS was conducted at MCB, Camp Lejeune and MCAS, New River in 1983. The IAS evaluated the potential hazards at various sites throughout the facility, including Site 44. The evaluation included a review of historical records, aerial photographs, inspections, and personnel interviews. Sampling of environmental media was not conducted. The IAS report concluded that, due to the negligible quantity of inert material reportedly disposed at Site 44, further investigations were not warranted. After further consideration at a later date, Site 44 was recommended for a SI because the Base housing area is located adjacent to the site.

Site Inspection

In 1991, an SI was conducted at Site 44. The SI consisted of the following field activities: the installation and sampling of three monitoring wells (44-GW01, 44-GW02, and 44-GW03); the collection of two soil samples from each monitoring well test boring (one near the surface and one just above the water table); the collection of two soil samples from six additional soil borings; and the collection of two surface water and sediment samples from Edwards Creek.

Contaminants detected during the SI included PAHs, pesticides, and inorganics in soil; VOCs, PAHs, and inorganics in groundwater; VOCs and inorganics in surface water; and pesticides and inorganics in sediment. Based on the findings of the SI, an RI/FS, including a human health and ecological RA, was recommended to further evaluate the nature and extent of soil, sediment, surface water, and groundwater contamination. Further characterization of upgradient groundwater and background soil, surface water, and sediment sampling was also recommended.

Remedial Investigation

From February through May 1995, an RI was conducted at Site 44. The RI consisted of the following field activities: a soil investigation, a groundwater investigation, a surface water and sediment investigation, a habitat evaluation and a bioassay. Results from the RI are summarized in Section 1.4.3. Results of the RA are summarized in Section 1.5.3.

Based on the human health and ecological RAs conducted during the RI, only inorganics in groundwater posed a risk to human health and the environment. These inorganics are naturally occurring and therefore, the only remedial action identified for Site 44 was the "no action" alternative.

1.3.4 Site 54

Previous investigations conducted at Site 54 include an IAS, a Confirmation Study, and an RI. The following paragraphs briefly describe these investigations.

Initial Assessment Study

In 1983, an IAS was conducted to evaluate the potential hazards at Site 54. The IAS was based upon a review of historical records, aerial photographs, inspections and personnel interviews. No sampling of environmental media was conducted. Based on the results of the IAS, a Confirmation Study was recommended for Site 54.

Confirmation Study

A two-part Confirmation Study was conducted at Site 54 from 1984 through 1987. The study included a Verification Step, performed in 1984, and a Confirmation Step performed in 1986 and 1987. The Confirmation Study focused on the presence of potential contaminants in soil, groundwater, surface water, and sediment. Low levels of petroleum contamination in soil, groundwater, and sediment were identified. Oil and grease were the most prevalent contaminant group encountered during both rounds of the groundwater investigation. Concentrations of inorganics in groundwater generally decreased from one sampling event to the next (1984 to 1986). Analytical results from groundwater, surface water and sediment samples indicated that the actual disposal area may extend further to the west than was first estimated.

The Confirmation Study recommended that further characterization of environmental media be implemented to complete the RI/FS process. However, due to the low toxicity of suspected contaminants, the Confirmation Study suggested that the scope of further investigations be limited. Rather than expending considerable resources to accurately define the volumes of contaminated media, a RA to determine possible risks to human health and the environment was recommended.

Remedial Investigations

An RI was conducted at Site 54 from February through May 1995. The RI consisted of the following field activities: a soil investigation, a groundwater investigation, and a habitat evaluation. In June of 1997, a Post-RI field investigation was conducted to define the limits of the VOCs and semi-volatile organic compounds (SVOCs) detected in the groundwater. Section 1.4.4 summarizes the findings of the RI. Section 1.5.4 summarizes the risk assessment completed during the RI.

Feasibility Study

The preferred remedial action, as originally introduced in the FS in 1998, was based on the nature and extent of contamination and the potential risks to human health or the environment. Monitored Natural Attenuation with Institutional and Engineering Controls was selected as the preferred remedial actions for Site 54 to address the benzene and naphthalene detected in the surficial aquifer at concentrations exceeding Federal and State standards. Based on the locations of the maximum detected concentrations of VOCs/SVOCs, it appears that the contaminated area of concern may have resulted from unintentional spillage of fuels during fuel transfer and the fire training exercises.

The preferred alternative for Site 54 included groundwater monitoring of VOCs and SVOCs with monitored natural attenuation. In addition, the preferred alternative was intended to prevent future potential exposure to contaminated groundwater through the incorporation of aquifer use controls, while the operational and engineering controls were expected to eliminate the potential for future groundwater contamination related to future fire training exercises. The aquifer use controls would prohibit use (except for monitoring purposes) of the aquifers within 1,000 feet of the estimated groundwater plume. Institutional controls also included recordation of a "Notice" at the Onslow County courthouse. The 1995 RI for Site 54 recommended completion of the operational and engineering control design requirements, including conversion of the existing burn pit to a new fully lined facility where clean fuels would be used as an accelerant. The RI also stated that contaminated soils discovered during the installation of this new pit are to be removed and disposed. This action was completed as proposed in April 2001.

Installation of New Fire Training Facility and Soil Removal Action

In April 2001, the RAC completed construction and remedial activities at Site 54. The UST was removed and contaminated soils and construction debris were excavated from the former burn pit. The soil excavation for Site 54 was roughly oval in shape with a length of 128 feet and a width of 96.5 feet. The excavation extended 9 feet below grade to the surface of groundwater (OHM 2001). Following the excavation, eight confirmatory samples were taken for PAHs, and no contaminants remained on site above cleanup goals (North Carolina Soil-to-Groundwater standards). Restoration activities included construction of a new concrete fire training area and installation of two propane tanks.

Groundwater Monitoring Program

The groundwater monitoring program at Site 54 began in July 1998 with quarterly collection of groundwater samples. The Long-Term Monitoring (LTM) program at Site 54 completed its 14th sampling event in April 2002. Groundwater monitoring was implemented at this site so that NA processes could be evaluated to determine the effectiveness of NA, and to assess if NA could be a viable remedial alternative for the site.

1.4 Nature and Extent of Contamination

1.4.1 Site 36

Remedial Investigation

Figure 1-6 identifies the soil, surface water/sediment, and groundwater sampling locations associated with the RI, while Table 1-2 summarizes the analytical results. VOCs, SVOCs, pesticides, PCBs, and inorganics were detected in surface and subsurface soil samples, however, the highest levels of these compounds occurred in the surface soils. VOCs and SVOCs appeared to be the compounds most directly linked to past disposal practices. A majority of the SVOCs were polynuclear aromatic hydrocarbon (PAH) compounds. PAHs, pesticides and inorganics were compared against USEPA Region IX Preliminary Remediation Goals (PRGs) for this FS. Contaminants of concern were retained only when they exceeded the PRG.

Groundwater contamination was detected in the northern and western portions of the study area. The presence of VOCs was limited to the shallow aquifer in the northern portion of the study area. TCE was detected in four monitoring wells at concentrations exceeding the State standard of 2.8 µg/L with a maximum TCE detection of 97 µg/L, from monitoring well 36-GW10IW. Inorganics were the most prevalent and widely distributed constituents detected in both shallow and deep groundwater. Iron and manganese were the most prevalent inorganic analytes.

Ten inorganics were detected in the surface water of Brinson Creek. None of these detections, however, exceeded either State or Federal standards for the protection of surface water. In the unnamed tributary, 1,2-dichloroethene (1,2-DCE) was detected at a concentration of 7 µg/L in a sample collected adjacent to the southwestern portion of the study area near an unimproved

vehicle access road. This detection does not exceed screening criteria. In addition to the detection of 1,2-DCE, 14 inorganics were detected in the surface water of the unnamed tributary. Copper, iron, and nickel were the only inorganics detected at concentrations in excess of either State screening values or the National Oceanic and Atmospheric Administration (NOAA) chronic screening values.

SVOCs, pesticides, and inorganics were detected in the sediment of Brinson Creek. The SVOCs diethylphthalate and di-n-butylphthalate were each detected once among the six sediment samples, at concentrations of 2,135 and 218 micrograms per kilogram (µg/kg). In the sediment of the unnamed tributary, VOCs, SVOCs, pesticides, and inorganics were detected. PCE was detected at a concentration of 4 µg/kg within a sample collected approximately 100 feet upstream of Brinson Creek. Three SVOCs (diethylphthalate, anthracene, and pyrene) were detected, but at concentrations that do not exceed applicable NOAA screening values. Inorganics were also positively detected.

Post-RI Field Investigation Results

Two additional groundwater monitoring wells were installed at Site 36 in June, 1997. These two monitoring wells, IR36-GW16IW and IR36-GW17, were sampled on July 2,1997 and analyzed for Target Compound List (TCL) volatiles.

Results of the Post-RI groundwater samples indicated low levels of TCE (6 J µg/L) and 1,2-DCE (5 J µg/L) within newly installed monitoring well IR36-GW16IW. Based on this well's location and the detected concentrations with respect to the extent of the groundwater plume estimated during the RI, the results of the Post-RI field investigation are consistent with the original RI findings.

Analytical results from monitoring well IR36-GW17 indicated non-detections of TCL volatile organics. These results further supported the conclusion that the VOCs identified in the northern portion of Site 36 are not the result of an off-site (upgradient) source.

Temporary Well Investigation Results

Six temporary monitoring wells were installed northeast of Site 36 across Brinson Creek on private property. TCE, the primary contaminant detected at Site 36, was not detected in any of the groundwater samples collected. Accordingly, the results support the conclusion that groundwater contamination detected at Site 36 has not migrated under Brinson Creek.

It appears that Brinson Creek is preventing contaminants detected at Site 36 from migrating downgradient and off site. The creek is a horizontal groundwater flow hydraulic barrier as evidenced by groundwater flow patterns. The groundwater elevation data were used to generate potentiometric surface maps and determine groundwater flow direction. Shallow groundwater flow (the surficial aquifer) in the study area is southwest, toward Brinson Creek. Intermediate groundwater flow (the upper portion of the Castle Hayne aquifer) in the study area is south, also toward Brinson Creek. This is based on static water levels measured in the temporary wells, converted to elevations from the survey data, and plotted on maps. Groundwater flow patterns observed at Site 36 during the RI reflect similar trends from this investigation. As shown in the Final RI Report for Operable Unit No. 6, (Site 36, August 22, 1996), shallow groundwater flow is northeast, toward Brinson Creek. Intermediate groundwater flow is east-northeast, also toward Brinson Creek with a component toward the New River. The RI investigation evidence also suggested that this pattern changed little with the seasons.

Groundwater Monitoring Program

The groundwater monitoring program at Site 36 began in October 1998 with quarterly collection of both groundwater and surface water samples. The most recent sampling initiative at Site 36 was conducted in April, 2002. Table 1-1 shows groundwater detections at Site 36 since monitoring began in 1998. TCE exceeds the NCWQS of 2.8 µg/L in 6 of 11 monitoring wells, with the highest detection being 54 µg/L, based on April 2002 data. In addition, 1,1,2,2-tetrachloroethane also exceeded the NCWQS interim standard of 0.17 µg/L in 2 wells during the April 2002 sampling event. The highest detection of 1,1,2,2-tetrachloroethane was 34 J µg/L.

1.4.2 Site 43

Figure 1-7 identifies the sampling locations associated with the previous field investigations, while Table 1-3 summarizes RI analytical results for Site 43. SVOCs, pesticides, and inorganics were detected in surface and subsurface soil samples. The presence and dispersion of SVOCs in soil, particularly PAH compounds, are most likely the result of past disposal operations at Site 43. SVOCs were identified in both surface and subsurface soil samples obtained from the cleared portion of the study area, adjacent to the gravel access road. Concentrations of SVOCs were more prevalent and detected at higher concentrations in surface samples, compared to SVOC concentrations in subsurface samples. In general, soil analytical results correspond directly to the visual identification of fill or graded material (including possible wastewater treatment plant sludge material) observed during the field investigation.

In groundwater, inorganics (particularly iron and manganese) were the most prevalent and widely distributed constituents detected. Inorganic concentrations were generally higher in groundwater samples collected from the surficial aquifer, as opposed to samples obtained from the deeper aquifer. In addition, 4-methylphenol was detected at a concentration of 2 µg/L in a sample obtained from temporary monitoring well 43-TW04, located in the northern portion of Site 43 near the confluence of Edwards and Strawhorn Creeks. However, this is less than the NCWQS Interim Standard of 3.5 µg/L. No other organic compounds were detected among groundwater samples at Site 43.

In surface water, VOCs, pesticides, and metals were detected. VOCs, SVOCs, pesticides, and metals were detected in sediment. These detections were determined to have originated from an upgradient source (e.g. Site 89), were naturally occurring (e.g. metals) or were from Base-wide applications of pesticides.

1.4.3 Site 44

Figure 1-8 identifies the surface and subsurface soil sampling locations and the groundwater sampling locations associated with the RI. In addition, Table 1-4 summarizes the analytical results from the RI. Positive detections of VOCs were limited to samples obtained from the surficial aquifer. No VOCs were detected in samples obtained from the deep aquifer, suggesting that these contaminants have not migrated from the surficial aquifer.

PCE was detected at an estimated concentration of 1 µg/L in the groundwater sample obtained from existing monitoring well 44-GW03. This concentration represents an exceedence of the State standard of 0.7 µg/L. No other VOCs were detected at this location; however, six SVOCs were detected. PCE was not detected in downgradient wells, indicating a very localized extent of contamination. Moreover, the relatively low VOC concentration suggests that its presence may be the result of unintentional spillage or limited disposal rather than from long-term disposal or buried containers.

Vinyl chloride, 1,2-DCE (total), and TCE were detected at concentrations of 10, 15, and 1 µg/L, respectively, in the sample obtained from temporary well 44-TW01. None of these VOCs were detected in any of the other Site 44 monitoring wells; however, the same contaminants were detected in a majority of surface water samples from nearby Edwards Creek. Temporary well 44-TW01 was installed in a low lying area, within 50 feet of Edwards Creek. During periods of seasonal flooding, the same VOCs detected among surface water samples most probably migrated from surface water to groundwater in areas immediately adjacent to Edwards Creek.

The following VOCs were detected at least once among the 13 surface water samples obtained from Edwards Creek (the maximum concentration of each VOC is provided):

- Vinyl chloride 38 µg/L
- 1,1-Dichloroethene 2 µg/L
- 1,2-Dichloroethene (total) 150 µg/L
- Trichloroethene 66 µg/L
- 1,1,2-Trichloroethane 1 µg/L
- 1,1,2,2-Tetrachloroethane 42 µg/L

TCE, 1,2-DCE (total), and 1,1,2,2-tetrachloroethane were detected in at least 12 of the 13 surface water samples obtained from Edwards Creek. Vinyl chloride and 1,1-DCE were detected eight and three times, respectively. Lastly, 1,1,2-trichloroethane was detected in only one surface water sample.

Maximum VOC concentrations were detected in samples obtained from portions of Edwards Creek that are upgradient of Site 44. Results from both the initial and supplemental sampling events illustrate a reduction in total VOC concentrations from upgradient to downgradient

sampling stations along Edwards Creek. Volatile analytical results from the September 1995 sampling event were generally lower than results from the initial sampling event conducted in May 1995. The same trend of relatively higher upgradient and lower downgradient VOC concentrations is evident.

During the September 1995 sampling event, an additional four sampling stations were added to the Edwards Creek surface water investigation. The additional sampling stations were placed several hundred feet upstream of Site 44, beyond the initial sampling stations. The analytical data from Edwards Creek suggests that a possible VOC source lies somewhere in the southeastern portion of Camp Geiger. Based on sampling of groundwater and soil conducted upstream of Site 44 adjacent to Edwards Creek during 1999 and 2000, the source of VOC contamination in Edwards Creek is originating from soil and groundwater at Site 89. A TCRA was completed in 2000 at Site 89 to remediate the contaminated soil. Site 89 soil was treated by thermal desorption and replaced on site. Groundwater at Site 89 is scheduled to be remediated, which will further reduce the source of contamination to Edwards Creek. In the meantime, an aeration pond has been constructed in Edwards Creek between Sites 89 and 44. The aeration pond should reduce VOC concentrations in surface water, which will reduce the impact of VOCs to downstream portions of the creek.

1.4.4 Site 54

Remedial Investigation

Figure 1-9 identifies the surface and subsurface soil sampling locations, and groundwater sampling locations associated with the RI. In addition, Table 1-5 summarizes analytical results from the RI for Site 54. SVOCs were identified in both surface and subsurface soil samples collected from the southern and southwestern portions of the study area. The majority of SVOCs detected in soil samples were PAH compounds. Only one SVOC (2-methylnaphthalene) and one VOC (acetone) were detected in the subsurface soil at concentrations exceeding 1,000 µg/kg. The detections of 2-methylnaphthalene or acetone, however, do not exceed the USEPA Region IX PRG of 1,600,000 µg/L for both compounds. In addition, inorganics were detected in both surface and subsurface soil samples at concentrations exceeding the Base-specific background levels.

In groundwater, inorganics were the most prevalent and widely distributed contaminants. Iron and manganese were the most prevalent inorganics, detected at concentrations exceeding State standards within nine groundwater samples each. Lead was detected in an upgradient well at a concentration of 39.7 µg/L, which was the only lead detection to exceed the NCWQS of 15 µg/L. No other inorganics were detected above applicable screening standards. Positive detections of organic compounds in groundwater were limited to portions of the study area immediately adjacent to the burn pit or UST and extending southwest of the burn pit. The presence of volatile and semivolatile compounds in samples obtained from this portion of the study area is consistent with current site operations. Six positive detections of benzene and five positive detections of naphthalene exceeded the State standards of 1 and 21 µg/L, respectively.

Post-RI Field Investigation

Three additional groundwater monitoring wells were installed at Site 54 in June, 1997. These three monitoring wells, IR54-GW11, IR54-GW12, and IR54-GW13, were sampled on July 1, 1997 and analyzed for TCL volatiles.

Results of the Post-RI groundwater samples collected from monitoring wells IR54-GW11 and IR54-GW13 indicated no VOC concentrations above detection limits. These two wells are located downgradient, but within a few hundred feet, of the initial VOC detections. One low concentration of benzene (4 µg/L) was detected in newly installed monitoring well IR54-GW12. This monitoring well is located just northwest of the UST location. Based on this well's location and the detected benzene concentration, the results of the Post-RI field investigation for Site 54 are consistent with the RI findings related to the extent of groundwater contamination. These results support the conclusion that the surficial groundwater plume identified in the vicinity of the burn pit and the UST have not migrated far from the assumed source locations.

Groundwater Monitoring Program

Groundwater monitoring began at Site 54 in July of 1998. Table 1-6 shows recent NCWQS exceedences from the monitoring program. There have been no detections of VOCs exceeding the NCWQS standards in the past 11 quarters of Post-RI Monitoring. Only one SVOC, bis[2-ethylhexyl]phthalate, was detected at levels above the NCWQS of 3 µg/L in the 3 sampling rounds (July 2000, October 2000, January 2001) prior to the removal action. In the October 2001 sampling event, three SVOCs were detected in monitoring well 54-GW11 at levels above

NCWQS. It is suspected that these detections are the result of site construction activities that impacted the integrity of the well. A Geoprobe sample collected adjacent to this well in January 2002 verified that the SVOCs detected in October 2001 were not present in the groundwater.

1.5 Risk Assessment Summary

This section provides a summary of the human health and ecological RAs completed during the RI for OU No. 6. Further information regarding the risk assessments can be referenced in the RI reports for each site.

1.5.1 Site 36

Human Health Risk Assessment

Military personnel, recreational fisherman, recreational users of the site surface water, trespassers and construction workers were all assessed as potential current receptors. Potential risks from surface soil, surface water, sediment, fish tissue and crab tissue were within acceptable risk levels for all receptors except the current fisherman. For the current fisherman, the total noncarcinogenic risk (9.1) and total carcinogenic risk (1×10^{-3}) were greater than acceptable noncarcinogenic and carcinogenic risk levels of one and 1×10^{-4}, respectively. This risk was mainly due to levels of arsenic and mercury found in fish tissue and levels of arsenic and lead found in crab tissue. Although a potential risk resulted, data indicate that the source generating the risk was not from Site 36.

Future potential child and adult residents were assessed for possible exposure to groundwater, surface soil, subsurface soil, surface water and sediment. A future construction worker was evaluated for surface and subsurface soil exposure. Potential noncarcinogenic risks were calculated for the child resident from groundwater (5.2) and subsurface soil (2.3) exposure. A noncarcinogenic risk (2.2) was calculated for the adult resident from groundwater. The iron in groundwater and surface soil contributed to these risks. However, iron is considered to be naturally occurring at MCB, Camp Lejeune and it is an essential nutrient. In fact, if iron were removed from the evaluation, risk from exposure to subsurface soil for the future child receptor would decrease from 2.2 to 0.9, within the acceptable risk range. As a result, the potential human health risk from exposure to iron in groundwater and surface soil is a conservative estimate.

Ecological Risk Assessment

Based upon the assessment of ecological risks, there is a slight potential for metals in the surface water and sediment, and a moderate potential for pesticides (4,4'-DDD and 4,4'-DDT) and diethylphthalate in the sediment, to decrease the population of aquatic life at the freshwater stations. There is a slight potential for metals in the surface water (copper, nickel) and sediment, and a moderate potential for lead, pesticides (4,4'-DDD and 4,4'-DDE) and diethylphthalate in the sediment, to decrease the population of aquatic life at the saltwater stations. The benthic macroinvertebrates do not appear to be impacted based upon the results of the sampling events.

A comparison of chronic daily intake (CDI) versus terrestrial reference values (TRV) was performed for Site 36. The CDI exceeded the TRV for all five terrestrial species evaluate, but the risks were higher for the cottontail rabbit and the raccoon. Aldrin, dieldrin, 4,4'-DDD and 4,4'-DDE were the only pesticides detected in the whole body fish tissue samples at concentrations above the proposed piscivorous wildlife criteria. None of the pesticides generated a risk to the raccoon ingesting the fish. Lead in fish and crab tissue also did not pose a risk to the raccoon ingesting the tissue. Cadmium was the only metal detected in the whole-body tissue samples above wildlife dietary levels that posed a risk to the raccoon. However, cadmium does not appear to be site-related.

Some potential impacts to soil invertebrates and plants may occur as a result of potential exposure to site contaminants. There is also a slight potential for a decrease in the terrestrial vertebrate population from exposure to site contaminants based on the terrestrial intake model.

1.5.2 Site 43

Human Health Risk Assessment

Current military personnel and adult and child trespassers were evaluated as potential receptors, and risk values were calculated for exposure to surface soil, surface water and sediment. There are no unacceptable risks for current receptors identified at Site 43.

Future child and adult residents were evaluated for exposure to groundwater, surface soil, surface water and sediment. Future construction workers were also evaluated for exposure to subsurface soil. There were no unacceptable carcinogenic risks identified for future receptors. However, noncarcinogenic risks were identified for groundwater ingestion for future child and adult residents. This is mostly the result of iron in groundwater at Site 43, which is considered to be a naturally occurring constituent throughout MCB, Camp Lejeune.

Ecological Risk Assessment

Pesticides in the surface water and sediment may potentially affect aquatic receptors. SVOCs in the sediment and inorganics in the surface water and sediment may also potentially affect aquatic receptors. However, SVOCs and pesticides only slightly exceeded the screening values, and thus indicate only a slight potential for risk. Based on this information, the potential ecological risks to the aquatic ecosystem are minimal and do not warrant remedial action at Site 43.

Based on a terrestrial intake model, quotient indices (QIs) were calculated to quantify potential ecological risks for terrestrial receptors. The QIs for bobwhite quail (1.5), cottontail rabbit (11.7) and raccoon (25.1) exceeded the acceptable QI of 1.0. Aluminum was the main contributor. Because the terrestrial intake model uses the conservative assumption that a raccoon will eat all of its fish from Site 43, the actual risk associated with aluminum is expected to be low.

1.5.3 Site 44

Human Health Risk Assessment

Under the current exposure scenario, military personnel and adult and child trespassers were evaluated as potential receptors, and risk values were generated for exposure to surface soil, surface water and sediment. There are currently no unacceptable human health risks for current receptors associated with the environmental media at Site 44.

Under a future risk scenario, child and adult residents were evaluated as potential receptors, and risk values were calculated for exposure to groundwater, surface soil, surface water and sediment. In addition, a construction worker receptor was evaluated for subsurface soil exposure. All risk values under the future scenario were acceptable with the exception of those calculated for future

child and adult residents exposed to groundwater. The elevated risk in groundwater is primarily due to the presence of vinyl chloride in one temporary well. Due to the location of this well, the vinyl chloride is likely the result of contamination from Site 89, located upstream of Site 44, since VOCs were otherwise not detected in surface soil, subsurface soil or groundwater at Site 44. Noncarcinogenic risk in groundwater is due to iron, which is naturally occurring at MCB, Camp Lejeune.

Ecological Risk Assessment

Ecological risks to aquatic receptors associated with SVOCs and inorganics appears to be minimal. Concentrations of inorganics in surface water and sediment, and SVOCs in sediment only slightly exceeded screening values or were detected infrequently.

Estimated CDI values for the cottontail rabbit and raccoon exceeded the TRV values. However, these risks are associated primarily to aluminum, iron and vanadium, which are not related to past site practices. QIs were also calculated, and they exceeded 1.0 for the cottontail rabbit (8.54) and raccoon (12.1). Because the QIs only slightly exceeded 1.0, the potential risks to these receptors appears to be insignificant.

1.5.4 Site 54

Human Health Risk Assessment

Potential current military personnel and trespassers were assessed for exposure to surface and subsurface soil, and were found to be within acceptable risk ranges.

Future potential child and adult residents were assessed for potential exposure to groundwater and subsurface soil. Future construction workers were assessed for subsurface soil. There were no unacceptable risks associated with the construction worker. However, there was a noncarcinogenic risk for the future child resident and noncarcinogenic and carcinogenic risks calculated for a future adult receptor related to ingestion of groundwater. The iron detected in groundwater was a primary contributor to these risks. Iron is naturally occurring at MCB, Camp Lejeune.

Ecological Risk Assessment

There is a low potential for organic compounds and inorganic analytes to decrease the population of aquatic life within nearby freshwater bodies. Concentrations of analytes in groundwater were used to simulate surface water conditions during the ecological risk assessment. Based on that simulation, anthracene and nickel exceeded applicable Surface Water Screening Values (SWSVs) in one groundwater sample. Xylenes, naphthalene, barium and manganese were detected below the concentrations that are expected to cause a decrease in aquatic life. Due to low water hardness and dilution after discharging to the receiving water, lead is not expected decrease the aquatic population.

Several organics (n-nitrosodiphenylamine, phenanthrene and pyrene) and inorganics (aluminum, chromium and vanadium) were detected at levels that exceed applicable surface soil screening values (SSSVs). As a result, some potential impacts to soil invertebrates and plants may occur. A comparison of CDI values to the TRV exceeded for all five terrestrial species evaluated, with higher risk for the cottontail rabbit and raccoon.

1.6 Conclusions of the Remedial Investigation and Post-RI Monitoring

1.6.1 Site 36

The following conclusions were derived from RI and Post-RI Monitoring conducted at Site 36:

- Metals are present in surface and subsurface soil predominantly in the central and eastern areas of the site (i.e., Open Field and Former Disposal Area). These areas correspond to former buried material and fill locations at the site. Cadmium, lead and antimony exceeded USEPA Region IX Residential PRGs.

- Lead was detected in 48 of 52 surface soil samples and 50 of 51 subsurface soil samples, with higher detections in subsurface soils than surface soils. The highest detection in the subsurface soils was 2,680 ppm, which exceeds the EPA directive of 400 ppm. Three surface soil samples and eight subsurface soil samples were greater than the EPA directive of 400 ppm.

- VOCs in groundwater are primarily limited to the northern portion of the site. This area was not included in the original study area but was subsequently added to the study. After an examination of historical aerial photographs, an approximately 2-acre ground scar was noted in this northern area. The VOCs of concern identified in the RI were 1,2-DCE (total), TCE, 1,1,2,2-tetrachloroethane, and PCE.

- The horizontal extent of VOCs in groundwater appears to be limited to the northern portion of the study area. This area has not been fully evaluated along its southern boundary although several wells downgradient from the affected area did not indicate the presence of VOCs.

- VOC occurrence in groundwater is limited to the surficial aquifer. VOCs are present in the lower portion of the surficial aquifer but do not appear to have migrated into the underlying Castle Hayne aquifer. It is likely that the surficial aquifer is discharging into Brinson Creek based on the groundwater flow pattern at the site, although VOCs were not detected in surface water.

- VOCs exceeding the NCWQSs in recent monitoring events are TCE, 1,1,2,2-tetrachloroethane and vinyl chloride. These VOCs exceeded the NCWQS in 6 of 11 wells.

- TCE had the highest concentration of detected VOCs, with a concentration of 54 µg/L in April 2001. This exceeds the NCWQS of 2.8 µg/L.

- Iron, manganese, and mercury were detected in groundwater at concentrations above state drinking water levels. The maximum levels of these metals were found predominantly in the Former Disposal and Open Field areas (i.e., buried and fill materials). Human health evaluations calculated from ingestion of iron in groundwater yielded a site risk.

- Copper, iron, and nickel were found in surface water at concentrations greater than federal screening levels. Nickel, manganese, copper, lead, and iron exceeded ecological criteria. Human health risks calculated from exposure to surface water were within acceptable risk levels.

- Cadmium, lead, mercury, nickel, and zinc are present in sediment. Lead in sediment generated an ecological risk. Pesticides in sediment generated the most significant ecological risk. Human health risks calculated from exposure to sediment were within acceptable ranges.

- Based upon results of the sampling, benthic macroinverterbrates do not appear to be impacted by site media. Currently, arsenic and mercury in fish tissue and arsenic and lead in crab tissue pose potential risk to human health.

1.6.2 Site 43

The following conclusions were derived from the RI conducted at Site 43:

- SVOCs, predominantly PAHs, were detected in soil samples obtained at Site 43. The observed PAHs were almost exclusively detected in samples obtained from a cleared area along the site access road. The same samples are believed to contain grit material from the former sewage disposal facility that was located adjacent to Site 43. Groundwater samples collected from monitoring wells within the same area did not exhibit PAHs. These compounds were evaluated for potential human health risk in soil and did not indicate unacceptable risks. The PAHs in soil may generate a potential adverse risk to plant and soil invertebrate receptors.

- Metals present in soil corresponded to areas with buried containers, fill, and graded soil. Metals in soil pose a slight ecological risk to terrestrial receptors. No unacceptable human health risks were calculated from exposure to metals in soil.

- Iron and manganese were detected in 10 of 10 groundwater samples, with eight iron detections and two manganese detections at concentrations above state drinking water standards. Of these two constituents, only exposure to iron in groundwater generated unacceptable human health risks. As noted in the report, iron and manganese are very common constituents in all media at MCB, Camp Lejeune. Accordingly, their presence is not likely associated with disposal activities at the site.

- Exposure to pesticides in surface water and sediment posed a potential adverse ecological risk. The pesticides are attributed to routine applications which occurred throughout the Base and are not due to disposal at the site. The level of copper in surface water also indicated a slight potential risk to ecological receptors.

1.6.3 Site 44

The following conclusions were derived from the RI conducted at Site 44:

- VOCs were detected throughout Edwards Creek. The highest levels of VOCs were detected in samples obtained from sampling stations located upgradient of Site 44. Based upon the distribution of positive detections, the source of VOCs does not appear to be originating from Site 44. Several potential sources have been identified upgradient of Site 44 (e.g., Site 89) and have been addressed with an aeration pond installed between Site 89 and Site 44. Other remedial options are being evaluated to address the source of contamination at Site 89.

- No unacceptable human health risks were calculated based on exposure to site surface water or sediment. Pesticides in sediment posed moderate ecological risks to aquatic receptors. Metals in site surface water were found at levels greater than criteria and may pose slight risks to aquatic receptors. Based upon soil screening values, metal concentrations in soil posed a potential risk to terrestrial receptors.

- Iron was detected at levels exceeding the NCWQS in groundwater samples obtained throughout Site 44. Iron in groundwater posed a potential risk to human health at Site 44. As noted in this report, iron is a very common constituent in all media at MCB, Camp Lejeune. A Base background study is currently being performed, with results available in Summer 2002, in order to assess whether these inorganics are within Base background screening levels.

1.6.4 Site 54

The following conclusions were derived from the RI and Post RI Monitoring conducted at Site 54:

- Several VOCs and SVOCs were detected in groundwater at Site 54 during the RI. In general, positive detections of organic compounds were limited to portions of the study area immediately adjacent to the former burn pit or former UST and the area extending southwest from the burn pit. Waste fuels, oils, and solvents were reportedly used in the past as fuel to simulate fire conditions; currently, only JP-type fuels are used during training exercises. While fuel was being transferred from the on-site UST to the burn pit and during training exercises, it is likely that spills onto the ground surface occurred. Given the fact that the on-site UST had been successfully tested for tightness and the burn pit lined with asphalt, this scenario is most likely the cause of organic compounds in groundwater. Accordingly, operations at the former burn pit are the primary source of these compounds in groundwater.

- A number of VOCs and SVOCs were also detected in soils obtained from Site 54. In general, the observed organic compounds in soil differed from those detected in groundwater.

- Iron, manganese, and lead were found at elevated levels in groundwater at Site 54. Iron, lead, and arsenic in groundwater generated unacceptable risks to human receptors. Groundwater discharge to the site surface water is not expected to cause a significant decrease in the aquatic population.

- Five of 13 groundwater samples had detections of lead, with one detection that exceeded the NCWQS of 15 µg/L. Elevated levels of lead in groundwater are likely the result of past site practices, and will be addressed in this FS.

- No VOCs have been detected above NCWQS standards in the 11 most recent sampling quarters of the groundwater monitoring program.

2.0 REMEDIATION GOALS AND REMEDIAL ACTION OBJECTIVES

This section presents a discussion of remediation goal options and remedial action objectives for OU No. 6. The remediation goal options and remedial action objectives are based on regulatory requirements, standards and guidance, as well as future land use considerations for OU No. 6.

2.1 Land Use Considerations/Land Use Controls

2.1.1 Site 36

Site 36 encompasses nearly 20 acres and is comprised primarily of open fields and wooded areas with dense understory (Figure 1-2). A gravel road bisects the site and provides access to Jack's Point Recreation Area, located approximately one-quarter mile to the east. Parts of the site have been changed due to the construction related to the NCDOT Route 17 bypass project. Several of the gravel roads that ran through the site have been widened and the elevation raised, and will serve as the subgrade for the Route 17 bypass. The Route 17 bypass construction extends outside the boundaries of the Site 36 study area to the west of the site.

Currently, the site is not used for military or Base operations and access is restricted. Access to the site is granted through the motorpool area at Camp Geiger by Base security. Future land use for the site has not been definitively determined, and possible future plans are varied. Therefore remedial alternatives will be developed that allow for both residential and industrial land uses.

Land use controls may be implemented to manage future land use, to restrict site access, or to restrict certain types of activities at a site. Examples of land use controls include restrictions such as fencing, aquifer use restrictions, or deed restrictions that limit allowable land uses and/or place restrictions on certain activities (e.g., excavation) at the site. Land use controls can be used to control all or parts of the site. Remedial alternatives that leave soil or groundwater on the site above the selected cleanup goal may include land use controls that either restrict access and/or restrict certain excavation/construction activities.

2.1.2 Site 43

Site 43 is located at the northern terminus of Agan Street, adjacent to an abandoned waste water treatment plant (Figure 1-3). An improved gravel loop road provides access to the main portion of the study area; other unimproved paths extend outward from this road.

It is desired that Site 43 be remediated for future residential land uses. Therefore, land use controls may be considered only in conjunction with other remedial actions.

2.1.3 Site 44

Figure 1-4 presents a site features map of Site 44. The site is partially surrounded by a six-foot chainlink fence constructed in 1995 to limit access/exposure to housing residents, and a portion of the site lies to the east of the fenced area.

It is desired that Site 44 be remediated for future industrial land uses. Therefore, land use controls may be considered for this site.

2.1.4 Site 54

Figure 1-5 presents a site features map for Site 54. The site is located near the southwest end of runway 5-23, within the operations area of MCAS, New River. An improved gravel road surrounds the area of the former burn pit, and the remainder of the site is comprised of a maintained lawn area.

Site 54 has served as a fire training burn pit since the mid-1950s. Excess fuels, oils and solvents were used to simulate fire conditions that would result from aircraft crashes. In April 2001, the RAC completed construction and remedial activities at Site 54. The UST was removed along with excavated contaminated soils and construction debris from the burn pit. Construction activities included a new concrete fire training area and two propane tanks.

Because of current site operations, it is desired that Site 54 remain used for industrial purposes. Therefore, land use controls may be considered for this site.

2.2 Media of Concern/Contaminants of Concern

2.2.1 Site 36

Surface soil and subsurface soil are media of concern for Site 36. During the RI, sample results detected concentrations of VOCs, SVOCs, pesticides, PCBs and inorganics in soil at Site 36. Risk generated by soil was primarily due to iron in soil, and not other organic or inorganic constituents. Among the organic constituents, VOCs and SVOCs are most directly linked to past disposal practices. The majority of the SVOCs detected were PAH compounds. Because constituents related to historical use of the site were detected at levels greater than the USEPA Region IX PRGs in localized areas, surface soil and subsurface soil are retained as media of concern at this site and PAHs, pesticides and lead are contaminants of concern (COCs).

Groundwater contamination was detected in the northern and western portions of the study area. Volatile compound detections were limited to the shallow aquifer in the northern portion of the study area. TCE exceeded state water quality standards in four wells during the RI. Inorganics were also present, and detections were widely scattered between the surficial and deeper aquifers. Iron and manganese were the most prevalent inorganics detected, however, they are naturally occurring in groundwater at the Base. Groundwater is retained as a media of concern and VOCs are potential COCs for groundwater at Site 36.

Detected concentrations of soil and groundwater contaminants at Site 36 will be compared to the remediation goals to be developed in Section 2.4 to generate a list of final COCs for this FS. Any COC that does not exceed its applicable regulatory remediation goal will be eliminated from the list of COCs, thus eliminating it from consideration in this FS. Contaminants that exceed the remediation goals are retained as final COCs. The list of final COCs will become the basis for defining areas of concern and evaluating remedial action alternatives for this site. Although only iron in subsurface soil and groundwater generated a risk at Site 36, localized areas of contamination that exceed USEPA Region IX PRG standards related to past site practices are present.

2.2.2 Site 43

SVOCs, pesticides and inorganics were detected in surface and subsurface soil samples at Site 43. The presence and dispersion of SVOCs in soil, particularly PAH compounds, are most likely the result of former disposal operations at Site 43. SVOCs were identified in both surface and subsurface soil samples obtained from the cleared portion of the study area, adjacent to the gravel access road. SVOC concentrations were much higher in surface soils then subsurface soils. Due to the detection of SVOCs in soils at Site 43, surface soil and subsurface soil are retained as media of concern for this FS.

In groundwater, inorganics (particularly iron and manganese) were the most prevalent and widely distributed constituents detected. Inorganic concentrations were generally higher from samples taken from the surficial aquifer, as opposed to samples collected from the deeper aquifer. The detected inorganics are naturally occurring and not related to past site practices. The SVOC 4-methylphenol was detected at a concentration of 2 µg/L from a temporary monitoring well. This does not exceed the NCWQS of 3.5 µg/L. No other organic compounds were detected at the site. Accordingly, groundwater will not be retained as a media of concern at this site.

Detected concentrations of soil contaminants at Site 43 will be compared to the remediation goals to be developed in Section 2.4 to generate a list of final COCs for this FS. Any COC that does not exceed its applicable regulatory remediation goal will be eliminated from the list of COCs, thus eliminating it from consideration in this FS. Contaminants that exceed the remediation goals are retained as final COCs. The list of final COCs will become the basis for defining areas of concern and evaluating remedial action alternatives for this site. Although only iron in groundwater generated a risk at Site 43, localized areas of contamination related to past site practices are present, at higher concentrations than the rest of the site.

2.2.3 Site 44

Soil sampling results from the RI show that inorganics are the most prevalent constituents and are evenly dispersed throughout the site. Because the inorganics did not generate an unacceptable risk, surface soil and subsurface soil were not retained as media of concern for Site 44.

Groundwater sampling results from the RI show that positive detections of volatile compounds were limited to the surficial aquifer. PCE was detected at an estimated concentration of 1 µg/L in a groundwater sample from monitoring well 44-GW03, exceeding the NCWQS of 0.7 µg/L. No other volatile contaminants were detected at this location. The lack of positive detections in other wells that are located hydraulically downgradient from this well indicates that the extent of organic contamination is limited. Moreover, the relatively low VOC concentration suggests that its presence may be the result of unintentional spillage or limited disposal rather than from long-term disposal or buried containers. Therefore, due to limited impact, groundwater is not retained as a media of concern at Site 44.

Based on the data collected during the RI and the results of the site-specific RA, there are no impacted media at Site 44. Only iron in groundwater generated a risk at the site. Accordingly, a no action alternative will be recommended for soil and groundwater at Site 44.

2.2.4 Site 54

Soil samples taken during the RI showed SVOC contamination, mostly from PAH compounds. Due to the removal action completed in April 2001 by the RAC, soil contamination has already been removed from the site. Following the excavation, eight confirmatory samples were taken for PAHs, and no contaminants remained on site above cleanup goals (NC SSLs). Therefore, surface and subsurface soil are not retained as media of concern at Site 54.

Groundwater at Site 54 has been sampled regularly since July 1998 as part of Post RI Monitoring. There have been no detections of VOCs in the past nine sampling quarters in groundwater (Baker 2001). Only one SVOC had been detected in three sampling quarters prior to the removal action (July 2000, October 2000 and January 2001) at a concentration slightly above the NCWQS. During the removal action, one groundwater sample was taken at the center of the excavation. There were no detections of PAHs above cleanup goals in this groundwater sample.

Groundwater sampling resumed in October 2001 following the completed removal action at Site 54. In the October 2001 sampling event three SVOCs were detected in one monitoring well (54-GW11) above the NCWQS. It was suspected that these detections were the result of the construction and remediation activities that occurred at Site 54 which impacted the integrity of this well. A Geoprobe sample collected adjacent to this well in January 2002 verified that the SVOCs detected in October 2001 were not present in the groundwater. Lead, however, was

detected in five of 13 groundwater samples and exceeds the NCWQS of 15 µg/L in one groundwater sample. Lead is not naturally occurring at the site and is likely related to past practices. Therefore, groundwater is retained as a media of concern at Site 54 until it can be demonstrated that lead meets the NCWQS.

Due to the effectiveness of the soil removal there is no further need to address areas of concern or COCs in soil at Site 54. Lead detections in the groundwater will be retained as a COC for Site 54. A no action alternative will be recommended for soil at Site 54. A no action alternative and a monitoring alternative will be considered at Site 54 to address the presence of lead in groundwater.

2.3 Applicable or Relevant and Appropriate Requirements (ARARs)

Regulatory requirements, standards, and guidance are also referred to as "applicable or relevant and appropriate requirements" (ARARs) and "to be considered" (TBCs) requirements. ARARs and TBCs are defined and described in general in Section 2.3.1. Section 2.3.2 presents and describes specific ARARs and TBCs identified as applicable or appropriate to OU No. 6.

2.3.1 Definition of Applicable or Relevant and Appropriate Requirements (ARARs) and "To Be Considered" (TBC) Requirements

Under Section 121(d)(1) of CERCLA, remedial actions must attain a degree of cleanup that assures protection of human health and the environment. Additionally, CERCLA remedial actions that leave any hazardous substances, pollutants, or contaminants on site must meet, upon completion of the remedial action, a level or standard of control that at least attains standards, requirements, limitations, or criteria that are "applicable or relevant and appropriate" under the circumstances of the release. These requirements are known as "ARARs" or applicable or relevant and appropriate requirements. ARARs are derived from federal and state laws.

ARARs are categorized as one of three basic types: chemical-specific, location-specific, and action-specific. Chemical-specific ARARs include requirements which set health or risk-based concentration limits or ranges for specific hazardous substances, pollutants, or contaminants. Federal Maximum Contaminant Levels (MCLs) established under the Safe Drinking Water Act (SDWA) are examples of chemical-specific ARARs.

Location-specific ARARs set restrictions on activities based upon the characteristics of the site. Examples include federal and state siting laws for hazardous waste facilities and sites on the National Register of Historic Places.

The third classification of ARARs, action-specific, refers to requirements that set controls or restrictions on particular activities related to the management of hazardous substances, pollutants, or contaminants. RCRA regulations for closure of hazardous waste storage units and pretreatment standards for discharges to publicly owned treatment works under the Clean Water Act (CWA) are examples of action-specific ARARs.

Subsection 121(d) of CERCLA requires that remedial actions meet a level or standard that at least attains federal and state substantive requirements that qualify as ARARs. Federal, state, or local permits are not necessary for removal or remedial actions to be implemented on site, but their substantive requirements or ARARs must be met.

ARARs for a particular site depend on the detected contaminants, specific site characteristics, and particular remedial actions proposed for the site. Potential ARARs identified for OU No. 6 are presented in Section 2.3.2.

Advisories, criteria, or guidance documents that do not meet the definition of ARARs, but may be considered to determine what is protective or are useful in developing CERCLA remedies are referred to as "to-be-considered" (TBC) requirements. The ARARs preamble [40 CFR Part 300.400(g)(3)] describes three types of TBCs: health effects information with a high degree of credibility, technical information on how to perform or evaluate site investigations or remedial actions, and policy.

2.3.2 Potential ARARs and TBCs for OU No. 6

The chemical-specific, location-specific, and action-specific ARARs and TBCs that were identified for OU No. 6 are presented below.

2.3.2.1 Chemical-Specific ARARs and TBCs

Primary chemical-specific ARARs, criteria, guidance and TBCs identified for the COCs in soil and groundwater at OU No. 6 are listed below. These ARARs/TBCs may applicable to site soils and groundwater and include:

- USEPA Region IX Residential and Industrial Preliminary Remediation Goals (PRGs)
- North Carolina Water Quality Standards (15A NCAC 2B)
- North Carolina Groundwater Standards (15A NCAC 2L)
- OSWER Directive for Lead
- Oil Pollution and Hazardous Substances Control Act (NCGS 143-215.75 et seq.)
- North Carolina Air Pollution Control Regulations (15A NCAC 2D, 2H, 2Q)
- North Carolina Hazardous Waste Management Rules (15A NCAC 13A .0009 & .0012)

Brief descriptions of some of the chemical-specific ARARs/TBCs as they pertain to OU No. 6 are provided below for further clarification.

USEPA Region IX PRGs

Preliminary Remediation Goals (PRGs) are tools for evaluating and cleaning up contaminated sites. They are risk-based concentrations derived from standardized equations, combining exposure information, assumptions, and EPA toxicity data. The USEPA Region IX PRGs are generic and are calculated without site specific information. PRGs should be viewed as guidelines, not legally enforceable cleanup or remediation standards. PRGs are not an ARAR; however, they are federal guidance and therefore are considered "TBC" information for OU No. 6.

USEPA Region IX Residential PRGs will be used for site "screening" and will be evaluated as initial remedial goals for VOCs, SVOCs, pesticides and metals in site soil. PRGs are not de facto cleanup standards and should not be applied as such. However, they are helpful in providing remediation targets to use during the analysis of different remedial alternatives.

North Carolina Water Quality Standards (Groundwater)

Under the North Carolina Administrative Code (NCAC), Title 15A, Subchapter 2L, Section .0200, (15A NCAC 2L.0200) the Department of Environment and Natural Resources (NC DENR) has established groundwater standards (NCWQS) for three classifications of groundwater within the State: GA, GSA and GC. Class GA waters are those groundwaters in the state naturally containing 250 mg/L or less of chloride. These waters are an existing or potential source of drinking water supply for humans. Class GSA waters are those groundwaters in the state naturally containing greater than 250 mg/L of chloride. These waters are an existing or potential source of water supply for potable mineral water and conversion to fresh water. Class GC water is defined as a source of water supply for purposes other than drinking. The NCAC T15A:02L.0300 has established sixteen river basins within the state as Class GC groundwaters (15A NCAC 2L.0201 and 2L.0300).

The water quality standards for groundwater are the maximum allowable concentrations resulting from any discharge of contaminants to the land or water of the state, which may be tolerated without creating a threat to human health or which could otherwise render the groundwater unsuitable for its intended best usage. If the water quality standard of a substance is less than the limit of detectability, the substance shall not be permitted in detectable concentrations. If naturally occurring substances exceed the established standard, the standard will be the naturally occurring concentration as determined by the state. Substances which are not naturally occurring and for which no standard is specified are not permitted in detectable concentrations for Class GA or Class GSA groundwaters (15 A NCAC 2L.0202).

The NCWQS for substances in Class GA and Class GSA groundwaters are established as the lesser of:

- Systemic threshold concentration (based on reference dose and average consumption)
- Concentration which corresponds to an incremental lifetime cancer risk of $1x10^{-6}$
- Taste threshold limit value
- Odor threshold limit value
- MCL
- National Secondary Drinking Water Standard

Note that the water quality standards for Class GA and Class GSA groundwaters are the same except for chloride and total dissolved solids concentrations (15A NCAC 2L.0202).

OSWER Directive for Lead

As part of the Superfund Administrative Improvements Initiative, an interim directive established a streamlined approach for determining protective lead levels in soil at CERCLA and RCRA facilities that are subject to corrective action under RCRA section 3004 (u) or 3008 (h). This directive recommended a screening level for lead in surface soil for residential land use at 400 mg/kg and 1,000 mg/kg for industrial land use. This interim directive, dated July 14, 1994, replaced all previous directives on soil lead cleanup for CERCLA and RCRA programs (USEPA 1994a).

A screening level represents a level of contamination of above which there may be enough concern to warrant a study of potential risks. This level is not a cleanup goal. Rather, this screening level may be used as a tool to determine which areas require further study and to encourage voluntary cleanup. Levels of contamination above the screening level would not automatically require a removal action or designate the area as lead contaminated. Consequently, this value will be the ARAR used in this FS for lead detected in surface soil at Site 36.

2.3.2.2 Location-Specific ARARs

Potential location-specific ARARs identified for OU No. 6 and an evaluation determining the applicability of these location-specific ARARs with respect to OU No. 6 are presented on Table 2-1. Based on this evaluation, specific sections of the following location-specific ARARs may be applicable to OU No. 6:

- Fish and Wildlife Coordination Act
- Federal Endangered Species Act
- North Carolina Endangered Species Act
- Executive Order 11990 on Protection of Wetlands
- Executive Order 11988 on Floodplain Management
- RCRA Location Requirements
- North Carolina Hazardous Waste Management Rules

- North Carolina Solid Waste Management Rules
- North Carolina Recordation of Inactive Hazardous Substance or Waste Disposal Areas
- North Carolina Coastal Management

Please note that the citations listed on Table 2-1 should not be interpreted to indicate that the entire citation is an ARAR. The citation listing is provided on the table as a general reference.

2.3.2.3 Action-Specific ARARs

Action-specific ARARs are typically evaluated during the development and detailed evaluation of alternatives since they are dependent on the type of action being considered. Nonetheless, potential action-specific ARARs for OU No. 6 have been identified and are listed on Table 2-2. These ARARs are based on RCRA, OSWER Directive, CWA, SDWA, and North Carolina State requirements. Note that the citations listed on Table 2-2 should not be interpreted to indicate that the entire citation is an ARAR. The citation listing is provided on the table as a general reference.

2.4 Remediation Goals and Final COCs

Remediation goals are established based on regulatory requirements, standards, and guidance. From the standards identified as ARARs or TBCs, a recommended remediation goal is chosen for each COC to be used in the development of remedial alternatives in the FS.

The remediation goals for COCs at OU No. 6 were selected based on regulatory requirements, standards, and guidance, and future land use considerations. Selected remediation goals for each site and the basis for each remedial goal are provided below.

2.4.1 Final Contaminants of Concern for Site 36

Contaminants present at Site 36 in exceedance of their remediation goals are COCs for this FS. In order to evaluate localized areas of contamination related to past site practices, each contaminant's maximum detected concentrations in surface soil and subsurface soil were compared to USEPA Region IX PRGs for residential land use. Groundwater at Site 36 was compared to NCWQS and Federal Maximum Contaminant Levels (MCLs).

Comparisons of contaminants to remediation goals for residential land use are presented in Tables 2-3 and 2-4 for surface soil and subsurface soil, respectively. The list of final COCs and their respective remediation goals for residential land use are summarized in Table 2-5. Although antimony, arsenic and cadmium exceed their respective PRGs, these inorganics do not generate unacceptable risk at the site and are not related to past site practices. They are likely naturally occurring and within Base background concentrations. They are therefore not retained as contaminants of concern.

Groundwater contaminants detected during the Post-RI Monitoring (April 2001 for metals and January 2002 for VOCs) were compared to the NCWQS. The comparison and selected COCs are presented in Tables 2-6 and 2-7, respectively.

2.4.2 Final Contaminants of Concern for Site 43

Contaminants present at Site 43 in exceedence of their remediation goals are COCs for this FS. The future land use at Site 43 is projected to be residential due to its proximity to a Base housing area. Localized areas of contamination related to past site practices have higher concentrations than other areas of the site. Therefore, maximum detected concentrations in surface soil and subsurface soil were compared to USEPA Region IX Residential PRGs.

Comparisons of contaminants to remediation goals for residential land use are presented in Tables 2-8 and 2-9 for surface soil and subsurface soil, respectively. The list of final COCs and their respective remediation goals for residential land use are summarized in Table 2-10.

Results from the RI show that iron and manganese were detected in groundwater. Both exceed the NCWQS standards of 300 µg/L and 50 µg/L, respectively. These inorganics, however, are naturally occurring and are likely within Base background concentrations. A Base background study is currently being conducted at MCB, Camp Lejeune. These inorganics will be evaluated against Base background when data becomes available.

2.4.3 Final Contaminants of Concern for Site 44

There were no media of concern identified at Site 44 and, therefore, no contaminants of concern are addressed for this site.

2.4.4 Final Contaminants of Concern for Site 54

Soil is not a media of concern at Site 54 due to the soil removal action completed in April 2001. Groundwater results from the RI show that only iron, lead and manganese exceed NCWQS standards. Iron and manganese are naturally occurring and may be within Base background concentrations. A Base background study is currently being conducted at MCB, Camp Lejeune. These inorganics will be evaluated against Base background when data becomes available. Lead, however, is likely related to past site practices. It is retained as a contaminant of concern.

2.5 Areas of Concern

Surface soil, subsurface soil, and groundwater have been identified as the media of concern for this FS for OU No. 6. The area of concern for soil represents the area of excavation for a soil removal alternative or the area of treatment for an in situ treatment alternative. Specific areas of concern for soil are defined as areas where contaminant concentrations exceed remedial goals as defined in Section 2.4 for residential land use.

These areas are used to define areas of concern and to estimate volumes of contaminated soil for each remedial action alternative in Section 4.0. The areas of concern for the various types of contaminants, as defined by exceedances of remediation goals, are illustrated in the figures introduced below. Corresponding approximate volumes or areas to be addressed are presented as a reference point:

Site 36

- Figure 2-1 - Area of Concern: Region IX Residential PRGs (Pesticides and PAHs)
  950 CY (assumes a depth of 2 feet)
- Figure 2-2 - Area of Concern: Lead in Soil (> 400 ppm)
  64, 500 ft^2 (1.48 acres)
- Figure 2-3 - Area of Concern: Groundwater (VOCs)

Site 43

- Figure 2-4 - Area of Concern: Region IX Residential PRGs (PAHs)
  750 CY (assumes a depth of 3 feet)

2.6 Remedial Action Objectives

Remedial action objectives are medium-specific or site-specific goals established for protecting human health and the environment. At OU No. 6, the specific media to be addressed by the remedial action is contaminated soil at Sites 36 and 43 and groundwater at Sites 36 and 54. Remedial action objectives for OU No. 6 are:

Site 36

- Remove or mitigate potential exposure to contaminated surface and subsurface soils on the site that contain contaminants related to past site practices in excess of the selected remediation goals (cleanup levels) for residential land use.

- Protect human health by mitigating the potential for exposure to the lead contaminated surface and subsurface soils.

- Prevent future exposure to VOC contaminated groundwater.

- Protect uncontaminated groundwater for future potential beneficial use.

Site 43

- Remove or mitigate potential exposure to contaminated surface and subsurface soils on the site that contain contaminants related to past site practices in excess of the selected remediation goals (cleanup levels) for residential land use.

Site 54

- Prevent future exposure to lead contaminated groundwater.
- Protect uncontaminated groundwater for future potential beneficial use.

3.0 IDENTIFICATION AND PRELIMINARY SCREENING OF REMEDIAL ACTION TECHNOLOGIES

Section 3.0 presents the identification and preliminary screening of remedial action technology types and process options that may be applicable to the remediation of media at OU No. 6. More specifically, general response actions are presented in Section 3.1. Remedial action technology types and process options for each general response action are discussed in Section 3.2. Preliminary screening of the remedial action technology types and process options for OU No. 6 are presented in Section 3.3. After the preliminary screening, the remaining technology types/process options undergo a process option evaluation for each individual site. The final set of remedial action technology types and a brief description of the evaluated options are also presented.

3.1 General Response Actions

General response actions are broad-based, medium-specific categories of actions that can be identified to satisfy the remedial action objectives of an FS. Due to the nature of soil contamination at OU No. 6, five general response actions have been identified for these sites. The general response actions include: no action, institutional controls, containment/removal actions, and in-situ and ex-situ treatment actions. For groundwater contamination, general response actions including no action, institutional controls and in-situ and ex-situ treatment actions have been selected. A brief description of these general response actions follows.

3.1.1 No Action

The NCP requires the evaluation of the no action response as part of the FS process. A no action response provides a baseline assessment for comparisons involving other remedial alternatives that offer a greater level of response. A no action alternative may be considered appropriate when there are no adverse or unacceptable risks to human health or the environment, or when a response action may cause a greater environmental or health danger than the no action alternative.

3.1.2 Institutional Controls

Institutional controls are various "institutional" actions that can be implemented at a site to minimize exposure to potential hazards at the site. These controls are typically considered to be "passive" actions such as limiting exposure to contaminated soil by access restrictions (e.g., fencing) or by placing restrictions on the allowable land uses of a contaminated area.

3.1.3 Containment/Removal Actions

This general response action combines both containment and removal actions. Containment actions include technologies that contain and/or isolate contaminants by covering, sealing, or providing an effective barrier over or around specific areas of concern. These actions also provide isolation and prevent direct exposure with or migration of the contaminated media.

Excavation is a method for removing contaminated soil using conventional heavy construction equipment such as backhoes, cranes, bulldozers and loaders. With respect to OU No. 6, the contaminated soil could be excavated and then treated (on-site or off-site) or sent off-site for disposal.

3.1.4 Treatment Actions

A typical general response action applicable to soil remediation involves a combination of removal, treatment, and/or disposal actions. Treatment actions (in-situ and ex-situ) can include biological, physical/chemical, and thermal treatment methods. In-situ treatments may result in production of process water or products from off-gas treatment systems. Ex-situ treatments may result in process water, products from off-gas treatment systems and/or contaminated soil. These remediation end products may need to be further treated or disposed. Treatment may include one of a number of on-site or off-site treatment actions. Disposal may include on-site or off-site landfill options in addition to recycling options.

Treatment actions for contaminated groundwater could include biological, thermal, and physical/chemical treatment alternatives that can be implemented either in-situ or ex-situ. Ex-situ treatment actions are all implemented in conjunction with extraction of groundwater and must meet surface water discharge requirements prior to discharge.

3.2 Identification of Remedial Action Technologies and Process Options

In this step, a set of potentially applicable technologies and process options will be identified for each of the general response actions listed in the previous section. The term, "technology type" refers to general categories of technologies such as physical/chemical, thermal, and biological. The term "process option" refers to specific processes, or technologies, within each generalized technology type. For example, soil washing and solvent extraction are process options under the technology type known as physical/chemical treatment for soil remediation. Several technology types may be identified for each general response action and numerous process options may exist within each generalized technology type.

Several technology types are presented for each response action for both soil and groundwater at OU No. 6. They are identified on Table 3-1.

3.3 Preliminary Screening of Remedial Action Technologies and Process Options

During the preliminary screening, the set of remedial action technology types and process options identified on Table 3-1 have been screened (or reduced) by evaluating the technology types with respect to contaminant-specific and site-specific factors. This screening step was accomplished by using available information from previous site investigations (i.e., information regarding contaminant types, contaminant concentrations, and site characteristics) to screen out technology types and process options that cannot be effectively implemented at the site (USEPA, 1988). In general, all technology types and process options that appear to be applicable to the site contaminants and site conditions have been retained for further evaluation. The preliminary screening for OU No. 6 is presented on Table 3-2.

3.4 Process Option Evaluation

The objective of the process option evaluation is to select only one representative process option for each applicable remedial technology type to simplify the subsequent development and evaluation of remedial alternatives. In some cases, more than one process option may be selected for a technology type if the processes are sufficiently different in their performance. It is important to note that the elimination of a process option does not mean that the process option can never be reconsidered for the site. The representative process option simply provides a basis for remedial alternative evaluation during the FS. However, the specific process option used to implement the remedial action may not be selected until the remedial design phase.

During the process option evaluation, the process options retained on Table 3-2 were further evaluated based on three criteria: effectiveness, implementability, and relative cost. The evaluation of effectiveness focused on: the potential effectiveness of a process option in meeting the remedial action objectives; the potential impacts to human health and the environment during the construction and implementation phase; and how reliable the process is with respect to the COCs. The evaluation of implementability focused on the administrative feasibility of implementing a technology (e.g., obtaining permits), since the technical implementability was previously considered in the preliminary screening. The evaluation of relative cost played a limited role in this screening. Only relative capital and operating and maintenance (O&M) costs were used instead of detailed estimates. As per USEPA guidance (USEPA, 1988), the relative cost analysis was made on the basis of engineering judgement.

A summary of the process option evaluation is presented on Table 3-3. It is important to note that the elimination of a process option does not mean that the process option can never be reconsidered for the site. As previously stated, the purpose of this process option evaluation is to select a representative process option to simplify the development and evaluation of the most appropriate potential alternatives.

As noted on Tables 3-2 and 3-3, several technology types and/or process options were eliminated from further evaluation because they were determined to be inappropriate based on site-specific characteristics and/or contaminant-specific characteristics that were identified for OU No. 6.

3.5 Final Set of Remedial Action Technologies/Process Options

Table 3-4 identifies the final set of feasible technology types and process options that were used to develop remedial action alternatives for the individual sites at OU No. 6. A brief description of each technology type/process option from the final set is presented below.

3.5.1 Site 36

3.5.1.1 No Action

The no action alternative will be considered for Site 36 for both soil and groundwater. The no action response provides a baseline for comparison with other response actions and the NCP requires that this alternative be evaluated. Under the no action response, the contaminated media

at the site will be left in place. Passive remediation of organic contaminants (i.e., natural attenuation) may occur, but will be unmonitored. No active institutional controls or active remediation efforts would be implemented at the site if the no action alternative were selected.

3.5.1.2 Site Access Restrictions

The site access restrictions process option includes the installation and/or maintenance of security fencing and signs around the contaminated media at Site 36. Warning signs would be posted along the fence. The fencing option would minimize direct exposure to the impacted soil at the site by reducing the potential for dermal contact with or ingestion of the soil.

3.5.1.3 Land Use Restrictions

Land use controls are implemented to manage future land use or to restrict certain types of activities at a site. Examples of land use controls include aquifer use restrictions or deed restrictions that limit allowable land uses and/or place restrictions on certain intrusive activities (e.g., excavation, installation of wells, or construction) at the site. Land use controls can be used to control all or parts of Site 36. Remedial alternatives that leave soil on the site above the selected cleanup goal may include land use controls that either restrict future allowable land uses and/or restrict certain excavation/construction activities. This process option eliminates exposure to the contaminated soil by restricting future exposure at the site.

3.5.1.4 Capping

A capping process option (i.e., soil cover) for Site 36 would consist of placing compacted soil fill, with topsoil and vegetation on top of the compacted fill. The soil cover would reduce the potential for direct exposure to the contaminated soil and would minimize the potential for contaminant migration via surface water runoff and erosion. A soil cover does not prevent infiltration from precipitation. As contaminants do remain in the soil, permanent erosion controls are required as well as excavation restrictions.

For this process option, all soils exceeding cleanup criteria would be capped with a soil cover. Therefore, a capping alternative can be implemented for cleanup to residential or industrial remediation goals.

3.5.1.5 Excavation and Landfill Disposal

The excavation process option involves the removal of contaminated soil from the site to a location where human and ecological exposure pathways are significantly reduced. Post-excavation confirmatory sampling will be conducted to ensure the removal of PAHs and pesticides to the appropriate final cleanup levels and to ensure a complete removal action. It is anticipated that excavated soils can be disposed at the Base landfill.

3.5.1.6 Enhanced Natural Attenuation

This in-situ treatment action would be enhanced with the injection of a Hydrogen Release Compound (HRC) in order to accelerate the dechlorination of TCE and other detected VOCs in groundwater at Site 36. The release of hydrogen helps a population of reductive dechlorinating bacteria, naturally occurring in the aquifer, to degrade the VOCs. Post-injection monitoring would continue to ensure effectiveness of the treatment.

3.5.1.7 Monitored Natural Attenuation

A long-term groundwater monitoring program would be implemented at Site 36. In a monitored natural attenuation process, groundwater is monitored to track contaminant concentrations and natural attenuation parameters. This action is a monitoring program to provide continual information regarding groundwater contaminant concentrations and migration over time.

3.5.2 Site 43

3.5.2.1 No Action

The no action alternative will be considered for Site 43 for both soil and groundwater. The no action response provides a baseline for comparison with other response actions and the NCP requires that this alternative be evaluated. Under the no action response, the contaminated media at the site will be left in place. Passive remediation of organic contaminants (i.e., natural attenuation) may occur, but will be unmonitored. No active institutional controls or active remediation efforts would be implemented at the site if the no action alternative were selected.

3.5.2.2 Capping

A capping process option (i.e., soil cover) for Site 43 would consist of placing compacted soil fill, with topsoil and vegetation on top of the compacted fill. The soil cover would reduce the potential for direct exposure to the contaminated soil and would minimize the potential for contaminant migration via surface water runoff and erosion. A soil cover does not prevent infiltration due to precipitation. As contaminants do remain in the soil, permanent erosion controls are required as well as excavation restrictions.

For this process option at Site 43, all soils exceeding residential cleanup criteria would be capped with a soil cover.

3.5.2.3 Excavation and Landfill Disposal

The excavation process option involves the removal of contaminated soil from the site to a location where human and ecological exposure pathways are significantly reduced. Post-excavation confirmatory sampling will be conducted to ensure the removal of PAHs to the appropriate residential cleanup levels and to ensure a complete removal action. It is anticipated that excavated soils from Site 43 can be disposed at the Base landfill.

3.5.3 Site 44

3.5.3.1 No Action

The no action alternative will be considered for Site 44 for both soil and groundwater. The no action response provides a baseline for comparison with other response actions and the NCP requires that this alternative be evaluated. Under the no action response, the contaminated media at the site will be left in place. Passive remediation of organic contaminants (i.e., natural attenuation) may occur, but will be unmonitored. No active institutional controls or active remediation efforts would be implemented at the site if the no action alternative were selected.

3.5.4 Site 54

3.5.4.1 No Action

The no action alternative will be considered for Site 54 for both soil and groundwater. The no action response provides a baseline for comparison with other response actions and the NCP requires that this alternative be evaluated. Under the no action response, the contaminated media at the site will be left in place. Passive remediation of organic contaminants (i.e., natural attenuation) may occur, but will be unmonitored. No active institutional controls or active remediation efforts would be implemented at the site if the no action alternative were selected.

3.5.4.2 Land Use Restrictions

Land use controls are implemented to manage future land use or to restrict certain types of activities at a site. Examples of land use controls include aquifer use restrictions or deed restrictions that limit allowable land uses and/or place restrictions on certain intrusive activities (e.g., excavation, installation of wells, or construction) at the site. Land use controls can be used to control all or parts of Site 54. This process option eliminates exposure to the contaminated groundwater by restricting future exposure at the site.

3.5.4.3 Groundwater Monitoring

A long-term groundwater monitoring program would be implemented at Site 54 to track contaminant concentrations. This action is a monitoring program to provide continual information regarding groundwater contaminant concentrations and migration over time.

4.0 DEVELOPMENT AND SCREENING OF REMEDIAL ACTION ALTERNATIVES

In this phase of the FS, process options and remedial action technologies are combined to form potential remedial action alternatives (RAAs) for each individual site of OU No. 6. The RAA development process and a description of the developed RAAs for each site are presented in Sections 4.1 through 4.4.

4.1 Site 36

The future land use of Site 36 is not yet determined. Residential land use RAAs would allow for future land uses such as housing, schools, parks, marinas, and/or office building uses.

RAAs for Site 36 were developed to address localized areas of contamination by combining the remedial action technologies and process options selected for this site in Section 3.0. Three RAAs were developed to address soil contamination detected at Site 36. These include the no action RAA for soil and two residential land use RAAs for pesticide, PAH and lead contaminated soil. Three RAAs were developed to address groundwater contamination detected at Site 36. These include the no action RAA for groundwater and two natural attenuation RAAs for groundwater.

These RAAs represent a wide range of response actions, remediation goals, land use controls, and remediation costs. A summary table that presents a description, allowable land uses, land use controls required, and cleanup goals for each RAA is provided as Table 4-1.

Soil

4.1.1 36S RAA 1: No Action

Under the no action RAA, no physical remedial actions will be performed to reduce the toxicity, mobility, or volume of contaminants identified in soil at Site 36. In addition, no land use controls such as intrusive activity restrictions or land use restrictions will be implemented at the site. The no action alternative is required by the NCP to provide a baseline for comparison with other RAAs that provide a greater level of response.

Although this RAA does not involve physical remediation, remediation of the soil contamination is expected to occur over time via natural attenuation of contaminants. These processes include naturally occurring biodegradation, volatilization, dilution, leaching, adsorption, and chemical reactions between subsurface materials. Under the No Action RAA, however, no means are provided to monitor or confirm the natural remediation process.

Since contaminants will remain at Site 36 under this RAA, the NCP [40 CFR 300.430(f)(4)] requires the lead agency to review the effects of this alternative at least once every five years.

4.1.2 36S RAA 2: Capping and Institutional Controls for Lead Contaminated Areas

36S RAA 2 is recommended for residential future land uses such as housing, schools, parks, or office locations. This RAA includes capping of localized impacted PAH and pesticide areas. Institutional controls will be implemented at this site to minimize exposure to potential hazards from lead contamination in surface and subsurface soils. The remediation goal for this RAA is to cap the localized PAH and pesticide impacted areas. For estimating purposes in this FS, the USEPA Region IX Residential PRGs for PAHs and pesticides were used to calculate the capping areas (see Table 2-5). In addition, lead impacted areas above the EPA OSWER directive (400 ppm) will be restricted from intrusive activities and limited to future industrial land uses.

Under this RAA all localized impacted PAH and pesticide areas would be capped. The capping areas for this option can be seen in Figure 4-1.

The total area to be capped is approximately 0.23 acres. The soil cover will consist of 12 inches of clean backfill and six inches of topsoil. A soil cap will mitigate dermal exposure and will control erosion and migration of contaminated soil. However, a soil cap will not minimize surface water infiltration and therefore does not protect the groundwater. The cap will be contoured so as to control erosion and sedimentation, and will be compacted and vegetated with native grasses and plant species. Because the area at Site 36 is heavily vegetated, clearing may be necessary before capping can take place. It is assumed that clean backfill can be obtained from an on-Base borrow source and that topsoil will be purchased from an off-site source. The cap will be inspected periodically to ensure that integrity is maintained. Cap restoration will be performed, as needed, based upon inspection results. For costing purposes, it is assumed that inspections and maintenance will be conducted annually.

Following placement of the soil cap, all disturbed areas would be revegetated with native grasses and plant species to control erosion. Access roads or other infrastructure that are disturbed or destroyed in the capping process would be restored to original conditions.

Lead contamination at Site 36 is concentrated in soils in the southeastern portion of the site. The EPA residential action level for lead in soil is 400 ppm. Therefore, any sampling location exceeding this concentration will be designated for institutional controls for intrusive activities and to limit the site to future industrial land uses. There are only three surface soil locations with a lead concentration above this action level. The majority of the lead contamination is in subsurface soils. Figure 4-1 shows the areas to be designated for institutional controls for lead contamination at Site 36.

Because contaminated soil that poses a potential human health risk will remain at the site, land use controls will be required for this alternative. Land use controls will include restrictions on intrusive activities at the site (e.g., excavation, installation of wells, or construction) other than for monitoring or future remediation purposes. These restrictions will be implemented through modifications of the Base Master Plan and presented in the "Notice of Inactive Hazardous Waste Disposal Site" plat maps prepared for the Onslow County register of deeds. These restrictions will remain in place until it can be demonstrated that the remediation goals for lead are achieved.

4.1.3 36S RAA 3: Excavation and Off-Site Disposal and Institutional Controls for Lead Contaminated Areas

Under this RAA, all localized PAH and pesticide impacted soil would be excavated and removed. Institutional controls will be implemented at this site to minimize exposure to potential hazards from lead contamination in surface and subsurface soils. The remediation goal for this RAA is to remove the localized PAH and pesticide impacted areas. For estimating purposes in this FS, the USEPA Region IX Residential PRGs for PAHs and pesticides were used to calculate the excavation areas (see Table 2-5). In addition, lead impacted areas above the EPA OSWER directive (400 ppm) will be restricted from intrusive activities.

The excavation area for this option can be seen in Figure 4-2 and the total volume for site-wide excavation is approximately 950 cubic yards (CY). Prior to excavation, the contamination at Site 36 may need to be further delineated since the areas have not been sampled since the RI

in 1995. Because areas of Site 36 are heavily vegetated, clearing may be necessary before excavation can take place. Underground utility lines running parallel to the improved gravel road near the OF-SB03 sampling cluster will have to be located prior to excavation.

Confirmatory sampling will take place to ensure that all contaminants exceeding remediation goals have been excavated. The final remedial goals will be determined during the remedial action design phase. Samples will be analyzed for PAHs and pesticides. The excavated soils will be transported to the Base landfill for proper disposal.

Following the excavation operation, the site would be restored by placing clean backfill (assumed to be from an on-Base borrow area) to bring the site back to its original grade. All disturbed areas would be revegetated with native grasses and plant species to control erosion. Access roads or other infrastructure that are disturbed or destroyed in the excavation process would be restored to original conditions.

Lead contamination at Site 36 is concentrated in soils in the southeastern portion of the site. The EPA residential action level for lead in soil is 400 ppm. Therefore, any sampling location exceeding this concentration will be designated for institutional controls. There are only three surface soil locations with a lead concentration above this action level. The majority of the lead contamination is in subsurface soils. Figure 4-2 shows the areas to be designated for institutional controls for lead contamination at Site 36.

Institutional controls can be implemented at this site to minimize exposure to potential hazards from lead contamination in surface and subsurface soils at the site. Under this RAA, defining areas that will have land use controls placed on them will minimize exposure to contaminated soil. These controls include future use restrictions. Excavation restrictions (i.e., intrusive activities) will also be necessary. These restrictions will be implemented through modifications of the Base Master Plan and presented in the "Notice of Inactive Hazardous Waste Disposal Site" plat maps prepared for the Onslow County register of deeds. These restrictions will remain in place until it can be demonstrated that the remediation goals are achieved.

4.1.4 36GW RAA 1: No Action

Under the no action RAA, no physical remedial actions will be performed to reduce the toxicity, mobility, or volume of contaminants identified in the groundwater at Site 36. In addition, no land use controls such as aquifer use restrictions or land use restrictions will be implemented at the site. The no action alternative is required by the NCP to provide a baseline for comparison with other RAAs that provide a greater level of response.

Although this RAA does not involve physical remediation, remediation of the groundwater contamination is expected to occur over time via natural attenuation of contaminants. These processes include naturally occurring biodegradation, volatilization, dilution, leaching, adsorption, and chemical reactions between subsurface materials. Under the No Action RAA, however, no means are provided to monitor or confirm the natural remediation process.

Since contaminants will remain at Site 36 under this RAA, the NCP [40 CFR 300.430(f)(4)] requires the lead agency to review the effects of this alternative at least once every five years.

4.1.5 36GW RAA 2: Enhanced Natural Attenuation

Under 36GW RAA 2 for groundwater, a hydrogen releasing compound (HRC) will be injected into the groundwater to reduce the toxicity, mobility, and volume of the groundwater contaminants at Site 36. HRC is a slowly dissolving polymer that releases hydrogen to accelerate the reductive dechlorination of TCE contamination at Site 36. HRC has been used at many sites and is widely accepted. HRC can be injected into the ground using direct push methods, such as a Geoprobe, or injection wells. The site will be monitored by sampling monitoring wells to ensure that natural attenuation is occurring and to determine when the site has reached NCWQS cleanup goals.

Injection of HRC will enhance the natural attenuation of VOC contaminants in groundwater at Site 36. At Site 36, the following evidence suggests that natural attenuation processes are already successfully degrading the chlorinated solvent contamination in the surficial aquifer:

- PCE and TCE have been detected within the VOC plume in the northern area of Site 36 (Figure 4-3). In addition, the TCE daughter products (1,2-DCE and vinyl chloride) have also been detected at this location.

- PCE and TCE were not detected in soil samples collected from this area, suggesting that the source has degraded or migrated to the surficial aquifer.

- The locations and concentrations of the TCE, 1,2-DCE and vinyl chloride detections within the northern area of the site are positioned as to suggest that the daughter products are a direct result of the PCE and TCE degradation.

Based upon this information, natural attenuation appears to be effective for the chlorinated solvent contamination detected in the surficial aquifer. Therefore, the injection of a HRC will enhance what is naturally occurring and expedite the process.

A monitoring program will be implemented to include both groundwater and surface water sampling. The surface water samples will be analyzed for VOCs. Groundwater samples will be analyzed for VOCs as well as the following natural attenuation parameters: nitrate, sulfate, methane, ethane, ethene, and chloride. Additionally, field analysis will be conducted on groundwater samples to determine the levels of dissolved oxygen, iron II, alkalinity, oxidation-reduction potential (ORP), pH, temperature, conductivity and major cations. Over time, the results will be used to analyze the natural attenuation process and the level of contaminant reduction that has occurred.

Site 36 is currently sampled quarterly to determine if contaminants detected during the RI have migrated, degraded through natural processes, or remain on site. The most recent sampling event took place in April, 2002 (Table 1-1). Results from recent quarterly monitoring events are detailed in the 2001 Annual Report and Table 1-1.

Figure 4-3 identifies the existing wells that will be used to monitor both VOCs and the natural attenuation parameters previously mentioned. Shallow and intermediate wells will monitor concentrations in the surficial aquifer, while the deep well will monitor the Castle Hayne aquifer to ensure that contaminates have not migrated vertically. Should additional sampling locations become necessary, they will be added to the monitoring program. If the analytical results indicate

that the groundwater quality has improved, the program may be modified to include fewer sampling locations or less frequent sampling events. However, for cost estimating purposes, two years of semi-annual sampling is assumed.

36GW RAA 2 includes aquifer use restrictions to prohibit future use of the aquifers within 1,000 feet of the VOC plume. These restrictions prevent the aquifers from being used as a potable water source. In addition, an intrusive activity boundary will also be included for the VOC plume area. These restrictions will be implemented through modifications of the Base Master Plan and presented in the "Notice of Inactive Hazardous Waste Disposal Site" plat maps prepared for the Onslow County register of deeds. These restrictions will remain in place until it can be demonstrated that the remediation goals are achieved.

Until remediation levels are met, the NCP [40 CFR 300.430(f)(4)] requires that the lead agency review the effects of this alternative at least once every five years.

4.1.6 36GW RAA 3: Monitored Natural Attenuation

Under 36GW RAA 3, no physical remedial actions will be conducted to reduce the toxicity, mobility, or volume of the groundwater contaminants at Site 36. The in-situ, naturally occurring biodegradation, dispersion, dilution, adsorption, volatilization, and chemical or biological stabilization/destruction of the VOCs in groundwater is expected in the form of natural attenuation. The term "natural attenuation" refers to the "naturally occurring processes in...groundwater environments that act without human intervention to reduce the mass, toxicity, mobility, volume, or concentration of contaminants in these media" (Weidemeier 1996).

Biodegradation may occur as an aerobic, anaerobic, or cometabolic processes. Aerobic processes involve oxidation-reduction reactions in which oxygen is the electron receptor. Anaerobic processes involve iron-reducing, denitrifying, and sulfate-reducing reactions. Cometabolic processes involve dioxide-reducing reactions and result in the accumulation of methane as the final product. Technical literature indicates that chlorinated solvent contamination can undergo natural attenuation through one or a combination of the biodegradation processes mentioned.

Based upon the information presented in Section 4.1.5, the natural attenuation alternative appears to be a feasible and reasonable remedial option for the chlorinated solvent contamination detected in the surficial aquifer.

The primary component of 36GW RAA 3 is a long-term monitoring (LTM) program. Similar to the plan identified under 36GW RAA 2, the monitoring program for 36GW RAA 3 will include both groundwater and surface water sampling. Surface water samples will be analyzed for VOCs, while groundwater samples will include laboratory analysis of the following parameters: VOCs, nitrate, sulfate, methane, ethane, ethene, and chloride. Additionally, field analysis will be conducted on groundwater samples to determine the levels of oxygen, iron II, alkalinity, ORP, pH, temperature, conductivity and major cations. Collection and review of the analytical results will indicate the type and degree of bioremediation that is occurring (i.e., aerobic, iron-reducing, denitrifying, sulfate-reducing, or methanogenic). Over time, the results will be used to analyze the natural attenuation process and the level and rate of contaminant reduction that has occurred, as well as to predict the rate of contaminant reduction that is expected.

Figure 4-4 identifies the wells that will be used to monitor both VOCs and the natural attenuation parameters mentioned in the previous paragraph. For this RAA, three new shallow wells and four new intermediate wells will be installed. Shallow and intermediate wells will monitor concentrations in the surficial aquifer, while the deep well will monitor the Castle Hayne aquifer to ensure that contaminants have not migrated vertically. Should additional sampling locations become necessary, they will be added to the monitoring program. If the analytical results indicate that the groundwater quality has improved, the program may be modified to include fewer sampling locations or less frequent sampling events. However, for cost estimating purposes, 4 years of semiannual sampling is assumed followed by 6 years of annual sampling for a total of 10 years of monitoring.

Site 36 is currently sampled quarterly to determine if contaminants detected during the RI have migrated, degraded through natural processes, or remain on site. The most recent sampling event took place in April, 2002 (Table 1-1). Results from recent quarterly monitoring events are detailed in the 2001 Annual Report and Table 1-1.

36GW RAA 3 includes aquifer use restrictions to prohibit future use of the aquifers within 1,000 feet of the VOC plume. These restrictions prevent the aquifers from being used as a potable water source. In addition, an intrusive activity boundary will also be included for the VOC plume area. These restrictions will be implemented through modifications of the Base Master Plan and presented in the "Notice of Inactive Hazardous Waste Disposal Site" plat maps prepared for the Onslow County register of deeds. These restrictions will remain in place until it can be demonstrated that the remediation goals are achieved.

Until remediation levels are met, the NCP [40 CFR 300.430(f)(4)] required that the lead agency review the effects of this alternative at least once every five years.

4.2 Site 43

RAAs for Site 43 were developed by combining the remedial action technologies and process options selected for the site in Section 3.0. Three RAAs were developed to address soil contamination detected at Site 43. These include the no action RAA for soil and two RAAs to address localized areas of soil contamination. The no action RAA for groundwater is presented in Section 4.2.4.

These RAAs represent a wide range of response actions, remediation goals, land use controls, and remediation costs. A summary table that presents a description, allowable land uses, land use controls required, and cleanup goals for each RAA is provided as Table 4-1.

4.2.1 43S RAA 1: No Action

Under the no action RAA, no physical remedial actions will be performed to reduce the toxicity, mobility, or volume of contaminants identified in soil at Site 43. In addition, no land use controls such as aquifer use restrictions or land use restrictions will be implemented at the site. The no action alternative is required by the NCP to provide a baseline for comparison with other RAAs that provide a greater level of response.

Although this RAA does not involve physical remediation, remediation of the soil contamination is expected to occur over time via natural attenuation of contaminants. These processes include naturally occurring biodegradation, volatilization, dilution, leaching, adsorption, and chemical reactions between subsurface materials. Under the No Action RAA, however, no means are provided to monitor or confirm the natural remediation process.

Since contaminants will remain at Site 43 under this RAA, the NCP [40 CFR 300.430(f)(4)] requires the lead agency to review the effects of this alternative at least once every five years.

4.2.2 43S RAA 2: Capping

43S RAA 2 is recommended for future residential land uses such as housing, schools, parks, or office locations. The remediation goal for this RAA is to remove the localized PAH impacted areas. For estimating purposes in this FS, the USEPA Region IX Residential PRGs for PAHs were used to calculate the capping areas (see Table 2-10).

Under this RAA all localized areas of PAH contamination would be capped. The areas to be capped for this RAA can be seen in Figure 4-5.

The total area to be capped is approximately 0.16 acres. The soil cover will consist of 12 inches of clean backfill and six inches of topsoil. A soil cap will mitigate dermal exposure and will control erosion and migration of contaminated soil. However, a soil cap will not minimize surface water infiltration and therefore does not protect the groundwater. The cap will be contoured so as to control erosion and sedimentation, and will be compacted and vegetated with native grasses and plant species. It is assumed that clean backfill can be obtained from an on-Base borrow source and that topsoil will be purchased from an off-site source. The cap will be inspected periodically to ensure that integrity is maintained. Cap restoration will be performed, as needed, based upon inspection results. For costing purposes, it is assumed that inspections and maintenance will be conducted annually.

Following placement of the soil cap, all disturbed areas would be revegetated with native grasses and plant species to control erosion. Access roads or other infrastructure that are disturbed or destroyed in the capping process would be restored to original conditions.

Because contaminated soil that poses a potential human health risk will remain at the site, land use controls will be required for this alternative. Land use controls will include restrictions on intrusive activities at the site (e.g., excavation, installation of wells, or construction) other than for monitoring or future remediation purposes. These restrictions will be implemented through modifications of the Base Master Plan and presented in the "Notice of Inactive Hazardous Waste Disposal Site" plat maps prepared for the Onslow County register of deeds. These restrictions will remain in place until it can be demonstrated that the remediation goals are achieved.

4.2.3 43S RAA 3: Excavation and Off-Site Disposal

For 43S RAA 3, all localized areas of PAH contamination would be excavated and removed. The excavation area for this option can be seen in Figure 4-6 and the total volume for site-wide excavation is approximately 750 CY.

Confirmatory sampling will take place to ensure that all contaminants exceeding screening criteria have been excavated. Samples will be analyzed for PAHs. The excavated soils will be transported to the Base landfill for proper disposal.

Following the excavation operation, the site would be restored by placing clean backfill (assumed to be from an on-Base borrow area) to bring the site back to it's original grade. All disturbed areas would be revegetated with native grasses and plant species to control erosion. Access roads or other infrastructure that are disturbed or destroyed in the excavation process would be restored to original conditions.

Groundwater

4.2.4 43GW RAA 1: No Action

Under the no action RAA, no physical remedial actions will be performed to reduce the toxicity, mobility, or volume of contaminants identified in groundwater at Site 43. In addition, no land use controls such as aquifer use restrictions or land use restrictions will be implemented at the site.

At Site 43, inorganics (particularly iron and manganese) were the most prevalent and widely distributed constituent detected. Although some samples exceeded the NCWQS, iron and manganese are naturally occurring and are often found in high concentrations throughout MCB, Camp Lejeune. It is unlikely that these inorganics are a result of previous site practices. Also, 4-methylphenol was detected at 2 µg/L in a sample from temporary monitoring well 43-TW04. This is less than the NCWQS interim standard of 3.5 µg/L. No other organic compounds were detected among groundwater samples. Therefore, groundwater at the site requires no further action.

Since contaminants will remain at Site 43 under this RAA, the NCP [40 CFR 300.430(f)(4)] requires the lead agency to review the effects of this alternative at least once every five years.

4.3 Site 44

Two RAAs were developed to address soil and groundwater at Site 44. These are the no action RAA for soil and groundwater. Since soil and groundwater detections are below remediation goals, there is no need for further remedial action at this site. A summary table for each RAA is provided as Table 4-1.

Soil

4.3.1 44S RAA 1: No Action

Under the no action RAA, no physical remedial actions will be performed to reduce the toxicity, mobility, or volume of contaminants identified in soil at Site 44. In addition, no land use controls such as aquifer use restrictions or land use restrictions will be implemented at the site. The no action alternative is required by the NCP to provide a baseline for comparison with other RAAs that provide a greater level of response.

Although this RAA does not involve physical remediation, remediation of the soil contamination is expected to occur over time via natural attenuation of contaminants. These processes include naturally occurring biodegradation, volatilization, dilution, leaching, adsorption, and chemical reactions between subsurface materials. Under the No Action RAA no means are provided to monitor or confirm the natural remediation process.

Since contaminants will remain at Site 44 under this RAA, the NCP [40 CFR 300.430(f)(4)] requires the lead agency to review the effects of this alternative at least once every five years.

Groundwater

4.3.2 44GW RAA 1: No Action

Under the no action RAA, no physical remedial actions will be performed to reduce the toxicity, mobility, or volume of contaminants identified in groundwater at Site 44. In addition, no land use controls such as aquifer use restrictions or land use restrictions will be implemented at the site.

At Site 44 there were 11 detections of VOCs and SVOCs, however only one exceeded standards. Temporary monitoring well 44-TW01 had a concentration of vinyl chloride of 10 µg/L which exceeds the NCWQS of 0.015 µg/L. Vinyl chloride was not detected in any other monitoring wells on site, only in surface water samples. This temporary well was installed in a low lying area and it is thought that contaminants may have migrated from the surface water to the groundwater during periods of seasonal flooding. There were many exceedences of the inorganics iron and manganese throughout the site. However, these inorganics are considered to be naturally occurring and not attributed to past site operations. Therefore, groundwater at this site requires no further action.

Since contaminants will remain at Site 44 under this RAA, the NCP [40 CFR 300.430(f)(4)] requires the lead agency to review the effects of this alternative at least once every five years.

4.4 Site 54

RAAs were developed by combining the remedial action technologies and process options selected for Site 54 in Section 3.0. Three RAAs were developed to address soil and groundwater at Site 54. These include the no action RAAs for soil and groundwater and a monitoring alternative to address lead contamination in groundwater. A summary table that presents a description, allowable land uses, land use controls required, and cleanup goals for each RAA is provided as Table 4-1.

Soil

4.4.1 54S RAA 1: No Action

Under the no action RAA, no physical remedial actions will be performed to reduce the toxicity, mobility, or volume of contaminants identified in soil at Site 54. In addition, no land use controls or land use restrictions will be implemented at the site.

In April 2001, a soil removal action was completed at the Crash Crew Fire Training Burn Pit at Site 54. A total of 4,960 cubic yards (6,461 tons) of PAH impacted soils were excavated, managed and disposed of during the project. Confirmatory soil samples were collected from the walls of the excavation at eight locations. One sample of groundwater at the bottom of the excavation was also collected. Each sample was analyzed for PAHs and all of the samples were non detect for PAHs (OHM, 2001).

Following the removal action, no contaminants exceed cleanup goals of North Carolina Soil to Groundwater criteria in soil at Site 54. Therefore, no further remedial action is needed to address soil contamination at the site.

Groundwater

4.4.2 54GW RAA 1: No Action

Under the no action RAA, no physical remedial actions will be performed to reduce the toxicity, mobility, or volume of contaminants identified in groundwater at Site 54. In addition, no land use controls such as aquifer use restrictions or land use restrictions will be implemented at the site.

Although this RAA does not involve physical remediation, remediation of the groundwater contamination may occur over time via natural attenuation of contaminants. These processes include naturally occurring biodegradation, volatilization, dilution, leaching, adsorption, and chemical reactions between subsurface materials. Under the No Action RAA, however, no means are provided to monitor or confirm the dilution of lead in the aquifer.

Since contaminants will remain at Site 54 under this RAA, the NCP [40 CFR 300.430(f)(4)] requires the lead agency to review the effects of this alternative at least once every five years.

4.4.3 54GW RAA2: Institutional Controls and Monitoring

Under 54GW RAA 2, no physical remedial actions will be conducted to reduce the toxicity, mobility, or volume of the groundwater contaminants at Site 54. Dilution or dispersion of the lead may occur in the aquifer as the contaminant source was removed during the April 2001 removal action.

The primary component of 54GW RAA 2 is a monitoring program. The monitoring program for this RAA will include only groundwater sampling. Groundwater samples will include laboratory analysis of lead. During the RI in 1995, only one groundwater sample exceeded the NCWQS of 15µg/L for lead. This was in monitoring well 54-GW02 at a concentration of 39.7 µg/L. It is possible that lead in the groundwater has already diluted to meet State standards. However, groundwater monitoring will be implemented to confirm this theory and to demonstrate four quarters of sampling with no exceedences of the NCWQS standards.

Figure 4-7 identifies the well (54-GW02) that will be used to monitor lead concentrations. For this RAA, one existing well will be sampled. For cost estimating purposes, 1 year of quarterly sampling is assumed followed by 1 year of semi-annual sampling for a total of 2 years of monitoring.

Site 54 is currently sampled quarterly to determine if contaminants detected during the RI have migrated, degraded through natural processes, or remain on site. The most recent sampling event took place in April, 2002. Results from recent quarterly monitoring events are detailed in the 2001 Annual Report and in Table 1-6.

54GW RAA 2 includes aquifer use restrictions to prohibit future use of the aquifer within 1,000 feet of the lead plume. These restrictions prevent the aquifer from being used as a potable water source. In addition, an intrusive activity boundary will also be included for the lead plume area. These restrictions will be implemented through modifications of the Base Master Plan and presented in the "Notice of Inactive Hazardous Waste Disposal Site" plat maps prepared for the Onslow County register of deeds. These restrictions will remain in place until it can be demonstrated that the remediation cleanup goals are achieved.

Until remediation levels are met, the NCP [40 CFR 300.430(f)(4)] requires that the lead agency review the effects of this alternative at least once every five years.

4.5 Screening of Remedial Action Alternatives

Typically, this section of the FS presents the initial screening of the potential RAAs. The objective of this screening is to make comparisons between similar alternatives so that only the most promising ones are carried through for further evaluation (USEPA, 1988). This screening is

an optional step in the FS process and is usually conducted if there are too many RAAs to carry through to detailed evaluations. In order to preserve a wide range of possible options for LANTDIV and the Base to consider, further screening of alternatives was not conducted. Every alternative for each individual site will be carried forward for the detailed evaluation.

5.0 DETAILED ANALYSIS OF REMEDIAL ACTION ALTERNATIVES

This section presents the detailed analysis of the remedial action alternatives that were developed in Section 4.0. Section 5.1 presents an overview of evaluation criteria that will be used in the detailed analysis. Sections 5.2 through 5.5 present the individual analyses of remedial action alternatives, and the comparative analysis of remedial action alternatives, for each individual site.

This detailed analysis has been conducted to provide sufficient information to compare the alternatives, select an appropriate remedy for the sites, and demonstrate satisfaction of the CERCLA remedy selection requirements in the Record of Decision (ROD). The extent to which alternatives are assessed during the detailed analysis is influenced by the available data, the number and types of alternatives being analyzed, and the degree to which alternatives were previously analyzed during their development and screening (USEPA, 1988).

The detailed analysis of alternatives was conducted in accordance with the "Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA" (USEPA, 1988) and the NCP, including the February 1990 revisions. In conformance with the NCP, seven of the following nine criteria were used for the detailed analysis:

- Overall protection of human health and the environment
- Compliance with ARARs
- Long-term effectiveness and permanence
- Reduction of toxicity, mobility, or volume through treatment
- Short-term effectiveness
- Implementability
- Cost
- State acceptance (not evaluated at this time)
- Community acceptance (not evaluated at this time)

State acceptance and community acceptance will be evaluated in the ROD by addressing comments received after the NC DENR (State) and the Restoration Advisory Board ([RAB] public representatives) have reviewed the FS and Proposed Remedial Action Plan (PRAP).

5.1 Overview of Evaluation Criteria

The following paragraphs describe the evaluation criteria that are used in the detailed analysis.

Overall Protection of Human Health and the Environment: Overall protection of human health and the environment is the primary criteria that a remedial action must meet. A remedy is considered protective if it adequately eliminates, reduces, or controls all current and potential site risks posed through each exposure pathway at the site. A site where hazardous substances remain without engineering or institutional controls allows for unlimited exposure for human and environmental receptors. Adequate engineering controls, institutional controls, or some combination of the two, can be implemented to control exposure and thereby ensure reliable protection over time. In addition, implementation of a remedy cannot result in unacceptable short-term risks or cross-media impacts on human health and the environment.

Compliance with Applicable or Relevant and Appropriate Requirements (ARARs): Compliance with ARARs is one of the statutory requirements for remedy selection. Alternatives are developed and refined throughout the FS process to ensure that they will meet all ARARs or that there is a sound rationale for waiving an ARAR. During the detailed analysis, the alternatives will be analyzed based on federal and state contaminant-specific, action-specific, and location-specific ARARs that were presented in Section 2.0 of this FS.

Long-Term Effectiveness and Permanence: This criterion reflects CERCLA's emphasis on implementing remedies that will ensure protection of human health and the environment over the long term. In evaluating alternatives for their long-term effectiveness and the degree of permanence they afford, the analysis will focus on the residual risks present at the site after the completion of the remedial action. The analysis will also include consideration of the following:

- Degree of threat posed by the hazardous substances remaining at the site.
- Adequacy of any controls (e.g., engineering and institutional controls) used to manage the hazardous substances remaining at the site.
- Reliability of those controls.

- Potential impacts on human health and the environment, should the remedy fail, based on assumptions included in the reasonable maximum exposure scenario.

Reduction of Toxicity, Mobility, or Volume Through Treatment: This criterion addresses the statutory preference for remedies that employ treatment as a principal element. The criterion ensures that the relative performance of the various treatment alternatives in reducing the toxicity, mobility, or volume will be assessed. Specifically, the analysis will examine the magnitude, significance, and irreversibility of reductions.

Short-Term Effectiveness: This criterion examines the short-term impacts associated with implementing the alternative. For example, implementation may impact the neighboring community, workers, or the surrounding environment. Short-term effectiveness also includes potential threats to human health and the environment associated with the excavation, treatment, and transportation of hazardous substances, the potential cross-media impacts of the remedy, and the time required to achieve protection of human health and the environment. Potential disruption of ecosystems must also be considered.

Implementability: Implementability considerations include the technical and administrative feasibility of the alternatives, as well as the availability of goods and services (including treatment, storage, or disposal capacity) associated with the alternative. Implementability considerations often affect the timing of remedial actions (e.g., limitations on the season in which the remedy can be implemented, the number and complexity of material handling steps, and the need to secure technical services). On-site activities must comply with the substantive portions of applicable permitting regulations.

Cost: Implementation costs include all capital costs and annual operation and maintenance (O&M) costs incurred over the life of the project. The focus during the detailed analysis is on the present worth of these costs. Costs are used to select the most cost-effective alternative that will achieve the remedial action objectives. In accordance with USEPA guidance (USEPA, 1988), the cost estimates will have an accuracy of -30 to +50 percent. The exact accuracy of each cost estimate depends upon the assumptions made and the availability of costing information. The net present worth costs are calculated assuming a five percent discount factor and a zero percent inflation rate.

State Acceptance: This criterion reflects the statutory requirement to provide for state involvement. For this project, and other MCB Camp Lejeune projects, state involvement is achieved throughout the remedial process through Partnering activities. State comments will be addressed during the development of the FS, the PRAP, and the ROD, as appropriate.

Community Acceptance: This criterion addresses the community's comments on the remedial alternatives under consideration, where "community" is broadly defined to include all interested parties. Community comments are taken into account throughout the remedial process during periodic RAB meetings; however, formal public comment will not be received until after the public comment period for the PRAP.

5.2 Site 36

5.2.1 Individual Analysis of Alternatives

The following subsections present the detailed analysis of RAAs for Site 36 on an individual basis. This individual analysis includes a brief description of each RAA followed by an assessment of how well the RAA performs against the evaluation criteria.

Soil

5.2.1.1 36S RAA 1: No Action

Under the no action alternative, soil at Site 36 will remain as is. No physical remedial actions will be implemented.

Overall Protection of Human Health and the Environment: Under 36S RAA 1, no physical remedial actions will be implemented to control potential exposure pathways or to reduce contaminant concentrations in soils. As a result, there will be no measurable reduction in potential human health or environmental risks.

Compliance with ARARs: Under 36S RAA 1, no active effort will be made to reduce contaminant levels to below federal and state chemical-specific ARARs. Over an indefinite period of time, however, passive remediation, in the form of natural attenuation processes, may reduce PAH,

pesticide and lead levels to below ARARs. No action-specific or location-specific ARARs apply to the no action alternative. Because contaminants will remain on site at levels exceeding requirements established by ARARs, 36S RAA 1 will require five-year reviews to ensure that adequate protection of human health and the environment is maintained.

Long-Term Effectiveness and Permanence: Under the no action alternative, any long-term or permanent effect on contaminant levels will depend on the effectiveness of natural attenuation. The extent to which natural attenuation may reduce contaminant levels, and the time it will take, are difficult to predict.

Reduction of Toxicity, Mobility, or Volume through Treatment: The no action alternative does not provide physical treatment processes for toxicity, mobility, or volume reduction of contaminated soil or sediment. Although passive treatment processes (i.e., natural attenuation) may eventually provide toxicity and volume reduction of the contaminated soil and sediments, the extent to which natural attenuation may reduce contaminant toxicity and volume is difficult to predict. Although 36S RAA 1 provides no means of measurement, this alternative may in time satisfy the statutory preference for treatment through natural attenuation.

Short-Term Effectiveness: As there are no physical remedial action activities associated with 36S RAA 1, there are no increased short-term potential risks to workers or the community. Also, there will be no additional short-term environmental impacts.

Implementability: The no action alternative is easily implemented since no additional construction or operation activities will be conducted. In terms of administrative feasibility, 36S RAA 1 should not require additional coordination with other agencies, although a waiver of the state ARARs may be required since contaminants exceeding these ARARs will be left on-site indefinitely. The availability of services, materials, and/or technologies is not applicable to this alternative.

Cost: There are no capital costs or O&M costs associated with this alternative. Therefore, the net present worth (NPW) is $0.

5.2.1.2 36S RAA 2:Capping and Institutional Controls for Lead Contaminated Areas

In 36S RAA 2, localized areas of PAH and pesticide contamination will be capped (Figure 4-1). At completion, these areas would be designated for residential land use. Land use controls will be implemented, however, as contaminants will remain on site. Exposure to lead contamination on site would also be controlled. Areas of lead contamination in soil greater than the EPA action level of 400 ppm would be restricted via institutional controls. This includes future land use restrictions and excavation restrictions.

Overall Protection of Human Health and the Environment: 36S RAA 2 involves capping of contaminated soils, therefore, this RAA will reduce potential risks to human health and the environment. The capping alternative will prevent human and ecological receptors from coming into contact with PAH and pesticide soil contaminants. These localized areas of contamination will be covered with one foot of clean backfill and 6 inches of topsoil. With proper maintenance of the soil cover, human health and the environment will be protected under this alternative. Institutional controls will include excavation restrictions that will be implemented at the site to protect the cap against possible intrusive activities.

This RAA also provides institutional controls that reduce potential risks to human health and the environment from exposure to lead contaminated areas. In designating areas for land use controls, the exposure pathways for lead at this site are controlled. Therefore, potential residential receptors are appropriately protected because institutional controls limit future land use to industrial uses such as a non-office warehouse, equipment storage area, or electrical substation. As contaminated soils may remain on site, excavation restrictions will be implemented at the site to prevent possible exposure to contaminated soil during intrusive activities.

Compliance With ARARs: Chemical-specific ARARs will be met in this alternative. Localized areas of PAH and pesticide contamination will be capped, and areas of soil contamination that exceed the EPA residential directive of 400 ppm will be protected via institutional controls. Several potential location-specific and action-specific ARARs identified for this site may be applicable or relevant and appropriate under this RAA because the alternative may include earth moving and capping activities and because the alternative includes contaminants that will remain on site. Activities at the site will be implemented such that all ARAR requirements are met.

Long-Term Effectiveness and Permanence: A soil cover will be effective for protecting human health and the environment in the long term if the cap is properly maintained. The soil cover will prevent human and ecological exposure to contaminated soils provided that the soil cover is properly installed and maintained. Capping will have a lower level of long-term effectiveness than excavation, but is appropriate for the low levels of contamination found at this site.

Land use controls would restrict future intrusive activities (e.g., excavation, installation of wells, or construction, other than for future remediation purposes) and the site would be restricted to future industrial land uses in the lead contaminated areas. These restrictions would be permanent.

Reduction of Toxicity, Mobility, or Volume Through Treatment: The toxicity of contaminants will not be reduced by this alternative because the contaminants will not be transformed into less toxic forms or destroyed by any physical, chemical, or thermal process. Although capping is not a treatment technology, the toxicity of Site 36 soil will be reduced because receptor pathways will be reduced. The mobility of contaminants will be reduced because the soil cover will prevent wind and water erosion, thereby preventing contaminated soil from migrating via sedimentation and erosion processes. However, soluble contaminants could leach due to infiltration of rainwater through the soil cover.

Institutional controls will also not reduce the toxicity, mobility, or volume of contaminants through treatment because land use and excavation restrictions are not treatment technologies. However, reduction of exposure pathways to the soil will eliminate the availability of contaminants to human or ecological receptors. There will be a reduction in mobility of contaminants that exceed clean-up goals at the site because contaminated soils will be restricted from invasive activities that may cause contaminant exposure or migration. The volume of the contaminated soil at the site will not be reduced because the soil will remain on the site. Therefore, the mobility and toxicity of contaminants at the site will be reduced, even though the contaminated soil itself will not be affected through treatment.

Short-Term Effectiveness: In the short-term, construction workers and ecological receptors may be exposed to disturbed contaminated soils. Exposure to human health and the environment will be minimized by the proper use of personal protective equipment, erosion and sediment control measures, and dust controls. Ecological habitats may be destroyed through clearing, however the area will be revegetated and habitats will be restored. It is estimated that the capping can be

implemented in less than one year, however revegtation may take longer to establish pre-capping conditions. Upon completion, this alternative will be effective for protecting human health and the environment.

Implementability: This alternative is easily implemented because no active treatment technologies will be used. Prior to capping, the site may need to be cleared as it is heavily vegetated in some areas. Commonly used earth moving equipment and site work procedures will be employed to place, contour and seed the clean backfill and topsoil.

Cost: Estimated capital and O&M costs for 36S RAA 2 are presented on Table 5-1. The estimated total net present worth cost for 36S RAA 2 is $188,000.

5.2.1.3 36S RAA 3: Excavation and Off-Site Disposal and Institutional Controls for Lead Contaminated Areas

36S RAA 3 involves the excavation of localized areas of PAH and pesticide contamination (Figure 4-2). Confirmatory sampling will take place to ensure that all contaminants exceeding remediation goals have been excavated. Samples will be analyzed for pesticides and PAHs. Excavated soils would be transported the Base landfill for proper disposal. Following the excavation operation, the site would be restored to pre-excavation conditions by revegetating the excavation areas.

Land use controls will be implemented, however, as contaminants will remain on site. Pathways to exposure of lead contamination on site would also be controlled. Areas of lead contamination in soil greater than the EPA action level of 400 ppm would be designated with institutional controls. This includes future land use restrictions and excavation restrictions.

Overall Protection of Human Health and the Environment: Because 36S RAA 3 involves excavation and off-site disposal of contaminated soils, this RAA will reduce potential risks to human health and the environment. Exposure pathways are eliminated with the site-wide excavation of contaminants that exceed residential cleanup levels. Ecological risk will also be eliminated in areas of the site that are excavated.

This alternative also provides institutional controls that reduce potential risks to human health and the environment. In designating areas for land use controls, the exposure pathways for lead exceeding residential land use criteria for this site are controlled. Therefore, potential residential receptors are appropriately protected because institutional controls limit future land use in lead contaminated areas to industrial uses. As contaminated soils remain on site, excavation restrictions will be implemented at the site to prevent possible exposure to contaminated soil during intrusive activities.

Compliance With ARARs: In 36S RAA 3, localized areas of PAH and pesticide contamination are removed from the site. Several potential location-specific and action-specific ARARs identified for this site will be applicable or relevant and appropriate under this RAA because the alternative includes earth moving, transport, and disposal activities.

Chemical-specific ARARs will also be met through institutional controls because areas of soil contamination that exceed the OSWER directive for lead will be designated with intrusive activity controls. Several potential location and action-specific ARARs identified for this site will be applicable or relevant and appropriate under this RAA because the alternative includes contaminants that will remain on site. Activities at the site will be implemented such that all ARAR requirements will be met.

Long-Term Effectiveness and Permanence: The excavation and disposal alternative will be an effective and permanent remedial action. The contaminated soil will be removed from the site and placed in an off-site disposal facility where contact with human and ecological receptors will be eliminated. This alternative will be effective in the long-term because PAH and pesticide contamination will be permanently removed from Site 36 and will no longer pose a potential risk to human health or the environment. Land use controls for lead would restrict future intrusive activities (e.g., excavation, installation of wells, or construction, other than for future remediation purposes) and the site would be restricted to future industrial land uses in lead contaminated areas. These restrictions would be permanent.

Reduction of Toxicity, Mobility, or Volume through Treatment: Neither toxicity, mobility, nor volume of contaminants will be reduced through treatment of this alternative because no treatment technologies will be used. However, the physical removal of the soil will eliminate the availability of contaminants to human or ecological receptors. Similarly, there will be no

mobility of contaminants that exceed cleanup goals at the site because they will be removed. The volume of the contaminated soil will not be reduced, but the soil will be removed from the site. Therefore, the volume, mobility, and toxicity of PAH and pesticide contaminants at the site will be reduced, even though the contaminated soil itself will not be treated.

Institutional controls will not reduce the toxicity, mobility, or volume of contaminants through treatment because land use and excavation restrictions are not treatment technologies. However, reduction of exposure pathways to the soil will eliminate the availability of contaminants to human or ecological receptors. There will be a reduction in mobility of contaminants that exceed clean-up goals at the site because contaminated soils will be restricted from invasive activities that may cause contaminant exposure or migration. The volume of the contaminated soil at the site will not be reduced because the soil will remain on the site. Therefore, the mobility and toxicity of contaminants at the site will be reduced, even though the contaminated soil itself will not be affected through treatment.

Short-Term Effectiveness: In the short-term, construction workers and ecological receptors may be exposed to disturbed contaminated soil. Exposures to human health and the environment will be minimized by the proper use of personal protective equipment, erosion and sediment control measures, and dust controls. This alternative can be implemented in less than one year. Upon completion, this alternative will be effective for protecting human health and the environment.

Implementability: This alternative is easily implemented because no active treatment technologies will be used. The excavation areas may need to be cleared prior to excavation due to heavy vegetation at the site. Also, underground utility lines will need to be located prior to excavation. Commonly used earth moving equipment and site work procedures will be employed to excavate and transport contaminated soil and to place, contour, and seed the clean backfill and topsoil.

Cost: Estimated capital and O&M costs for 36S RAA 3 are presented on Table 5-2. The estimated total net present worth cost for 36S RAA 3 is $200,000.

Groundwater

5.2.1.4 36GW RAA 1: No Action

Under the no action alternative, groundwater at Site 36 will remain as is. No physical remedial actions will be implemented.

Overall Protection of Human Health and the Environment: Under 36GW RAA 1, no physical remedial actions will be implemented to control potential exposure pathways or to reduce contaminant concentrations in groundwater. As a result, there will be no measurable reduction in potential human health or environmental risks.

Compliance with ARARs: Under 36GW RAA 1, no active effort will be made to reduce contaminant levels to below federal and state chemical-specific ARARs. Over an indefinite period of time, however, passive remediation, in the form of natural attenuation processes, may reduce VOC levels to below ARARs. No action-specific or location-specific ARARs apply to the no action alternative. Because contaminants will remain on site at levels exceeding requirements established by ARARs, 36GW RAA 1 will require five-year reviews to ensure that adequate protection of human health and the environment is maintained.

Long-Term Effectiveness and Permanence: Under the no action alternative, any long-term or permanent effect on contaminant levels will depend on the effectiveness of natural attenuation. The extent to which natural attenuation may reduce contaminant levels, and the time it will take, are difficult to predict.

Reduction of Toxicity, Mobility, or Volume through Treatment: The no action alternative does not provide physical treatment processes for toxicity, mobility, or volume reduction of contaminated groundwater. Although passive treatment processes (i.e., natural attenuation) may eventually provide toxicity and volume reduction of the contaminated groundwater, the extent to which natural attenuation may reduce contaminant toxicity and volume is difficult to predict. Although 36GW RAA 1 provides no means of measurement, this alternative may in time satisfy the statutory preference for treatment through natural attenuation.

Short-Term Effectiveness: As there are no physical remedial action activities associated with 36GW RAA 1, there are no increased short-term potential risks to workers or the community. Also, there will be no additional short-term environmental impacts.

Implementability: The no action alternative is easily implemented since no additional construction or operation activities will be conducted. In terms of administrative feasibility, 36GW RAA 1 should not require additional coordination with other agencies, although a waiver of the state ARARs may be required since contaminants exceeding these ARARs will be left on-site indefinitely. The availability of services, materials, and/or technologies is not applicable to this alternative.

Cost: There are no capital costs or O&M costs associated with this alternative. Therefore, the net present worth (NPW) is $0.

5.2.1.5 36GW RAA 2: Enhanced Natural Attenuation

Overall Protection of Human Health and the Environment: Under 36GW RAA 2, HRC will be injected into the surficial aquifer to expedite the natural attenuation process and reduce groundwater contamination. Treatment via natural attenuation processes will be relied upon to further reduce contaminant levels. An additional component of 36GW RAA 2 is a long-term groundwater and surface water monitoring program. Surface water samples will be analyzed for VOCs. Groundwater samples will be analyzed for VOCs and natural attenuation parameters. These parameters will indicate the type of natural biodegradation that is occurring in the aquifer, and the amount of contaminant reduction that has occurred over time and can be expected in the future. Sampling results will also help to determine if additional HRC injection is necessary. 36GW RAA 2 includes aquifer use restrictions to prohibit future use of the aquifers as a potable water source, and an intrusive activity boundary within the VOC area.

Compliance with ARARs: Under 36GW RAA 2, HRC injection will enhance natural attenuation processes to reduce contaminant levels to below chemical-specific ARARs. Natural attenuation processes are expected to eventually achieve these ARARs. No action-specific or location-specific ARARs apply to this alternative.

Long-Term Effectiveness and Permanence: Allowing for enhanced natural attenuation of groundwater is a feasible solution because sampling results indicate that contamination is not entering Brinson Creek and the chlorinated solvent contamination appears to already be naturally attenuating. Through monitoring and aquifer use restrictions, 36GW RAA 2 provides a means for observing contaminant concentrations over time and prohibiting future potable use of the aquifer. As a result, 36GW RAA 2 will ensure the safety of potential receptors over time and will provide long-tem effectiveness and permanence. Five-year reviews will also be required to ensure that adequate protection of human health and the environment is maintained.

Reduction of Toxicity, Mobility, or Volume Through Treatment: 36GW RAA 2, enhanced natural attenuation, includes an injection of HRC into the surficial aquifer to reduce the toxicity, mobility or volume of contaminated groundwater through treatment. Reduction in contaminant concentration is expected to continue through the natural attenuation process. Toxicity of the contaminants will naturally be reduced to cleanup levels through biodegradation.

Short-Term Effectiveness: Under 36GW RAA 2, the only activities that may increase risk to the community or to workers include monitoring well installation, Geoprobe injection of HRC into the surficial aquifer and periodic groundwater and surface water sampling. However, proper handling procedures and personal protective equipment should protect the community and workers from these risks. No additional environmental impacts will be caused by this RAA. Although the time required for the groundwater to naturally attenuate to cleanup goals is unknown, two years has been approximated in the cost estimate.

Implementability: 36GW RAA 2 is fairly easily implemented. The required monitoring well installation, Geoprobe HRC injection, groundwater and surface water sampling and ordinance procurement are standard practices. This alternative will not require coordination with other agencies. Annual reports must be submitted to document the sampling process. All required services, materials, or technologies should be readily available.

Cost: Estimated capital and O&M costs for 36GW RAA 2 are presented on Table 5-3. The estimated total net present worth cost for 36GW RAA 2 is $691,000.

5.2.1.6 36GW RAA 3: Monitored Natural Attenuation

Under 36GW RAA 3, no physical remedial actions will be implemented for the surficial aquifer contamination. Instead, treatment via natural attenuation processes will be relied upon to reduce contaminant levels. The main component of 36GW RAA 3 is a long-term groundwater and surface water monitoring program. Groundwater samples will be analyzed for VOCs and natural attenuation parameters. These parameters will indicate the type of natural biodegradation that is occurring in the aquifer, and the amount of contaminant reduction that has occurred over time and can be expected in the future. Surface water samples will be analyzed for VOCs. 36GW RAA 3 includes aquifer use restrictions to prohibit future use of the aquifers as a potable water source and an intrusive activity boundary for the VOC plume area.

Overall Protection of Human Health and the Environment: Under 36GW RAA 3, contaminants in the surficial aquifer will remain on-site. However, these contaminants do not appear to be adversely affecting human health or the environment. Since both TCE and its daughter products (1,2-DCE) and vinyl chloride have been detected at the site, the contamination already appears to be naturally attenuating. Also, volatile contaminants do not appear to be impacting Brinson Creek. Surface water sampling has not detected any VOC contamination in the creek. Therefore, during the natural attenuation process, it is not expected that contaminants would impact Brinson Creek. Based on this information, additional physical groundwater treatment is not necessary to provide a solution for the surficial aquifer. 36GW RAA 3 ensures the protection of human health and the environment through natural attenuation, monitoring and aquifer use restrictions. Thus, 36GW RAA 3 will mitigate the potential for direct exposure, and provide overall protection of human health and the environment.

Compliance with ARARs: Under 36GW RAA 3, no physical effort will be made to enhance or reduce contaminant levels to below chemical-specific ARARs. Natural attenuation processes, however, are expected to eventually achieve these ARARs. Thus, 36GW RAA 3 has the potential to remediate the groundwater over an extended period of time. No action-specific or location-specific ARARs apply to this alternative.

Long-Term Effectiveness and Permanence: Allowing the groundwater to naturally attenuate is a feasible and reasonable solution because sampling results indicate that contamination is not entering Brinson Creek and the chlorinated solvent appears to already be naturally attenuating.

Through monitoring and aquifer use restrictions, 36GW RAA 3 provides a means for observing contaminant concentrations over time and prohibiting future potable use of the aquifer. As a result, 36GW RAA 3 will ensure the safety of potential receptors over time and will provide long-tem effectiveness and permanence. Five-year reviews will also be required to ensure that adequate protection of human health and the environment is maintained.

Reduction of Toxicity, Mobility, or Volume Through Treatment: 36GW RAA 3, monitored natural attenuation, does not provide any treatment to reduce the toxicity, mobility or volume of contaminated groundwater through treatment. However, reduction is expected through the natural attenuation process. Toxicity of the contaminants will naturally be reduced to cleanup levels through biodegradation.

Short-Term Effectiveness: Under 36GW RAA 3, the only activities that may increase risk to the community or to workers include monitoring well installation and periodic groundwater and surface water sampling. However, proper handling procedures and personal protective equipment should protect the community and workers from these risks. No additional environmental impacts will be caused by this RAA. Although the time required for the groundwater to naturally attenuate to cleanup goals is unknown, 10 years has been approximated in the cost estimate.

Implementability: 36GW RAA 3 is easily implemented. The required monitoring well installation, groundwater and surface water sampling and ordinance procurement have been easily implemented at other Operable Units at MCB Camp Lejeune. This alternative will also not require coordination with other agencies. Annual reports must be submitted to document the sampling process. All required services, materials, or technologies should be readily available.

Cost: Estimated capital and O&M costs for 36GW RAA 3 are presented on Table 5-4. The estimated total net present worth cost for 36GW RAA 3 is $410,000.

5.2.2 Comparative Analysis

This section presents a comparative analysis of the six RAAs presented for Site 36. The purpose of the comparative analysis is to identify the relative advantages and disadvantages of each RAA. Thus, the seven previously introduced criteria used for the detailed analysis will be the basis for the following comparative analysis.

5.2.2.1 Overall Protection of Human Health and the Environment

Soil

Each alternative will protect human health and the environment for the desired future land use with the exception of 36S RAA 1, the no action alternative. 36S RAA 3 is most protective of human health and the environment because in this alternative, localized areas of contamination are removed from the site. 36S RAA 2 offers reduced exposure pathways through capping. Both 36S RAA 2 and 36S RAA 3 control exposure pathways for lead contamination, and accordingly protect human health, through future land use and excavation restrictions. However, no physical means will be used to protect the environment from exposure to lead contamination at Site 36.

Groundwater

36GW RAA 1, the no action alternative, will not reduce potential risks to human health and the environment. 36GW RAAs 2 and 3 both reduce potential human health risks because of the aquifer use restrictions that limit future use of the aquifers as a potable water source. 36GW RAA 2 may achieve site cleanup goals for groundwater in a shorter time frame than the other alternatives.

5.2.2.2 Compliance with ARARs

Soil

All of the RAAs, except for no action, meet the chemical-specific ARARs and remedial goals for the desired future land use, as presented in Section 2.0 of this FS. Location-specific and action-specific ARARs are met as applicable within each RAA.

Groundwater

All of the RAAs, except for no action, meet the chemical-specific ARARs and remedial goals for the desired future land use, as presented in Section 2.0 of this FS. Location-specific and action-specific ARARs are met as applicable within each RAA.

5.2.2.3 Long-Term Effectiveness and Permanence

Soil

The no action alternative will not be effective over the long term in protecting human health and the environment because the contaminants will remain at the site and will not be contained, removed or treated. 36S RAA 3 will be effective in the long term because PAH and pesticide contamination is removed to residential land use cleanup levels or controls are in place to protect potential receptors. 36S RAA 2, a residential capping alternative, will be effective in the long term if the soil cover is properly maintained into the future, and land use controls will protect potential receptors.

Groundwater

The effectiveness of 36GW RAAs 1, 2 and 3 depends upon how well natural attenuation reduces VOC contamination at the site. Although the time it will take for the site to reach cleanup levels is difficult to predict, 36GW RAA 2 should enhance and accelerate the natural attenuation process and complete it in a shorter time frame. Also, 36GW RAAs 2 and 3 include monitoring for progress to be observed, and aquifer use restrictions to provide future protection against human exposure to contaminants groundwater at the site. 36GW RAA 1 does not provide adequate controls to protect against future exposure to groundwater at the site.

5.2.2.4 Reduction of Toxicity, Mobility, or Volume Through Treatment

Soil

The no action alternative will not reduce the toxicity, mobility, or volume of contaminated soil at Site 36. 36S RAA 2 will reduce the mobility of PAH and pesticide contaminants but not the toxicity or volume of the soil itself. However, because capping will reduce contact with contaminated soil by human and ecological receptors, the potential toxicity will be reduced. 36S RAA 3 will reduce the toxicity, mobility, and volume of contaminants for the desired future land use through removal of contaminants from the site. 36S RAA 2 and 36S RAA 3 will not reduce the toxicity, mobility or volume of lead contaminated soil, but would control exposure to lead contaminated soils on site.

Groundwater

36GW RAA 2 is an in-situ treatment process that will reduce the toxicity and volume of contaminants in groundwater at Site 36. The injection of HRC into the plume is considered an active treatment. 36GW RAAs 1 and 3 involve passive treatment through natural attenuation. It is expected that the toxicity and volume of contaminants in groundwater will be reduced over time through natural attenuation.

5.2.2.5 Short-Term Effectiveness

Soil

The no action alternative is not effective for protecting human health and the environment in the short term. The contaminants will remain in place and will not be disturbed. 36S RAA 3 requires excavation of contaminated soil that could increase the exposure of construction workers and ecological receptors to contaminated soils in the short term. However, exposure to human health and the environment will be minimized by the proper use of personal protective equipment, erosion and sediment control measures, and dust controls. 36S RAAs 2 and 3 will be effective for protecting human health against lead exposure as soon as the land use controls are implemented. It is estimated that all the alternatives can be implemented in less than one year.

Groundwater

The short term effectiveness of 36GW RAAs 2 will vary due to heavy equipment (drill rigs, Geoprobe) being onsite, and the amount of time it will take to implement this RAA. Implementation of 36GW RAAs 1, 2 or 3 does not pose any substantial short term risks to the community or workers. The time necessary for natural attenuation to reduce site contamination to cleanup goals is unknown. However, it is expected that groundwater remediation under 36GW RAA 2 will take less time than 36GW RAAs 1 or 3.

5.2.2.6 Implementability

Soil

The no action alternative requires no effort because no changes will be made to affect current site conditions. 36S RAAs 2 and 3 are more difficult to implement and require the mobilization and operation of specialized equipment, and more effort for planning and design. They also simply involve the implementation of land use controls and excavation restrictions for lead contaminated soils at the site. Land use controls are required for each alternative except the no action alternative.

Groundwater

The no action alternative is the easiest to implement, as it requires no operation and maintenance, or institutional controls. 36GW RAA 3, monitored natural attenuation, is the next most easily implemented, as it only requires periodic monitoring, which involves conventional services and equipment. 36GW RAA 2 would be the most difficult to implement. Injection wells or direct push methods will be necessary to inject the HRC into the contaminated groundwater. 36GW RAA 2 will also require periodic monitoring.

5.2.2.7 Cost

Estimated capital and O&M costs for each RAA are presented on Tables 5-1 through 5-4. The estimated total net present worth cost for each RAA is provided below.

Soil

36S RAA 1: No Action	$0
36S RAA 2: Capping and Institutional Controls for Lead Contaminated Areas	$188,000
36S RAA 3: Excavation and Off-Site Disposal and Institutional Controls for Lead Contaminated Areas	$200,000

Groundwater

36GW RAA 1: No Action	$0
36GW RAA 2: Enhanced Natural Attenuation	$691,000
36GW RAA 3: Monitored Natural Attenuation	$410,000

5.3 Site 43

5.3.1 Individual Analysis of Alternatives

The following subsections present the detailed analysis of RAAs for Site 43 on an individual basis. This individual analysis includes a brief description of each RAA followed by an assessment of how well the RAA performs against the evaluation criteria.

Soil

5.3.1.1 43S RAA 1:No Action

Under the no action alternative, soil at Site 43 will remain as is. No physical remedial actions will be implemented.

Overall Protection of Human Health and the Environment: Under 43S RAA 1, no physical remedial actions will be implemented to control potential exposure pathways or to reduce contaminant concentrations in soils. As a result, there will be no measurable reduction in potential human health or environmental risks.

Compliance with ARARs: Under 43S RAA 1, no active effort will be made to reduce contaminant levels to below federal and state chemical-specific ARARs. Over an indefinite period of time, however, passive remediation, in the form of natural attenuation processes, may reduce PAH levels to below ARARs. No action-specific or location-specific ARARs apply to the no action alternative. Because contaminants will remain on site at levels exceeding requirements established by ARARs, 43S RAA 1 will require five-year reviews to ensure that adequate protection of human health and the environment is maintained.

Long-Term Effectiveness and Permanence: Under the no action alternative, any long-term or permanent effect on contaminant levels will depend on the effectiveness of natural attenuation. The extent to which natural attenuation may reduce contaminant levels, and the time it will take, are difficult to predict.

Reduction of Toxicity, Mobility, or Volume through Treatment: The no action alternative does not provide physical treatment processes for toxicity, mobility, or volume reduction of contaminated soil. Although passive treatment processes (i.e., natural attenuation) may eventually provide toxicity and volume reduction of the contaminated soil, the extent to which natural attenuation may reduce contaminant toxicity and volume is difficult to predict. Although 43S RAA 1 provides no means of measurement, this alternative may in time satisfy the statutory preference for treatment through natural attenuation.

Short-Term Effectiveness: As there are no physical remedial action activities associated with 43S RAA 1, there are no increased short-term potential risks to workers or the community. Also, there will be no additional short-term environmental impacts.

Implementability: The no action alternative is easily implemented since no additional construction or operation activities will be conducted. In terms of administrative feasibility, 43S RAA 1 should not require additional coordination with other agencies, although a waiver of the state ARARs may be required since contaminants exceeding these ARARs will be left on-site indefinitely. The availability of services, materials, and/or technologies is not applicable to this alternative.

Cost: There are no capital costs or O&M costs associated with this alternative. Therefore, the net present worth (NPW) is $0.

5.3.1.2 43S RAA 2: Capping

In 43S RAA 2, localized areas of PAH contamination will be capped (Figure 4-5). Upon completion, the entire site would be designated for residential land use.

Overall Protection of Human Health and the Environment: 43S RAA 2 involves capping of contaminated soils, therefore, this RAA will reduce potential risks to human health and the environment. The capping alternative will prevent human and ecological receptors from coming into contact with soil contaminants. The contaminated soil will be covered with one foot of clean backfill and then six inches of topsoil. With proper maintenance of the soil cover, human health and the environment will be protected, because this alternative reduces an exposure pathway to the contaminated soil. Institutional controls will include excavation restrictions that will be implemented at the site to protect the cap against possible intrusive activities.

Compliance With ARARs: Chemical-specific ARARs will be met in this alternative. Soils with localized areas of PAH contamination will be capped. Several potential location-specific and action-specific ARARs identified for this site will be applicable or relevant and appropriate under this RAA because the alternative includes earth moving, and capping activities. Activities at the site will be implemented such that all ARAR requirements are met.

Long-Term Effectiveness and Permanence: A soil cover will be effective for protecting human health and the environment in the long term if the cap is properly maintained. The soil cover will prevent human and ecological exposure to contaminated soils provided that the soil cover is properly installed and maintained. Capping will have a lower level of long-term effectiveness than excavation, but is appropriate for the low levels of contamination found at this site.

Reduction of Toxicity, Mobility, or Volume Through Treatment: The toxicity of contaminants will not be reduced by this alternative because the contaminants will not be transformed into less toxic forms or destroyed by any physical, chemical, or thermal process. Although this is not a treatment technology, reducing exposure pathways of potential receptors will reduce the toxicity of Site 43 soils. The mobility of contaminants will be reduced because the soil cover will prevent wind and water erosion, thereby preventing contaminated soil from migrating via sedimentation and erosion processes. However, soluble contaminants could leach due to infiltration of rainwater through the soil cover.

Short-Term Effectiveness: In the short-term, construction workers and ecological receptors may be exposed to disturbed contaminated soils. Exposure to human health and the environment will be minimized by the proper use of personal protective equipment, erosion and sediment control measures, and dust controls. Ecological habitats may be destroyed through clearing, however the

area will be revegetated and habitats will be restored. It is estimated that the capping can be implemented in less than one year, however revegetation may take longer to establish original conditions. Upon completion, this alternative will be effective for protecting human health and the environment.

Implementability: This alternative is easily implemented because no active treatment technologies will be used. Prior to capping, the site may need to be cleared as it is heavily vegetated in some areas. Commonly used earth moving equipment and site work procedures will be employed to place, contour and seed the clean backfill and topsoil.

Cost: Estimated capital and O&M costs for 43S RAA 2 is presented on Table 5-5. The estimated total net present worth cost for 43S RAA 2 is $169,000.

5.3.1.3 43S RAA 3: Excavation and Off-Site Disposal

43S RAA 3 involves the excavation of soils that contain contaminant concentrations in excess of remediation goals for residential land use (Figure 4-6). Confirmatory sampling will take place to ensure that all contaminants exceeding remediation goals have been excavated. Samples will be analyzed for PAHs. Excavated soils would be transported the Base landfill for proper disposal. Following the excavation operation, the site would be restored to pre-excavation conditions.

Overall Protection of Human Health and the Environment: Because 43S RAA 3 involves excavation and off-site disposal of contaminated soils, this RAA will reduce potential risks to human health and the environment. Exposure pathways are eliminated with the site-wide excavation of contaminants that exceed residential cleanup levels. Ecological risk will also be eliminated in areas of the site that are excavated.

Compliance With ARARs: In 43S RAA 3, contaminated soils that exceed EPA Region IX Residential PRGs are removed from the site. Several potential location-specific and action-specific ARARs identified for this site will be applicable or relevant and appropriate under this RAA because the alternative includes earth moving, transport, and disposal activities. Activities at the site will be implemented such that all ARAR requirements will be met.

Long-Term Effectiveness and Permanence: The excavation and disposal alternative will be an effective and permanent remedial action. The contaminated soil will be removed from the site and placed in an off-site disposal facility where contact with human and ecological receptors will be eliminated. This alternative will be effective in the long-term because the contaminants will be permanently removed from Site 43 and will no longer pose a potential risk to human health or the environment.

Reduction of Toxicity, Mobility, or Volume through Treatment: Neither toxicity, mobility, nor volume of contaminants will be reduced through treatment under either option of this alternative because no treatment technologies will be used. However, the physical removal of the soil will eliminate the availability of contaminants to human or ecological receptors. Similarly, there will be no mobility of contaminants that exceed cleanup goals at the site because they will be removed. The volume of the contaminated soil will not be reduced, but the soil will be removed from the site. Therefore, the volume, mobility, and toxicity of contaminants at the site will be reduced, even though the contaminated soil itself will not be treated.

Short-Term Effectiveness: In the short-term, construction workers and ecological receptors may be exposed to disturbed contaminated soil. Exposures to human health and the environment will be minimized by the proper use of personal protective equipment, erosion and sediment control measures, and dust controls. This alternative can be implemented in less than one year. Upon completion, this alternative will be effective for protecting human health and the environment.

Implementability: This alternative is easily implemented because no active treatment technologies will be used. The excavation areas may need to be cleared prior to excavation due to heavy vegetation at the site. Commonly used earth moving equipment and site work procedures will be employed to excavate and transport contaminated soil/sediments and to place, contour, and seed the clean backfill and topsoil.

Cost: Estimated capital and O&M costs for 43S RAA 3 are presented on Table 5-6. The estimated total net present worth cost for 43S RAA 3 is $119,000.

Groundwater

5.3.1.4 43GW RAA 1: No Action

Under the no action alternative, groundwater at Site 43 will remain as is. No physical remedial actions will be implemented.

Overall Protection of Human Health and the Environment: Under 43GW RAA 1, no physical remedial actions will be implemented to control potential exposure pathways or to reduce contaminant concentrations in groundwater. As a result, there will be no measurable reduction in potential human health or environmental risks.

Compliance with ARARs: Under 43GW RAA 1, no active effort will be made to reduce contaminant levels to below federal and state chemical-specific ARARs. Over an indefinite period of time, passive remediation, in the form of natural attenuation processes, may reduce SVOC levels to below ARARs. No action-specific or location-specific ARARs apply to the no action alternative.

Long-Term Effectiveness and Permanence: Under the no action alternative, any long-term or permanent effect on contaminant levels will depend on the effectiveness of natural attenuation. The extent to which natural attenuation may reduce contaminant levels, and the time it will take, are difficult to predict.

Reduction of Toxicity, Mobility, or Volume through Treatment: The no action alternative does not provide physical treatment processes for toxicity, mobility, or volume reduction of contaminated groundwater. Although passive treatment processes (i.e., natural attenuation) may eventually provide toxicity and volume reduction of the contaminated groundwater, the extent to which natural attenuation may reduce contaminant toxicity and volume is difficult to predict.

Short-Term Effectiveness: As there are no physical remedial action activities associated with 43GW RAA 1, there are no increased short-term potential risks to workers or the community. Also, there will be no additional short-term environmental impacts.

Implementability: The no action alternative is easily implemented since no additional construction or operation activities will be conducted. In terms of administrative feasibility, 43GW RAA 1 should not require additional coordination with other agencies, although a waiver of the state ARARs may be required since contaminants exceeding these ARARs will be left on-site indefinitely. The availability of services, materials, and/or technologies is not applicable to this alternative.

Cost: There are no capital costs or O&M costs associated with this alternative. Therefore, the net present worth (NPW) is $0.

5.3.2 Comparison of Alternatives

This section presents a comparative analysis of the three RAAs presented for soil for Site 43. Only one RAA is presented for groundwater, and therefore no comparative analysis will be completed for groundwater at Site 43. The purpose of the comparative analysis is to identify the relative advantages and disadvantages of each RAA. Thus, the seven previously introduced criteria used for the detailed analysis will be the basis for the following comparative analysis for soil remedial alternatives.

5.3.2.1 Overall Protection of Human Health and the Environment

Each alternative will protect human health and the environment for the desired future land use with the exception of 43S RAA 1, the no action alternative. 43S RAA 3 is most protective of human health and the environment because in this alternative contaminants exceeding residential cleanup goals are removed from the site. 43S RAA 2 offers reduced exposure pathways for residential land uses through capping.

5.3.2.2 Compliance with ARARs

All of the RAAs, except for no action, meet the chemical-specific ARARs and remedial goals for the desired future land use, as presented in Section 2.0 of this FS. Location-specific and action-specific ARARs are met as applicable within each RAA.

5.3.2.3 Long-Term Effectiveness and Permanence

The no action alternative will not be effective over the long term in protecting human health and the environment because the contaminants will remain at the site and will not be contained, removed or treated. 43S RAA 3 will be most effective in the long term because site contamination exceeding residential cleanup goals is permanently removed from the site. 43S RAA 2, a residential capping alternative, will be effective in the long term if the soil cover is properly maintained into the future.

5.3.2.4 Reduction of Toxicity, Mobility, or Volume Through Treatment

The no action alternative will not reduce the toxicity, mobility, or volume of contaminated soil at Site 43. 43S RAA 2 will reduce the mobility of contaminants but not the toxicity or volume of the soil itself. However, because capping will reduce contact with contaminated soil by human and ecological receptors, the potential toxicity will be reduced. 43S RAA 3 will reduce the toxicity, mobility, or volume of contaminants for the desired future land use through removal of contaminants from the site.

5.3.2.5 Short-Term Effectiveness

The no action alternative is not effective for protecting human health and the environment in the short term. The contaminants will remain in place and will not be disturbed. 43S RAA 3 requires excavation of contaminated soil that could increase the exposure of construction workers and ecological receptors to contaminated soils in the short term. However, exposure to human health and the environment will be minimized by the proper use of personal protective equipment, erosion and sediment control measures, and dust controls. It is estimated that all the alternatives can be implemented is less than one year.

5.3.2.6 Implementability

The no action alternative requires no effort because no changes will be made to affect current site conditions. 43S RAAs 2and 3 are more difficult to implement and require the mobilization and operation of specialized equipment, and more effort for planning and design. Excavation restrictions (i.e., intrusive activity controls) are placed on 43S RAA 2. This required land use control is easily implemented and will be maintained by the Base through their Base Master Planning Process.

5.3.2.7 Cost

Estimated capital and O&M costs for each RAA are presented on Tables 5-5 and 5-6. The estimated total net present worth cost for each RAA is provided below.

Soil

43S RAA 1: No Action	$0
43S RAA 2: Capping	$169,000
43S RAA 3: Excavation and Off-Site Disposal	$119,000

Groundwater

43GW RAA 1: No Action	$0

5.4 Site 44

5.4.1 Individual Analysis of Alternatives

The following subsections present the detailed analysis of RAAs for Site 44 on an individual basis. This individual analysis includes a brief description of each RAA followed by an assessment of how well the RAA performs against the evaluation criteria.

Soil

5.4.1.1 44S RAA 1: No Action

Under the no action alternative, soil at Site 44 will remain as is. No physical remedial actions will be implemented.

Overall Protection of Human Health and the Environment: Under 44S RAA 1, no physical remedial actions will be implemented to control potential exposure pathways or to reduce contaminant concentrations in soils. As a result, there will be no measurable reduction in potential human health or environmental risks.

Compliance with ARARs: Under 44S RAA 1, no active effort will be made to reduce contaminant levels to below federal and state chemical-specific ARARs. Over an indefinite period of time, however, passive remediation, in the form of natural attenuation processes, may reduce arsenic levels to below ARARs. No action-specific or location-specific ARARs apply to the no action alternative. Because contaminants will remain on site at levels exceeding requirements established by ARARs, 44S RAA 1 will require five-year reviews to ensure that adequate protection of human health and the environment is maintained.

Long-Term Effectiveness and Permanence: Under the no action alternative, any long-term or permanent effect on contaminant levels will depend on the effectiveness of natural attenuation. The extent to which natural attenuation may reduce arsenic levels, and the time it will take, are difficult to predict.

Reduction of Toxicity, Mobility, or Volume through Treatment: The no action alternative does not provide physical treatment processes for toxicity, mobility, or volume reduction of contaminated soil or sediment. Although passive treatment processes (i.e., natural attenuation) may eventually provide toxicity and volume reduction of the contaminated soil and sediments, the extent to which natural attenuation may reduce contaminant toxicity and volume is difficult to predict. Although 44S RAA 1 provides no means of measurement, this alternative may in time satisfy the statutory preference for treatment through natural attenuation.

Short-Term Effectiveness: As there are no physical remedial action activities associated with 44S RAA 1, there are no increased short-term potential risks to workers or the community. Also, there will be no additional short-term environmental impacts.

Implementability: The no action alternative is easily implemented since no additional construction or operation activities will be conducted. In terms of administrative feasibility, 44S RAA 1 should not require additional coordination with other agencies, although a waiver of the state ARARs may be required since contaminants exceeding these ARARs will be left on-site indefinitely. The availability of services, materials, and/or technologies is not applicable to this alternative.

Cost: There are no capital costs or O&M costs associated with this alternative. Therefore, the net present worth (NPW) is $0.

Groundwater

5.4.1.3 44GW RAA 1: No Action

Under the no action alternative, groundwater at Site 44 will remain as is. No physical remedial actions will be implemented.

Overall Protection of Human Health and the Environment: Under 44GW RAA 1, no physical remedial actions will be implemented to control potential exposure pathways or to reduce contaminant concentrations in groundwater. As a result, there will be no measurable reduction in potential human health or environmental risks.

Compliance with ARARs: Under 44GW RAA 1, no active effort will be made to reduce contaminant levels to below federal and state chemical-specific ARARs. Over an indefinite period of time, however, passive remediation, in the form of natural attenuation processes, may reduce contaminant levels to below ARARs. No action-specific or location-specific ARARs apply to the no action alternative.

Long-Term Effectiveness and Permanence: Under the no action alternative, any long-term or permanent effect on contaminant levels will depend on the effectiveness of natural attenuation. The extent to which natural attenuation may reduce contaminant levels, and the time it will take, are difficult to predict.

Reduction of Toxicity, Mobility, or Volume through Treatment: The no action alternative does not provide physical treatment processes for toxicity, mobility, or volume reduction of contaminated groundwater. Although passive treatment processes (i.e., natural attenuation) may eventually provide toxicity and volume reduction of the contaminated groundwater, the extent to which natural attenuation may reduce contaminant toxicity and volume is difficult to predict.

Short-Term Effectiveness: As there are no physical remedial action activities associated with 44GW RAA 1, there are no increased short-term potential risks to workers or the community. Also, there will be no additional short-term environmental impacts.

Implementability: The no action alternative is easily implemented since no additional construction or operation activities will be conducted. In terms of administrative feasibility, 44GW RAA 1 should not require additional coordination with other agencies, although a waiver of the state ARARs may be required since contaminants exceeding these ARARs will be left on-site indefinitely. The availability of services, materials, and/or technologies is not applicable to this alternative.

Cost: There are no capital costs or O&M costs associated with this alternative. Therefore, the net present worth (NPW) is $0.

5.4.2 Comparison of Alternatives

Only one RAA is presented for both soil and groundwater at Site 44, and therefore a comparative analysis is not necessary for this site.

5.5 Site 54

5.5.1 Individual Analysis of Alternatives

The following subsections present the detailed analysis of RAAs for Site 54 on an individual basis. This individual analysis includes a brief description of each RAA followed by an assessment of how well the RAA performs against the evaluation criteria. For Site 54, only the no action alternative has remained through the screening process for soil. Due to the removal action completed in April 2001, soil contamination has already been removed from the site. Following the excavation, confirmatory samples demonstrated that no contaminants remain on site above cleanup goals. Two RAAs are presented for groundwater at Site 54.

Soil

5.5.1.1 54S RAA 1: No Action

Under the no action alternative, soil at Site 54 will remain as is. No physical remedial actions will be implemented.

Overall Protection of Human Health and the Environment: Under 54S RAA 1, no physical remedial actions will be implemented. There is currently no contaminated soil on site that exceeds cleanup goals.

Compliance with ARARs: Under 54S RAA 1, no active effort will be made to remediate soil at Site 54. Contaminant levels are below federal and state chemical-specific ARARs following the removal action.

Long-Term Effectiveness and Permanence: Under the no action alternative for Site 54, long-term or permanent effect on contaminant levels will be effective, because contaminants were previously removed from the site. Therefore, taking no action at the site now will not eliminate the effect of the previous remedial action taken at the site.

Reduction of Toxicity, Mobility, or Volume through Treatment: The no action alternative does not provide physical treatment processes for toxicity, mobility, or volume reduction of contaminated soil. However, this is reasonable for Site 54 because contaminated soils have been removed from the site.

Short-Term Effectiveness: As there are no physical remedial action activities associated with 54S RAA 1, there are no increased short-term potential risks to workers or the community. Also, there will be no additional short-term environmental impacts.

Implementability: The no action alternative is easily implemented since no additional construction or operation activities will be conducted. In terms of administrative feasibility, 54S RAA 1 should not require additional coordination with other agencies. The availability of services, materials, and/or technologies is not applicable to this alternative.

Cost: There are no capital costs or O&M costs associated with this alternative. Therefore, the net present worth (NPW) is $0.

Groundwater

5.5.1.2 54GW RAA 1: No Action

Under the no action alternative, groundwater at Site 54 will remain as is. No physical remedial actions will be implemented. Groundwater at Site 54 has had no detections of VOCs in the past nine sampling quarters. Only one SVOC was detected in the past sampling quarter (January 2002) at a concentration above the NCWQS. During the removal action, one groundwater sample was taken at the center of the excavation. There were no detections of PAHs above cleanup goals in this groundwater sample. During the RI, one groundwater sample exceeded the NCWQS for lead.

Overall Protection of Human Health and the Environment: Under 54GW RAA 1, no physical remedial actions will be implemented to control potential exposure pathways or to reduce contaminant concentrations in groundwater. As a result, there will be no measurable reduction in potential human health or environmental risks.

Compliance with ARARs: Under 54GW RAA 1, no active effort will be made to reduce contaminant levels to below federal and state chemical-specific ARARs. Over an indefinite period of time, however, dilution or diffusion may reduce contaminant levels to below ARARs. No action-specific or location-specific ARARs apply to the no action alternative.

Long-Term Effectiveness and Permanence: Under the no action alternative, any long-term or permanent effect on contaminant levels will depend on the dispersion of lead throughout the aquifer.

Reduction of Toxicity, Mobility, or Volume through Treatment: The no action alternative does not provide physical treatment processes for toxicity, mobility, or volume reduction of contaminated groundwater. Although passive treatment processes may eventually provide toxicity and volume reduction of the contaminated groundwater, the extent to which these physical processes may reduce contaminant toxicity and volume is difficult to predict.

Short-Term Effectiveness: As there are no physical remedial action activities associated with 54GW RAA 1, there are no increased short-term potential risks to workers or the community. Also, there will be no additional short-term environmental impacts.

Implementability: The no action alternative is easily implemented since no additional construction or operation activities will be conducted. In terms of administrative feasibility, 54GW RAA 1 should not require additional coordination with other agencies, although a waiver of the state ARARs may be required since contaminants exceeding these ARARs will be left on-site indefinitely. The availability of services, materials, and/or technologies is not applicable to this alternative.

Cost: There are no capital costs or O&M costs associated with this alternative. Therefore, the net present worth (NPW) is $0.

5.5.1.3 54GW RAA 2: Institutional Controls and Monitoring

Under 54GW RAA 2, no physical remedial actions will be implemented for the surficial aquifer contamination. Instead, treatment via natural attenuation processes will be relied upon to reduce contaminant levels. The main component of 54GW RAA 2 is a long-term groundwater monitoring program. Groundwater samples will be analyzed for lead. 54GW RAA 2 includes aquifer use restrictions to prohibit future use of the aquifers as a potable water source and an intrusive activity boundary for the lead plume area. These controls will be in place until NCWQS remediation goals of 15 µg/L for lead have been achieved for four sampling quarters.

Overall Protection of Human Health and the Environment: Under 54GW RAA 2, lead in the surficial aquifer will remain on-site. Lead in groundwater indicated a potential for adverse health effects for a future child receptor. Based upon the exceedence of NCWQS remedial goals for lead, additional physical groundwater treatment is necessary to provide a justifiable solution for the surficial aquifer. 54GW RAA 2 ensures the protection of human health and the environment through monitoring and aquifer use restrictions. Thus, 54GW RAA 2 will mitigate the potential for direct exposure, and provide overall protection of human health and the environment.

Compliance with ARARs: Under 54GW RAA 2, no physical effort will be made to enhance or reduce contaminant levels to below chemical-specific ARARs. Physical processes such as diffusion and dispersion, however, are expected to eventually achieve these ARARs. Thus, 54GW RAA 2 has the potential to remediate the groundwater over an extended period of time. No action-specific or location-specific ARARs apply to this alternative.

Long-Term Effectiveness and Permanence: Through monitoring and aquifer use restrictions, 54GW RAA 2 provides a means for observing contaminant concentrations over time and prohibiting future potable use of the aquifer. As a result, 54GW RAA 2 will ensure the safety of potential receptors over time and will provide long-term effectiveness and permanence. Five-year reviews will also be required to ensure that adequate protection of human health and the environment is maintained.

Reduction of Toxicity, Mobility, or Volume Through Treatment: 54GW RAA 2 does not provide any treatment to reduce the toxicity, mobility or volume of contaminated groundwater through treatment. However, reduction is expected through physical process.

Short-Term Effectiveness: Under 54GW RAA 2, the only activities that may increase risk to the community or to workers include periodic groundwater sampling. However, proper handling procedures and personal protective equipment should protect the community and workers from these risks. No additional environmental impacts will be caused by this RAA. Although the time required for the groundwater to reach cleanup goals is unknown, two years has been approximated in the cost estimate.

Implementability: 54GW RAA 2 is easily implemented. The required groundwater sampling and ordinance procurement have been easily implemented at other Operable Units at MCB, Camp Lejeune. This alternative will also not require coordination with other agencies. Annual reports must be submitted to document the sampling process. All required services, materials, or technologies should be readily available.

Cost: Estimated capital and O&M costs for 54GW RAA 2 are presented on Table 5-7. The estimated total net present worth cost for 54GW RAA 2 is $44,000.

5.5.2 Comparison of Alternatives

Only one RAA is presented for both soil and therefore a comparative analysis is not necessary for soil at this site. This section presents a comparative analysis of the two RAAs presented for Site 54 groundwater. The purpose of the comparative analysis is to identify the relative advantages and disadvantages of each RAA. Thus, the seven previously introduced criteria used for the detailed analysis will be the basis for the following comparative analysis.

5.5.2.1 Overall Protection of Human Health and the Environment

Each alternative will protect human health and the environment for the desired future land use with the exception of 54GW RAA 1, the no action alternative. 54GW RAA 2 is more protective of human health and the environment because in this alternative aquifer use and intrusive boundary restrictions will reduce exposure pathways.

5.5.2.2 Compliance with ARARs

All of the RAAs, except for no action, meet the chemical-specific ARARs and remedial goals for groundwater, as presented in Section 2.0 of this FS. Location-specific and action-specific ARARs are met as applicable within each RAA.

5.5.2.3 Long-Term Effectiveness and Permanence

The no action alternative will not be effective over the long term in protecting human health and the environment because the contaminants will remain at the site and will not be contained, removed or treated. 54GW RAA 2 will be more effective in the long term because site contamination exceeding NCWQS remedial goals is monitored and restricted through institutional controls.

5.5.2.4 Reduction of Toxicity, Mobility, or Volume Through Treatment

The no action alternative will not reduce the toxicity, mobility, or volume of contaminated soil at Site 54. 54GW RAA 2 will not reduce the toxicity or volume of the groundwater itself. However, because controls will reduce contact with contaminated groundwater by receptors, the potential toxicity will be reduced.

5.5.2.5 Short-Term Effectiveness

The no action alternative is not effective for protecting human health and the environment in the short term. The contaminated groundwater will remain in place and will not be disturbed. 54GW RAA 2 requires monitoring of contaminated groundwater that could increase the exposure of construction workers and ecological receptors to contaminated groundwater in the short term. However, exposure to human health and the environment will be minimized by the proper use of personal protective equipment. It is estimated that all the alternatives can be implemented is less than two years.

5.5.2.6 Implementability

The no action alternative requires no effort because no changes will be made to affect current site conditions. The required monitoring of 54GW RAA 2 is also easy to implement, and has been successfully implemented at many sites throughout MCB, Camp Lejeune. Intrusive activity controls and aquifer use controls are placed on 54GW RAA 2. These required land use controls are easily implemented and will be maintained by the Base through their Base Master Planning Process.

5.5.2.7 Cost

Estimated capital and O&M costs for 54GW RAA 2 are presented on Table 5-7. The estimated total net present worth cost for each RAA is provided below.

Soil

54S RAA 1: No Action	$0

Groundwater

54GW RAA 1: No Action	$0
54GW RAA 2: Institutional Controls and Monitoring	$44,000

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TABLES

TABLE 1-1
SITE 36 POST-RI MONITORING RESULTS
OPERABLE UNIT NO. 6, SITES 36, 43, 44 and 54
CORRECTIVE ACTION PLAN, CTO-0219
MCB CAMP LEJEUNE, NORTH CAROLINA

	NCWQS	October 1998	January 1999	April 1999	July 1999	October 1999	January 2000	April 2000	July 2000	October 2000	January 2001	April 2001	July 2001	October 2001	January 2002	April 2002
36-GW03																
2-Hexanone	280 (1)	ND	ND	ND	ND	10 R	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Acetone	700	ND	ND	ND	ND	10 R	ND	ND	ND	ND	ND	ND	ND	ND	ND	11 J
36-GW09																
2-Hexanone	280 (1)	ND	ND	ND	ND	10 R	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Acetone	700	4 J	ND	ND	ND	10 R	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
36-GW10																
1,1,2,2-Tetrachloroethane	0.17 (1)	1 J	ND	ND	8	ND	4 J	6	3 J	5	7	ND	4 J	3 J	4J	ND
2-Butanone	170	ND	ND	ND	ND	10 R	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2-Hexanone	280 (1)	ND	ND	ND	ND	10 R	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
4-Methyl-2-pentanone	NE	ND	ND	ND	ND	10 R	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Acetone	700	ND	ND	ND	ND	10 R	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Methylene Chloride	5	ND	ND	3 J	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
cis-1,2-Dichloroethene	70	ND	ND	ND	ND	ND	ND	ND	ND	ND	21	ND	ND	ND	ND	ND
Trichloroethene	2.8	3 J	2 J	1 J	10	ND	8	11	4 J	7	47	4 J	9	7	11	4 J
36-GW10DW																
2-Hexanone	280 (1)	ND	ND	ND	ND	10 R	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Acetone	700	ND	ND	ND	ND	10 R	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Methylene Chloride	5	ND	ND	2 J	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
36-GW10IW																
1,1,2,2-Tetrachloroethane	0.17 (1)	4 J	3 J	2 J	4 J	4 J	6	6	6	8	8	10	9	8	7	10 J
2-Hexanone	280 (1)	ND	ND	ND	ND	10 R	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Acetone	700	ND	ND	ND	ND	10 R	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Methylene Chloride	5	ND	ND	3 J	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
cis-1,2-Dichloroethene	70	21	17	19	21	23	26	20	20	20	ND	18	20	21	20	24
Vinyl Chloride	0.015	3 J	ND	1 J	ND	2	2	ND	2	2 J	ND	ND	ND	ND	2	ND
Trichloroethene	2.8	41	31	38	43	50	46	44	44	49	12	43	49	49	44	54
Total 1,2-Dichloroethene	70	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	23	20	27
trans-1,2-Dichloroethene	70	ND	1 J	1 J	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	3 J
36-GW13																
1,1,2,2-Tetrachloroethane	0.17 (1)	3 J	ND	1 J	ND	4 J	ND	ND	ND	3 J	ND	ND	ND	ND	ND	ND
2-Hexanone	280 (1)	ND	ND	ND	ND	10 R	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Acetone	700	ND	ND	ND	ND	10 R	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
cis-1,2-Dichloroethene	70	2 J	3 J	4 J	3 J	3 J	4 J	3 J	ND	2 J	4 J	3 J	3 J	4 J	ND	3 J
Vinyl Chloride	0.015	3 J	ND	4 J	ND	1 J	2	3	1 J	1 J	ND	ND	ND	ND	1 J	ND
Trichloroethene	2.8	2 J	1 J	2 J	2 J	3 J	ND	ND	ND	2 J	ND	3 J	3 J	3 J	3 J	3 J
Total 1,2-Dichloroethene	70	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	4 J	ND	3 J
trans-1,2-Dichloroethene	70	2 J	2 J	2 J	ND	ND	2 J	ND	ND	ND	ND	ND	ND	ND	ND	ND

TABLE 1-1 (continued)
SITE 36 POST RI MONITORING DETECTIONS
OPERABLE UNIT NO. 6, SITES 36, 43, 44 and 54
CORRECTIVE ACTION PLAN, CTO-0219
MCB CAMP LEJEUNE, NORTH CAROLINA

	NCWQS	October 1998	January 1999	April 1999	July 1999	October 1999	January 2000	April 2000	July 2000	October 2000	January 2001	April 2001	July 2001	October 2001	January 2002	April 2002
36-GW13IW																
2-Hexanone	280 (1)	ND	ND	ND	ND	10 R	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Acetone	700	ND	ND	3 J	ND	10 R	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Methylene Chloride	5	ND	ND	1 J	ND	ND	ND	ND	ND	ND	ND	ND	ND	3 J	ND	ND
cis-1,2-Dichloroethene	70	4 J	3 J	3 J	4 J	5 J	4 J	3 J	3 J	ND	3 J	3 J	4J	ND	3 J	4 J
Total 1,2-Dichloroethene	70	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	3 J	3 J	4 J
Vinyl Chloride	0.015	ND	ND	ND	ND	ND	1 J	ND	2 J	1 J	ND	ND	1J	1 J	2 J	ND
36-GW16IW																
1,1,2,2-Tetrachloroethane	0.17 (1)	3 J	4 J	9	17	16 J	13	11	16	24	16	16	20	21	20	34 J
2-Hexanone	280 (1)	ND	ND	ND	ND	10 R	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Acetone	700	ND	ND	2 J	ND	10 R	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
cis-1,2-Dichloroethene	70	4 J	5	5	6	7	6	6	6	5	ND	6	7	7	7	8
Trichloroethene	2.8	5 J	8	13	21	24	20	19	21	26	26	25	30	31	28	40
Total 1,2-Dichloroethene	70	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	9	7	8
Vinyl Chloride	0.015	ND	ND	ND	ND	ND	1 J	ND	ND	ND	ND	ND	ND	1 J	1 J	ND
36-GW18																
1,1,2,2-Tetrachloroethane	0.17 (1)	4 J	ND	1 J	3 J	ND	ND	ND	2 J	ND	ND	ND	ND	NS	ND	ND
2-Butanone	170	4 J	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NS	ND	ND
2-Hexanone	280 (1)	ND	ND	ND	ND	10 R	ND	ND	ND	ND	ND	ND	ND	NS	ND	ND
Acetone	700	ND	ND	3 J	ND	10 R	ND	ND	ND	ND	ND	ND	ND	NS	ND	ND
Methylene Chloride	5	ND	ND	3 J	ND	ND	ND	ND	ND	ND	ND	ND	ND	NS	ND	ND
cis-1,2-Dichloroethene	70	3 J	2 J	2 J	4 J	3 J	3 J	5 J	6	4 J	4 J	4 J	7	NS	5 J	6
trans-1,2-Dichloroethene	70	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NS	ND	3 J
Trichloroethene	2.8	4 J	3 J	3 J	4 J	3 J	3 J	4 J	4 J	3 J	3 J	2 J	4J	NS	3 J	4J
Total 1,2-Dichloroethene	70	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NS	5 J	8
Vinyl Chloride	0.015	ND	ND	ND	ND	8	ND	ND	2	1 J	ND	ND	2 J	NS	1 J	ND
36-GW18IW																
2-Hexanone	280 (1)	ND	ND	ND	ND	10 R	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Acetone	700	ND	ND	ND	ND	10 R	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
cis-1,2-Dichloroethene	70	16	14	15	13	13	15	12	11	11	12	10	12	12	10	13
Trichloroethene	2.8	2 J	2 J	2 J	ND	13	ND	ND	ND	2 J	3 J	3 J	3 J	3 J	3 J	4 J
Total 1,2-Dichloroethene	70	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	13	10	13
Vinyl Chloride	0.015	3 J	ND	2 J	ND	2 J	2 J	ND	ND	2 J	ND	ND	2	3	2	ND
36-GW19																
Methylene Chloride	5	ND	ND	2 J	ND	ND	ND	ND	ND	ND	ND	ND	ND	NS	NS	NS

- All concentrations in ug/L

Shaded constituents exceed the NCWQS standards

Notes:

ND - Not Detected
NE - Not Established
(1) NCWQS Interim Standard
NS - Not Sampled
J - Analyte detected; value is estimated

TABLE 1-2
REMEDIAL INVESTIGATION RESULTS FOR SITE 36
OPERABLE UNIT NO. 6, SITES 36, 43, 44 and 54
FEASIBILITY STUDY, CTO-0219
MCB CAMP LEJEUNE, NORTH CAROLINA

Media	Fraction	Detected Contaminants	Screening Criteria [5]	Site Contamination		Maximum Location	Detection Frequency	Distribution
				Min.	Max.			
Surface Soil	Volatiles	Trichloroethene	2,800	4	4	FDA-SB03	1/61	eastern, former disposal area
		Tetrachloroethene	5,700	2	3	36-GW12	3/61	northern, ground scar area
		Toluene	520,000	8	98	OF-SB01	4/61	south central, open field
		Styrene	1,700,000	39	39	GS-SB03	1/61	northern, ground scar area
		Xylene (total)	210,000	7	7	OF-SB06B	1/61	south central, open field
	Semivolatiles	n-Nitro-di-n-propylamine	69	320	320	DAB-SB03	1/57	southeastern, drum area
		Naphthalene (PAH)	56,000	48	120	OF-SB04	2/57	1 south central, 1 western
		2-Methylnapthalene	1,600,000	54	82	OA-SB01A	2/57	1 south central, 1 western
		Acenaphthene (PAH)	3,700,000	330	330	OF-SB04	1/57	south central, open field
		Dibenzofuran	290,000	150	150	OF-SB04	1/57	south central, open field
		Fluorene (PAH)	2,600,000	200	200	OF-SB04	1/57	south central, open field
		Phenanthrene (PAH)	NA	59	2,500	OF-SB04	4/57	scattered
		Anthracene (PAH)	22,000,000	780	780	OF-SB04	1/57	south central, open field
		Carbazole	NA	240	240	OF-SB04	1/57	south central, open field
		Fluoranthene (PAH)	2,300,000	54	5,500	OF-SB04	5/57	4 southeastern, drum area
		Pyrene (PAH)	2,300,000	41	11,000	OF-SB04	8/57	5 southeastern, drum area
		Butylbenzylphthalate	12,000,000	51	290	OA-SB03	3/57	western
		B(a)anthracene (PAH)	620	46	3,900	OF-SB04	2/57	1 south central, 1 southeastern
		Chrysene (PAH)	62,000	51	4,600	OF-SB04	5/57	3 southeastern, drum area
		B(b)fluoranthene (PAH)	620	51	3,600	OF-SB04	3/57	scattered
		B(k)fluoranthene (PAH)	6,200	39	1,500	OF-SB04	2/57	1 south central, 1 southeastern
		Benzo(a)pyrene (PAH)	62	40	3,300	OF-SB04	2/57	1 south central, 1 western
		I(1,2,3-cd)pyrene (PAH)	620	46	2,700	OF-SB04	3/57	scattered
		D(a,h)anthracene (PAH)	62	720	720	OF-SB04	1/57	south central, open field
		B(g,h,i)perylene (PAH)	NA	2,400	2,400	OF-SB04	1/57	south central, open field
	Pesticides	gamma-BHC (Lindane)	440	4	4	OF-SB06D	1/57	south central, open field
		Aldrin	29	5	5.1	OF-SB03	3/57	1 open field, 2 adjacent toSB01
		Heptachlor	110	1.9	1.9	FCA-SB12	1/57	southwestern, former cleared area
		Heptachlor epoxide	53	2	67	OA-SB01I	10/57	scattered, 3 adjacent to SB01
		Endosulfan I	370000	8.3	36	OA-SB01E	3/57	all adjacent to SB01
		Dieldrin	30	2	16,000	OF-SB03	21/57	scattered
		4-4'-DDE	1700	2.2	2,600	OA-SB01A	49/57	widely scattered, prevalent
		Endrin	18000	9.9	9.9	OA-SB08	1/57	eastern, former disposal area
		4-4'-DDD	2400	2.8	550	OA-SB01A	37/57	widely scattered, prevalent
		Endosulfan Sulfate	NA	2.5	4.2	OF-SB06	2/57	1 south central, 1 western
		4-4'-DDT	1700	1.8	12,000	OA-SB01A	48/57	widely scattered, prevalent
		Endrin Ketone	NA	15	15	OF-SB03	1/57	south central, open field
		Endrin aldehyde	NA	12	12	OF-SB02	1/57	south central, open field
		alpha-Chlordane	1600	1.2	980	OA-SB05	15/57	scattered
		gamma-Chlordane	1600	1.2	840	OA-SB05	10/57	scattered
	PCBs (1)	Aroclor 1248	220	68	24,000	OA-SB01I	9/57	western, surrounding SB01
		Aroclor 1254	220	92	530	OA-SB01	3/57	western, surrounding SB01
	Metals	Aluminum	76,000	1,010	17,600	FCA-SB09	52/52	scattered
		Antimony	31	3.3	31.7	OA-SB08	7/46	scattered
		Arsenic	22	0.39	10.4	OA-SB08	43/52	scattered

TABLE 1-2 (continued)
REMEDIAL INVESTIGATION RESULTS FOR SITE 36
OPERABLE UNIT NO. 6, SITES 36, 43, 44 and 54
FEASIBILITY STUDY, CTO-0219
MCB CAMP LEJEUNE, NORTH CAROLINA

Media	Fraction	Detected Contaminants	Screening Criteria [5]	Site Contamination		Maximum Location	Detection Frequency	Distribution
				Min.	Max.			
Surface Soil (Continued)	Metals (Continued)	Barium	5,400	4.5	141	OA-SB08	51/52	scattered
		Beryllium	150	0.18	0.18	FCA-SB10	1/52	1 detection southwest
		Cadmium	37	0.7	6.3	OA-SB08	8/52	scattered
		Calcium	NA	106	103,000	OF-SB06	51/52	scattered
		Chromium	210	1.6	51.6	OA-SB08	52/52	scattered
		Cobalt	4,700	0.88	9	OA-SB08	10/52	scattered
		Copper	2,900	0.6	445	OA-SB08	39/52	scattered
		Iron	23,000	863	86,200	OA-SB08	52/52	scattered
		Lead	400	4.3	836	OA-SB08	48/52	scattered
		Magnesium	NA	52	1,020	DAD-SB01	52/52	scattered
		Manganese	1,800	2.1	940	OA-SB08	52/52	scattered
		Mercury	23	0.1	2.4	OA-SB05	18/52	scattered
		Nickel	1,600	1	48.3	OA-SB08	26/52	scattered
		Potassium	NA	33.7	676	FCA-SB05	32/52	scattered
		Selenium	390	0.32	0.53	36-SB06D	12/52	scattered
		Silver	390,000	0.6	12	OF-SB04	8/48	3 south central
		Sodium	NA	9.6	358	DAD-SB01	31/52	scattered
		Vanadium	550	2.9	46	OA-SB08	50/52	scattered
		Zinc	23,000	2.1	1,320	OA-SB08	50/52	scattered
Subsurface Soil	Volatiles	Acetone	1,600,000	12	480	GS-SB03	8/62	1 exceeds blank, ground scar area
		1,2-Dichloroethene (total)	63,000	4	4	OA-SB01	1/62	western
		Trichloroethene	2,800	3	5	FDA-SB01	3/62	2 eastern, 1 western
		Benzene	670	3	3	FDA-SB01	1/62	eastern, former disposal area
		Toluene	520,000	5	17	OF-SB06	5/62	south central, open field
		Xylene (total)	210,000	2	6	FDA-SB06	8/62	scattered
	Semivolatiles	1,4-Dichlorobenzene	3,400	97	97	DAB-SB02	1/57	southeastern, drum area
		2-Methylphenol	3,100,000	510	510	DAB-SB01	1/58	southeastern, drum area
		4-Methylphenol	310,000	43	43	DAB-SB01	1/58	southeastern, drum area
		Isophorone	510,000	2,100	2,100	DAB-SB01	1/58	southeastern, drum area
		Naphthalene (PAH)	56,000	41	41	OA-SB01A	1/57	western
		2-Methylnaphthalene	1,600,000	65	85	FDA-SB02	2/57	1 eastern, 1 western
		Phenanthrene (PAH)	NA	48	190	OA-SB07	3/57	scattered
		Di-n-butylphtalate	6,100,000	56	56	OA-SB01	1/58	western
		Fluoranthene (PAH)	2,300,000	130	320	OA-SB07	3/57	2 eastern, 1 south central
		Pyrene (PAH)	2,300,000	59	320	OA-SB07	5/57	scattered
		Butylbenzylphtalate	12,000,000	42	170	OA-SB03	3/57	scattered
		B(a)anthracene (PAH)	620	69	140	OA-SB07	3/57	scattered
		Chrysene (PAH)	62,000	41	200	OA-SB07	5/57	3 eastern, former disposal area
		B(b)fluoranthene (PAH)	620	44	170	OA-SB07	5/57	4 eastern, 1 south central
	Semivolatiles	B(k)fluoranthene (PAH)	6,200	42	68	OA-SB07	3/57	eastern, former disposal area
		Benzo(a)pyrene (PAH)	62	72	450	GS-SB03	4/57	3 eastern, 1 northern
		I(1,2,3-cd)pyrene (PAH)	620	48	110	OA-SB07	3/57	eastern, former disposal area
		B(g,h,i)perylene (PAH)	NA	42	89	OA-SB07	2/57	eastern, former disposal area
	Pesticides	gamma-BHC (Lindane)	440	4	4	OF-SB06D	1/56	open field
		Aldrin	29	1.5	16	36-GW11	5/56	3 southeastern, 2 eastern

TABLE 1-2 (continued)
REMEDIAL INVESTIGATION RESULTS FOR SITE 36
OPERABLE UNIT NO. 6, SITES 36, 43, 44 and 54
FEASIBILITY STUDY, CTO-0219
MCB CAMP LEJEUNE, NORTH CAROLINA

Media	Fraction	Detected Contaminants	Screening Criteria [5]	Site Contamination		Maximum Location	Detection Frequency	Distribution
				Min.	Max.			
Subsurface Soil (Continued)	Pesticides (continued)	Heptachlor Epoxide	53	3.4	14	36-GW11	3/56	3 eastern, former disposal area
		Dieldrin	30	2.2	1,200	FDA-SB05	17/56	scattered
		4,4'-DDE	1,700	2.3	1,700	OA-SB01A	29/56	widely scattered, prevalent
		Endrin	18,000	2.4	5	OF-SB06B	5/56	scattered
		Endosulfan II	NA	2.0	2.0	OF-SB06B	1/56	south central, open field
		4,4'-DDD	2,400	2.3	1,300	FDA-SB05	30/56	widely scattered, prevalent
		4,4'-DDT	1,700	2.8	3,100	OA-SB01A	28/56	widely scattered, prevalent
		Endrin Aldehyde	NA	3.5	32	FDA-SB05	3/56	2 south central, 1 eastern
		alpha-Chlordane	1,600	1.6	750	36-GW11	12/56	primarily eastern
		gamma-Chlordane	1,600	2.3	770	36-GW11	9/56	primarily eastern
	PCBs (1)	Aroclor 1248	220	19	850	OA-SB01	5/56	western, adjacent to SB01
	Metals	Aluminum	76,000	752	19,700	FDA-SB05	51/51	scattered
		Antimony	31	4.9	21.6	36-GW11	7/44	eastern
		Arsenic	22	0.2	25.9	FDA-SB01	41/51	eastern and central
		Barium	5,400	2	475	36-GW11	50/51	scattered
		Beryllium	150	0.17	0.18	FCA-SB10	2/51	southwestern
		Cadmium	37	0.7	42.8	36-GW11	11/51	eastern and central
		Calcium	NA	15	46,300	OF-SB06B	49/51	scattered
		Chromium	210	1.4	71.9	36-GW11	50/51	eastern and central
		Cobalt	4,700	0.48	9.4	OA-SB07	16/51	scattered
		Copper	2,900	0.5	1,320	OF-SB06B	31/51	scattered
		Iron	23,000	408	132,000	36-GW11	51/51	scattered
		Lead	400	1.2	2,680	OA-SB07	50/51	scattered
		Magnesium	NA	20.2	2,700	36-GW11	51/51	scattered
		Manganese	1,800	0.85	1,260	FDA-SB01	47/51	scattered
		Mercury	23	0.12	3.9	OA-SB07	13/51	east/southeastern
		Nickel	1,600	1.1	72.1	DAD-SB02	24/51	scattered
		Potassium	NA	47.2	1,640	FDA-SB06	32/51	scattered
		Selenium	390,000	0.4	1.2	OF-SB06	4/51	southcentral
		Silver	390	0.55	0.89	36-GW11	3/48	east central
		Sodium	NA	5.2	501	FDA-SB06	34/51	scattered
		Vanadium	550	1.6	52.6	OF-SB06	49/51	scattered
		Zinc	23,000	0.9	2,580	FDA-SB05	41/51	scattered
Groundwater	Volatiles (2)	Methylene Chloride	5	1	1	36-GW10	1/29	does not exceed standard
		1,2-Dichloroethene (total)	70	4	37	36-GW10IW	8/29	none exceed standard
		Trichloroethene	2.8	3	97	36-GW10IW	10/29	6 exceed standard, northern
		Tetrachloroethene	0.7	1	2	36-GW10IW	2/29	both exceed standard, northern
		1,1,2,2-Tetrachloroethane	0.17	3	10	36-GW10IW	6/29	northern, former ground scar area
	Semivolatiles	ND	--				0/17	
	Pesticides	4,4'-DDD	0.14	0.06	0.06	36-GW10	1/18	northern, during Round One only
	PCBs	ND	--				0/18	
	Total Metals	Iron	300	3.3	16,900	36-GW02	20/22	12 exceed standard, scattered
		Manganese	50	19.2	3,180	36-GW09	20/22	12 exceed standard, scattered
		Mercury	1.1	1.4	1.4	36-TW02	1/22	1 exceeds standard, southern

TABLE 1-2 (continued)
REMEDIAL INVESTIGATION RESULTS FOR SITE 36
OPERABLE UNIT NO. 6, SITES 36, 43, 44 and 54
FEASIBILITY STUDY, CTO-0219
MCB CAMP LEJEUNE, NORTH CAROLINA

Media	Fraction	Detected Contaminants	Screening Criteria [5]	Site Contamination		Maximum Location	Detection Frequency	Distribution
				Min.	Max.			
Surface Water(3)	Volatiles	1,2-Dichloroethene (total)	2,240	7	7	36-SW02	1/7	UT, upgradient of open field
	Semivolatiles	ND	--				0/7	
	Pesticides	ND	--				0/7	
	PCBs	ND	--				0/7	
	Metals (4)	Copper	6.5	56.5	56.5	36-SW01	1/7	1 exceeds fresh standard, not background
		Iron	1,000	967	4840	36-SW03	7/7	3 exceed fresh standard and background
		Nickel	8.3	16.4	31.4	36-SW02	4/7	1 exceeds salt standard
Sediment	Volatiles	Tetrachloroethane	NA	4	4	36-SD04	1/13	near mouth of UT at BC
	Semivolatiles	Diethylphthalate	NA	330	2,135	36-SD05	3/13	UT and near mouth of UT
		Anthracene	85	46	46	36-SD04	1/13	does not exceed standard, UT
		Di-n-butylphthalate	NA	218	218	36-SD06	1/13	BC, adjacent to ground scar area
		Pyrene (PAH)	350	316	316	36-SD02	1/13	UT, does not exceed standard
	Pesticides	Aldrin	NA	0.9	0.9	36-SD01	1/13	UT, upgradient
		Dieldrin	NA	0.8	52	36-SD06	3/13	2 from BC, minimum from UT
		4,4'-DDE	2	32	1,200	36-SD05	9/13	9 exceed standard, higher in BC
		Endrin	0.02	6.6	6.6	36-SD02	1/13	UT, upgradient of open field
		4,4'-DDD	2	14	1,140	36-SD05	12/13	12 exceed standard
		Endosulfan Sulfate	NA	3	3	36-SD02	1/13	UT, upgradient of open field
		4,4'-DDT	1	3	46	36-SD05	11/13	11 exceed standard
		Endrin Ketone	NA	11	11	36-SD03	1/13	UT, adjacent to open field
		Endrin Aldehyde	NA	3.5	7.6	36-SD05	2/13	1 from BC, 1 from UT
		alpha-Chlordane	0.5	6.5	13	36-SD07	2/13	2 exceed standard, upgradient BC
	PCBs	ND	--				0/13	
	Metals (4)	Cadmium	5	1.4	8.7	36-SD02	2/15	1 exceeds standard and background, UT
		Lead	35	7.1	15,100	36-SD06	12/15	7 exceed standard, 1 exceeds background
		Mercury	0.15	0.2	0.7	36-SD04	3/4	3 exceed standard, 11 rejected
		Nickel	30	2.1	77.1	36-SD03	11/15	1 exceeds standard, from UT
		Zinc	120	25.3	140	36-SD02	5/5	1 exceeds standard, not background, UT

Notes:

- Concentrations are presented in ug/L for liquid and ug/kg for solids (ppb), metal concentrations for soils and sediments are presented in mg/kg (ppm).

(1) PCB contaminated soil was removed during the removal action that OHM conducted in 1997.

(2) An additional round of groundwater samples were collected from wells which exhibited concentrations of volatiles during the first round.

(3) Surface water detections were compared to appropriate NCWQS and NOAA screening values, based upon the observed percentage of saltwater at each sampling location.

(4) Total metals in surface water and sediment were compared to the range of positve detections in upgradient samples at MCB, Camp Lejeune.

(5) Screening criteria are provided as a reference point and are Region IX Residential PRGs for surface and subsurface soil, NCWQS for groundwater, and NOAA for surface water and sediment

BC - Brinson Creek
BEHP - bis(2-ethylhexyl)phthalate
NA - Not applicable
NCWQS - North Carolina Water Quality Standard
ND - Not detected
NOAA - National Oceanic and Atmospheric Administration
MCL - Federal Maximum Contaminant Level
PAH - Polynuclear aromatic hydrocarbon
UT - Unnamed Tributary

Table 1-3
REMEDIAL INVESTIGATION RESULTS FOR SITE 43
OPERABLE UNIT NO. 6, SITES 36, 43, 44 and 54
FEASIBILITY STUDY, CTO-0219
MCB CAMP LEJEUNE, NORTH CAROLINA

Media	Fraction	Detected Contaminants	Screening Criteria [3]	Site Contamination		Maximum Location	Detection Frequency	Distribution
				Min.	Max.			
Surface Soil	Volatiles	ND	--				0/7	
	Semivolatiles	4-Methylphenol	310,000	120	120	DA1-SB02	1/28	northeastern portion of site
		2-Methylnapthalene	1,600,000	74	74	WA-SB01A	1/28	clearing adjacent to 43-GW01
		Acenaphthylene	NA	71	71	WA-SB01A	1/28	clearing adjacent to 43-GW01
		Acenaphthene (PAH)	3,700,000	45	2,100	WA-SB01A	3/28	clearing adjacent to 43-GW01
		Dibenzpfuran	290,000	35	870	WA-SB01A	2/28	clearing adjacent to 43-GW01
		Fluorene (PAH)	2,600,000	53	1,700	WA-SB01A	3/28	clearing adjacent to 43-GW01
		Phenanthrene (PAH)	NA	54	5,900	WA-SB01A	8/28	clearing adjacent to 43-GW01
		Anthracene (PAH)	22,000,000	44	820	WA-SB01A	3/28	clearing adjacent to 43-GW01
		Carbazole	NA	99	350	WA-SB01A	5/28	clearing adjacent to 43-GW01
		Fluoranthene (PAH)	2,300,000	49	60,000	WA-SB01A	10/28	clearing adjacent to 43-GW01
		Pyrene (PAH)	2,300,000	49	64,000	WA-SB01A	10/28	clearing adjacent to 43-GW01
		Butylbenzylphthalate	12,000,000	50	420	OA-SB03	3/28	maximum northeast of clearing
		B(a)anthracene (PAH)	620	51	40,000	WA-SB01A	9/28	clearing adjacent to 43-GW01
		Chrysene (PAH)	62,000	110	46,000	WA-SB01A	9/28	clearing adjacent to 43-GW01
		B(b)fluoranthene (PAH)	620	44	52,000	WA-SB01A	10/28	clearing adjacent to 43-GW01
		B(k)fluoranthene (PAH)	6,200	57	20,000	WA-SB01A	9/28	clearing adjacent to 43-GW01
		Benzo(a)pyrene (PAH)	62	79	39,000	WA-SB01A	9/28	clearing adjacent to 43-GW01
		I(1,2,3-cd)pyrene (PAH)	620	42	27,000	WA-SB01A	10/28	clearing adjacent to 43-GW01
		D(a,h)anthracene (PAH)	62	47	1,200	WA-SB01A	8/28	clearing adjacent to 43-GW01
		B(g,h,i)perylene (PAH)	NA	87	24,000	WA-SB01A	9/28	clearing adjacent to 43-GW01
	Pesticides	Heptachlor epoxide	53	2	2	WA-SB01A	1/7	clearing adjacent to 43-GW01
		4-4'-DDE	1,700	5.7	1,000	DA1-SB03	5/7	maximum northeast
		4-4'-DDD	2,400	3,000	3,000	DA1-SB03	1/7	northeastern portion of site
		4-4'-DDT	1,700	10	1,000	DA1-SB03	4/7	maximum northeast
		Endrin aldehyde	NA	5.4	5.4	DA2-SB03	1/7	north of clearing
	PCBs	ND	--	--	--	--	0/7	
	Metals	Cadmium	37	0.7	1.7	WA-SB02	2/21	separate areas
		Chromium	210	1.1	106	DA1-SB02	21/21	scattered

Table 1-3 (continued)
REMEDIAL INVESTIGATION RESULTS FOR SITE 43
OPERABLE UNIT NO. 6, SITES 36, 43, 44 and 54
FEASIBILITY STUDY, CTO-0219
MCB CAMP LEJEUNE, NORTH CAROLINA

Media	Fraction	Detected Contaminants	Screening Criteria [3]	Site Contamination		Maximum Location	Detection Frequency	Distribution
				Min.	Max.			
Surface Soil (continued)	Metals (continued)	Copper	2,900	0.5	55.7	DA2-SB01	17/21	north of clearing
		Lead	400	4.3	246	DA2-SB01	20/21	scattered
		Manganese	1,800	2.8	189	DA2-SB01	21/21	scattered
		Mercury	23	0.1	0.5	DA1-SB02	3/21	drum areas
		Nickel	1,600	1.1	5	DA2-SB01	8/21	scattered
		Zinc	23,000	1.5	595	DA1-SB02	21/21	scattered
Subsurface Soil	Volatiles	ND	--				0/7	
	Semivolatiles	Phenanthrene (PAH)	NA	430	430	WA-SB02	1/20	clearing adjacent to 43-GW01
		Carbazole	NA	73	73	WA-SB02	1/20	clearing adjacent to 43-GW01
		Fluoranthene (PAH)	2,300,000	850	850	WA-SB02	1/20	clearing adjacent to 43-GW01
		Pyrene (PAH)	2,300,000	1,800	1,800	WA-SB02	1/20	clearing adjacent to 43-GW01
		Butylbenzylphtalate	12,000,000	39	440	OA-SB03	2/20	north of clearing
		B(a)anthracene (PAH)	620	390	390	WA-SB02	1/20	clearing adjacent to 43-GW01
		Chrysene	62,000	740	740	WA-SB02	1/20	clearing adjacent to 43-GW01
		B(b)fluoranthene (PAH)	620	780	780	WA-SB02	1/20	clearing adjacent to 43-GW01
		B(k)fluoranthene (PAH)	6,200	340	340	WA-SB02	1/20	clearing adjacent to 43-GW01
		Benzo(a)pyrene (PAH)	62	570	570	WA-SB02	1/20	clearing adjacent to 43-GW01
		I(1,2,3-cd)pyrene (PAH)	620	890	890	WA-SB02	1/20	clearing adjacent to 43-GW01
		B(g,h,i)perylene (PAH)	NA	790	790	WA-SB02	1/20	clearing adjacent to 43-GW01
	Pesticides	4,4'-DDE	1,700	9	9	DA1-SB03	1/7	northeastern portion or site
		4,4'-DDD	2,400	1,200	1,200	DA1-SB03	1/7	northeastern portion or site
		4,4'-DDT	1,700	45	45	DA1-SB03	1/7	northeastern portion or site
	PCBs	ND	--				0/7	
	Metals	Copper	2,900	0.4	3.6	OA-SB01	6/20	north of clearing
Groundwater	Volatiles	ND	--				0/10	
	Semivolatiles	4-Methylphenol	3.5	2	2	43-TW04	1/10	north near SHC and EC
	Pesticides	ND	--				0/10	
	PCBs	ND	--				0/6	
	Total Metals	Iron	300	109	33,800	43-TW04	10/10	8 exceed standard, scattered
		Manganese	50	4.4	107	43-TW04	10/10	2 exceed standard, central and north

Table 1-3 (continued)
REMEDIAL INVESTIGATION RESULTS FOR SITE 43
OPERABLE UNIT NO. 6, SITES 36, 43, 44 and 54
FEASIBILITY STUDY, CTO-0219
MCB CAMP LEJEUNE, NORTH CAROLINA

Media	Fraction	Detected Contaminants	Screening Criteria [3]	Site Contamination		Maximum Location	Detection Frequency	Distribution
				Min.	Max.			
Surface Water (1)	Volatiles	1,2-Dichloroethene (total)	2,240	2	2	EC-SW02	2/6	neither exceed standard, EC
	Semivolatiles	ND	--				0/6	
	Pesticides	4,4-DDE	0.14	0.1	0.1	EC-SW01	2/6	do not exceed standard, 1 EC, 1 SHC
		4,4-DDD	0.025	0.1	0.6	EC-SW01	3/6	3 exceed standard, 1 EC, 2 SHC
	PCBs	ND	--				0/6	
	Metals (2)	Copper	2.9	1.8	3.2	EC-SW02	3/6	1 exceed standard, not background
Sediment	Volatiles	Carbon Disulfide	NA	3	26	EC-SD02	3/12	2 from EC and 1 from SHC
	Semivolatiles	4-Methylphenol	NA	210	210	SHC-SD03	1/12	adjacent to study area, SHC
		Pyrene (PAH)	350	200	200	EC-SD02	1/12	does not exceed standard, EC
		Benzo(a)pyrene (PAH)	400	290	1,900	SHC-SD02	4/12	3 exceed standard, 2 EC and 1 SHC
	Pesticides	4,4'-DDE	2	12	8,900	SHC-SD04	10/12	10 exceed standard, scattered
		Endrin	NA	12	16	EC-SD01	2/11	1 detection EC and 1 SHC
		4,4'-DDD	2	5.6	37,000	SHC-SD04	11/12	11 exceed standard, scattered
		4,4'-DDT	1	9.3	180	EC-SD01	6/12	6 exceed standard, scattered
		alpha-Chlordane	0.5	7.2	49	SHC-SD03	8/12	8 exceed standard, scattered
		gamma-Chlordane	0.5	9.6	74	SHC-SD03	9/12	9 exceed standard, scattered
	PCBs	ND	--				0/9	
	Metals (2)	Lead	35	6.1	206	SHC-SD03	12/12	7 exceed standard, none exceed background
		Mercury	0.15	0.4	0.7	EC-SD01	2/12	2 exceed standard
		Silver	1	1.9	2.8	EC-SD02	2/12	2 exceed standard, neither exceed BB
		Zinc	120	1.5	338	EC-SD01	12/12	4 exceed standard, none exceed background

Notes:

- Concentrations are presented in µg/L for liquid and µg/kg for solids (ppb), metal concentrations for soils and sediments are presented in mg/kg (ppm).
(1) Positive contaminant detections in surface water were compared to appropriate NCWQS and NOAA saltwater screening values.
(2) Total metals in surface water and sediment were also compared to the range of positive detections in upgradient samples at MCB, Camp Lejeune.
(3) Screening criteria are provided as a reference point and are Region IX Residential PRGs for surface and subsurface soil, NCWQS for groundwater, and NOAA for surface water and sediment

ARAR - Applicable or Relevant and Appropriate Requirements
BC - Brinson Creek
BEHP - bis(2-ethylhexyl)phthalate
NCWQS - North Carolina Water Quality Standard
EC - Edwards Creek
NA - Not applicable
ND - Not detected
NOAA - National Oceanic and Atmospheric Administration

Table 1-4
REMEDIAL INVESTIGATION RESULTS FOR SITE 44
OPERABLE UNIT NO. 6, SITES 36, 43, 44 and 54
FEASIBILITY STUDY, CTO-0219
MCB CAMP LEJEUNE, NORTH CAROLINA

Media	Fraction	Detected Contaminants	Screening Criteria [3]	Site Contamination		Maximum Location	Detection Frequency	Distribution
				Min.	Max.			
Surface Soil	Volatiles	ND	--				0/13	
	Semivolatiles	bis(2-Chloroethyl)ether	210	550	550	OA-SB06	1/13	eastern
		2,6-Dinitrotoluene	61,000	380	380	OA-SB02	1/13	open area
		I(1,2,3-cd)pyrene (PAH)	620	220	220	OA-SB05	1/13	east central
		B(g,h,i)perylene (PAH)	NA	57	200	OA-SB05	2/13	east central
	Pesticides	4-4'-DDE	1,700	10	140	OA-SB05	4/13	scattered
		4-4'-DDD	2,400	7.4	7.4	OA-SB03	1/13	near march area
		4-4'-DDT	1,700	4.6	4.5	OA-SB03	4/13	scattered
	PCBs	ND	--				0/7	
	Metals	Arsenic	26.2	0.8	4.9	WA-SB02	13/13	evenly dispersed
		Chromium	210	4.2	16.4	OA-SB01	12/13	evenly dispersed
		Copper	2,900	0.9	910	OA-SB03	12/13	near marsh area
		Lead	400	5.9	31.7	OA-SB03	11/13	near marsh area
		Manganese	1,800	4.9	44.2	OA-SB03	13/13	evenly dispersed
		Zinc	23,000	2.7	156	OA-SB03	13/13	max. near marsh
Subsurface Soil	Volatiles	ND	--				0/13	
	Semivolatiles	I(1,2,3-cd)pyrene (PAH)	620	55	130	OA-SB05	2/13	east central
		B(g,h,i)perylene (PAH)	NA	40	120	OA-SB05	3/13	east central
	Pesticides	4-4'-DDE	1,700	3.2	370	44-GW01DW	4/13	scattered
		4-4'-DDD	2,400	5.6	2,500	44-GW01DW	4/13	scattered
		4-4'-DDT	1,700	150	150	44-GW01DW	1/13	central
	PCBs	ND	--				0/7	
	Metals	Arsenic	26	0.3	2.5	WA-SB04	10/13	west central
		Copper	2,900	0.4	3	44-GW01DW	9/13	central
		Lead	400	1.4	9	44-GW01DW	11/13	central
		Manganese	1,800	1.3	9.3	WA-SB02	13/13	2 exceed BB
		Nickel	1,600	1.3	15.8	44-GW01DW	6/13	2 exceed BB
		Zinc	23,000	0.8	10.8	WA-SB04	12/13	west central
Groundwater	Volatiles	Vinyl Chloride	0.015	10	10	44-TW01	1/9	1 exceeds standard, marsh area
		1,2-Dichloroethene (total)	70	15	15	ww-TW01	1/9	does not exceed standard, marsh
		Trichloroethene	2.8	1	1	44-TW01	1/9	does not exceed standard, marsh
		Tetrachloroethene	0.17	1	1	44-GW03	1/9	1 exceeds standard, southwestern

Table 1-4 (continued)
REMEDIAL INVESTIGATION RESULTS FOR SITE 44
OPERABLE UNIT NO. 6, SITES 36, 43, 44 and 54
FEASIBILITY STUDY, CTO-0219
MCB CAMP LEJEUNE, NORTH CAROLINA

Media	Fraction	Detected Contaminants	Screening Criteria [3]	Site Contamination		Maximum Location	Detection Frequency	Distribution
				Min.	Max.			
Groundwater (continued)	Semivolatiles	Naphthalene (PAH)	21	71	71	44-GW03	1/9	1 exceed standard, southwestern
		2-Methylnaphthalene	28	4	4	44-GW03	1/9	southwestern, near access road
		Acenaphthene (PAH)	80	13	13	44-GW03	1/9	does not exceed standard
		Dibenzofuran	28	6	6	44-GW03	1/9	southwestern, near access road
		Fluorene (PAH)	280	7	7	44-GW03	1/9	does not exceed standard
		Phenanthrene (PAH)	210	7	7	44-GW03	1/9	does not exceed standard
		Carbazole	NA	4	4	44-GW03	1/9	southwestern, near access road
	Pesticides	ND	--				0/9	
	PCBs	ND	--				0/9	
	Total Metals	Iron	300	285	72,900	44-GW04	9/9	8 exceed standard, scattered
		Manganese	50	21.6	241	44-GW04	8/9	5 exceed standard, scattered
Surface Water (1)	Volatiles	Vinyl Chloride	525	7	38	EC-SW08	8/16	max. upgradient, decreases by site
		1,1-Dichloroethene	303	1	2	EC-SW06	3/16	each detection upgradient
		1,2-Dichloroethene (total)	NA	2	150	EC-SW01	14/16	max. upgradient, decrease by site
		Trichloroethene	92.4	2	66	EC-SW01	14/16	max. upgradient, decreases by site
		1,1,2-Trichloroethane	940	1	1	EC-SW08	1/16	upgradient
		1,1,2,2-Tetrachloroethane	10.8	5	42	EC-SW08	12/16	9 exceed standard, max. upgradient
	Semivolatiles	Phenol	58	1	1	UT-SW01	1/8	low detection, UT
	Pesticides	ND	--				0/8	
	PCBs	ND	--				0/8	
	Metals (3)	Lead	1.3	0.8	11.2	EC-SW02	2/8	1 exceeds standard and background
		Zinc	58.9	17.3	61.3	EC-SW03	7/8	1 exceeds standard, not background
Sediment	Volatiles	Acetone	NA	15	610	UT-SD01	11/16	1 exceeds blank cont. level (240)
	Semivolatiles	Pentachlorophenol	NA	340	740	EC-SD01	2/16	up and downgradient, EC
		Penanthrene (PAH)	225	49	250	UT-SD03	5/16	primarily UT
		Carbazole	NA	79	79	UT-SD03	1/16	near confluence with EC, UT
		Fluoranthene (PAH)	600	95	740	UT-SD03	6/16	1 exceeds standard, UT
		Pyrene (PAH)	350	42	490	UT-SD03	7/16	1 exceeds standard, UT
		Butylbenzylphthalate	NA	48	48	UT-SD02	1/16	by concrete outflow/culvert, UT
		B(a)anthracene (PAH)	230	50	170	UT-SD03	3/16	do not exceed standard, UT
		Chrysene (PAH)	400	44	460	UT-SD03	7/16	1 exceeds standard, UT
		B(b)fluoranthene (PAH)	NA	52	600	UT-SD03	6/16	UT and downgradient of UT

Table 1-4 (continued)
REMEDIAL INVESTIGATION RESULTS FOR SITE 44
OPERABLE UNIT NO. 6, SITES 36, 43, 44 and 54
FEASIBILITY STUDY, CTO-0219
MCB CAMP LEJEUNE, NORTH CAROLINA

Media	Fraction	Detected Contaminants	Screening Criteria [3]	Site Contamination		Maximum Location	Detection Frequency	Distribution
				Min.	Max.			
Sediment (continued)	Semivolatiles (continued)	B(k)fluoranthene (PAH)	NA	49	200	UT-SD03	3/16	all detections from UT
		Benzo(a)pyrene (PAH)	400	56	300	UT-SD03	3/16	do not exceed standard, UT
		B(g,h,i)perylene (PAH)	NA	49	71	UT-SD02	2/16	1 detection EC and 1 UT
	Pesticides	Aldrin	NA	2.6	2.6	UT-SD03	1/14	UT
		Heptachlor Epoxide	NA	5.2	5.2	UT-SD03	1/14	UT
		4-4'-DDE	2	9.3	310	UT-SD02	16/16	16 exceed standard
		4-4'-DDD	2	5.5	770	UT-SD02	16/16	16 exceed standard
		4-4'-DDT	1	2.5	130	EC-SD05	10/14	10 exceed standard, prevalent
		alpha-Chlordane	.05	2	14	EC-SD05	13/16	13 exceed standard, prevalent
		gamma-Chlordane	.05	2.7	16	EC-SD05	13/16	13 exceed standard, prevalent
	PCBs	ND	--				0/13	
	Metals (2)	Lead	35	8.4	56.3	UT-SD03	16/16	3 exceed standard, not background
		Zinc	120	6.3	144	EC-SD05	16/16	1 exceeds standard, not background

Notes:

- Concentrations are presented in ug/L for liquid and ug/kg for solids (ppb), metal concentrations for soils and sediments are presented in mg/kg (ppm).

(1) Surface water detections were compared to appropriate NCWQS and NOAA screening values, based upon the observed percentage of saltwater at each sampling location.

(2) Total metals in surface water and sediment were compared to the range of positive detections in upgradient samples at MCB, Camp Lejeune.

(3) Screening criteria are provided as a reference point and are Region IX Residential PRGs for surface and subsurface soil, NCWQS for groundwater, and NOAA for surface water and sediment

BEHP - bis(2-ethylhexyl)phthalate
EC - Edwards Creek
NA - Not applicable
NCWQS - North Carolina Water Quality Standard
UT - Unnamed Tributary
NOAA - National Oceanic and Atmospheric Administration
MCL - Federal Maximum Contaminant Level
PAH - Polynuclear aromatic hydrocarbon

Table 1-5
REMEDIAL INVESTIGATION RESULTS FOR SITE 54
OPERABLE UNIT NO. 6, SITES 36, 43, 44 and 54
FEASIBILITY STUDY, CTO-0219
MCB CAMP LEJEUNE, NORTH CAROLINA

Media	Fraction	Detected Contaminants	Screening Criteria [1]	Site Contamination		Maximum Location	Detection Frequency	Distribution
				Min.	Max.			
Surface Soil	Volatiles	ND	--				0/11	
	Semivolatiles	n-Nitrosodiphenylamine	99,000	160	160	DD-SB01	1/11	south, drainage ditch
		Phenanthrene (PAH)	NA	98	120	DD-SB03	2/11	south, drainage ditch
		Fluoranthene (PAH)	2,300,000	62	67	DD-SB01	2/11	south, drainage ditch
		Pyrene (PAH)	2,300,000	99	150	DD-SB01	2/11	south, drainage ditch
		Butylbenzylphthalate	12,000,000	50	320	DD-SB04	2/11	south, drainage ditch
		Di-n-octylphthalate	NA	150	150	SB08	1/11	southwest of burn pit
	PCBs	ND	--				0/4	
	Metals	Chromium	210	5.7	9.1	DD-SB04	4/4	drainage ditch
		Zinc	23,000	8.3	16.7	DD-SB04	4/4	2 exceed BB, drainage ditch
Subsurface Soil	Volatiles	Acetone	1,600,000	1,200	1,200	DD-SB05	1/19	1 exceeds blank, drainage ditch
		Xylene (total)	210,000	12	300	SB08	2/19	southwest of burn pit
	Semivolatiles	Naphthalene (PAH)	56,000	760	760	SB08	1/19	southwest of burn pit
		2-Methylnaphthalene	1,600,000	1,700	1,700	DD-SB05	1/19	south, drainage ditch
		Acenaphthene (PAH)	3,700,000	94	94	DD-SB05	1/19	south, drainage ditch
		Fluorene (PAH)	2,600,000	420	420	DD-SB05	1/19	south, drainage ditch
		Phenanthrene (PAH)	NA	160	160	DD-SB05	1/19	south, drainage ditch
		Pyrene (PAH)	2,300,000	43	43	DD-SB05	1/19	south, drainage ditch
		Butylbenzylphtalate	12,000,000	56	56	DD-SB03	1/19	south, drainage ditch
	PCBs	ND	--				0/8	
	Metals	Lead	400	1.4	11.5	DD-SB03	8/8	scattered
		Nickel	1,600	1.1	6.2	DD-SB02	6/8	south and southwest
Groundwater	Volatiles	Carbon Disulfide	700	4	4	54-GW10	1/17	does not exceed standard, east
		1,2-Dichloroethene (total)	NA	5	23	54-TW03	3/17	none exceed standard, southeast
		Trichloroethene	2.8	1	1	54-TW03	1/17	does not exceed standard, southeast
		Benzene	1	5	40	54-TW04	6/17	6 exceed standard, south and east
		Toluene	1,000	22	83	54-TW03	2/17	do not exceed standard, southeast
		Ethylbenzene	29	6	26	54-TW04	3/17	none exceed standard, southeast
		Xylene (total)	530	27	130	54-TW03	3/17	none exceed standard, southeast

Table 1-5 (continued)
REMEDIAL INVESTIGATION RESULTS FOR SITE 54
OPERABLE UNIT NO. 6, SITES 36, 43, 44 and 54
FEASIBILITY STUDY, CTO-0219
MCB CAMP LEJEUNE, NORTH CAROLINA

Media	Fraction	Detected Contaminants	Screening Criteria (1)	Site Contamination		Maximum Location	Detection Frequency	Distribution
				Min.	Max.			
Groundwater (continued)	Semivolatiles	Phenol	300	1	1	54-TW04	1/17	does not exceed standard, east
		Nitrobenzene	NA	2	2	54-TW04	1/17	east of burn pit, adjacent to UST
		2,4-Dimethylphenol	140	3	3	54-TW06	1/17	east of burn pit, adjacent to UST
		Naphthalene (PAH)	21	1	240	54-TW03	7/17	5 exceed standard, south and east
		2-Methylnaphthalene	28	1	160	54-TW03	6/17	south and east, 3 of 6 at UST
		Diethylphthalate	5,000	1	37	54-TW03	5/17	none exceed standard, southeast
		Anthracene (PAH)	2,100	1	1	54-TW05	1/17	does not exceed standard, UST
		Di-n-butylphthalate	700	1	2	54-GW09	2/17	do not exceed standard, scattered
	Pesticides	ND	--				0/1	
	PCBs	ND	--				0/13	
		Iron	300	193	74,100	54-TW03	12/13	9 exceed standard, scattered
	Metals	Lead	15	1.9	39.7	54-GW02	5/13	1 exceeds standard, upgradient
		Manganese	50	25.2	1,280	54-GW03	13/13	9 exceed standard, scattered

Notes:
- Concentrations are presented in ug/L for liquid and ug/kg for solids (ppb), metal concentrations for soils and sediments are presented in mg/kg (ppm).

(1) Screening criteria are provided as a reference point and are Region IX Residential PRGs for surface and subsurface soil and NCWQS for groundwater

ARAR - Applicable or Relevant and Appropriate Requirements
NA - Not applicable
NCWQS - North Carolina Water Quality Standard
ND - Not detected
NOAA - National Oceanic and Atmospheric Administration
MCL - Federal Maximum Contaminant Level
PAH - Polynuclear aromatic hydrocarbon

TABLE 1-6

SITE 54 LONG TERM MONITORING DATA [1]

OPERABLE UNIT NO. 6, SITES 36, 43, 44 and 54

FEASIBILITY STUDY, CTO-0219

MCB CAMP LEJEUNE, NORTH CAROLINA

Date of Sampling Event	Semivolatiles Detected Above NCWQS	Result	NCWQS Screening Criteria	Location
January 2000	ND	--	NA	NA
April 2000	ND	--	NA	NA
July 2000	Bis(2-Ethylhexyl) Phthalate	6J	3	54-GW12
October 2000	Bis(2-Ethylhexyl) Phthalate	5J	3	54-GW09
January 2001	Bis(2-Ethylhexyl) Phthalate	17	3	54-GW10
October 2001	4-Methylphenol	350 J	3.5 [2]	54-GW11
	Naphthalene	1200 J	21	54-GW11
	Phenol	600 J	300	54-GW11
January 2002	Bis(2-Ethylhexyl) Phthalate	210	3	54-GW11

- All concentrations reported in ug/L

Notes:

(1) There were no VOC detections exceeding the NCWQS during the shown reporting periods

(2) Interim Standard

J - Analyte was positively identified, value is estimated

NA - Not Applicable

NCWQS - North Carolina Water Quality Standards

ND - None Detected above NCWQS

TABLE 2-1
POTENTIAL LOCATION-SPECIFIC ARARs
OPERABLE UNIT NO. 6, SITES 36, 43, 44 AND 54
FEASIBILITY STUDY, CTO-0219
MCB CAMP LEJEUNE, NORTH CAROLINA

Potential Location-Specific ARAR	General Citation	ARAR Evaluation
National Historic Preservation Act of 1966 - requires action to take into account effects on properties included in or eligible for the National Register of Historic Places and to minimize harm to National Historic Landmarks.	16 USC 470, 40 CFR 6.301(b), and 36 CFR 800	No known historic properties are within or near OU No. 6, therefore, this act will not be considered an ARAR.
Archeological and Historic Preservation Act - establishes procedures to provide for preservation of historical and archeological data which might be destroyed through alteration of terrain.	16 USC 469, and 40 CFR 6.301(c)	No known historical or archeological data is known to be present at OU No. 6, therefore, this act will not be considered an ARAR.
Historic Sites, Buildings and Antiquities Act - requires action to avoid undesirable impacts on landmarks on the National Registry of Natural Landmarks.	16 USC 461467, and 40 CFR 6.301(a)	No known historic sites, buildings or antiquities are within or near OU No. 6, therefore, this act will not be considered as an ARAR.
Fish and Wildlife Coordination Act - requires action to protect fish and wildlife from actions modifying streams or areas affecting streams.	16 USC 661–666	Brinson Creek, Edwards Creek and unamed tributarites are loacted on OU No. 6. If remedial actions are implemented to modify these waterways, this act will be considered an ARAR.
Federal Endangered Species Act - requires action to avoid jeopardizing the continued existence of listed endangered species or modification of their habitat.	16 USC 1531, 50 CFR 200, and 50 CFR 402	Many protected species have been sited near and on MCB Camp Lejeune such as the American alligator, the Bachmans sparrow, the Black skimmer, the Green turtle, the Loggerhead turtle, the piping plover, the Red-cockaded woodpecker, and the rough-leaf loosestrife (LeBlond, 1991),(Fussell, 1991),(Walters, 1991). Therefore, this will be considered an ARAR.

TABLE 2-1 (continued)
POTENTIAL LOCATION-SPECIFIC ARARs
OPERABLE UNIT NO. 6, SITES 36, 43, 44 AND 54
FEASIBILITY STUDY, CTO-0219
MCB CAMP LEJEUNE, NORTH CAROLINA

Potential Location-Specific ARAR	General Citation	ARAR Evaluation
North Carolina Endangered Species Act – per the North Carolina Wildlife Resources Commission. Similar to the Federal Endangered Species Act, but also includes State special concern species, State significantly rate species, and the State watch list.	GS 113–331 to 113–337	Since the American alligator has been sighted within MCB Camp Lejeune, this will be considered an ARAR.
Rivers and Harbors Act of 1899 (Section 10 Permit) – requires permit for structures or work in or affecting navigable waters.	33 USC 403	No remedial actions will affect the navigable waters of Northeast Creek. Therefore, this act will not be considered an ARAR.
Executive Order 11990 on Protection of Wetlands – establishes special requirements for federal agencies to avoid the adverse impacts associated with the destruction or loss of wetlands and to avoid support of new construction in wetlands if a practicable alternative exists.	Executive Order Number 11990, and 40 CFR 6	Wetlands are present in areas of Ou No. 6. Therefore, this will be an applicable ARAR.
Executive Order 11988 on Floodplain Management – establishes special requirements for federal agencies to evaluate the adverse impacts associated with direct and indirect development of a floodplain.	Executive Order Number 11988, and 40 CFR 6	Based on the Federal Ememrgency Management Agency's Flood Insurance Rate Map for Onslow County, OU No. 6 is primarily within a minimal flooding zone (outside the 500-year floodplain). There are some site boundary areas ithin OU No. 6, however, that are within the 100-year floodplain (FEMA, 1987). Therefore this will be retained as an ARAR for OU No. 6.
Wilderness Act – requires that federally owned wilderness area are not impacted. Establishes nondegradation, maximum restoration, and protection of wilderness areas as primary management principles.	16 USC 1131, and 50 CFR 35.	No known federally-owned wilderness areas are located near OU No. 6, therefore, this act will not be considered an ARAR.
National Wildlife Refuge System – restricts activities within a National Wildlife Refuge.	16 USC 668, and 50 CFR 27	No known National Wildlife Refuge areas are located near OU No. 6, therefore, this will not be considered an ARAR.
Scenic Rivers Act – requires action to avoid adverse effects on designated wild or scenic rivers.	16 USC 1271, and 40 CFR 6.302(e)	No known wild or scenic rivers are located near OU No. 6, therefore, this act will not be considered an ARAR.

TABLE 2-1 (continued)
POTENTIAL LOCATION-SPECIFIC ARARs
OPERABLE UNIT NO. 6, SITES 36, 43, 44 AND 54
FEASIBILITY STUDY, CTO-0219
MCB CAMP LEJEUNE, NORTH CAROLINA

Potential Location-Specific ARAR	General Citation	ARAR Evaluation
Coastal Zone Management Act – requires activities affecting land or water uses in a coastal zone to certify noninterference with coastal zone management.	16 USC 1451	No activities at the site will affect land or water uses in a coastal zone, therefore, this act will not be considered an ARAR.
Clean Water Act (Section 404) – prohibits discharge of dredged or fill material into wetland without a permit.	33 USC 404	No actions to discharge dredged or fill material into wetlands will be considered for OU No. 6, therefore, this act will not be considered an ARAR.
RCRA Location Requirements – limitations on where on–site storage, treatment, or disposal of RCRA hazardous waste may occur.	40 CFR 264.18	These requirements may be applicable if the remedial actions for OU No. 6 include the on–site storage, treatment, or disposal of RCRA hazardous waste (although no RCRA hazardous waste is expected to be present at OU No. 6). Therefore, these requirements may be an applicable ARAR.
North Carolina Hazardous Waste Management Rules	15A NCAC 13 A	Location requirements and land disposal restrictions for hazardous waste excavated, stored, and/or treated onsite. This may be an applicable ARAR.
North Carolina Solid Waste Management Rules	15A NCAC 13B.1600	Siting requirements for solid waste landfill activities. This may be an applicable ARAR for OU NO. 6.
North Carolina Recordation of Inactive Hazardous Substance or Waste Disposal Areas	NCGS 130A-310.8	State requirement for recordation of inactive hazardous waste sites. This may be an applicable ARAR for OU NO. 6.
North Carolina Coastal Management	15 A NCAC 7H	Guidelines for areas of environmental concern. This may be an applicable ARAR.

Notes:

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

TABLE 2-2
POTENTIAL ACTION-SPECIFIC ARARs
OPERABLE UNIT NO. 6, SITES 36, 43, 44 AND 54
FEASIBILITY STUDY, CTO-0219
MCB CAMP LEJEUNE, NORTH CAROLINA

Standard [1]	Action	General Citation
RCRA	Capping	40 CFR 264
	Closure	40 CFR 264, 244
	Container Storage	40 CFR 264, 268
	New Landfill	40 CFR 264
	New Surface Impoundment	40 CFR 264
	Dike Stabilization	40 CFR 264
	Excavation, Groundwater Diversion	40 CFR 264, 268
	Incineration	40 CFR 264, 761
	Land Treatment	40 CFR 264
	Land Disposal	40 CFR 264, 268
	Slurry Wall	40 CFR 264, 268
	Tank Storage	40 CFR 264, 268
	Treatment	40 CFR 264, 265, 268; 42 USC 6924; 51 FR 40641; 52 FR 25760
	Waste Pile	40 CFR 264, 268
CWA	Discharge to Water of United States	40 CFR 122, 125, 136
	Direct Discharge to Ocean	40 CFR 125
	Discharge to POTW	40 CFR 403, 270
	Dredge/Fill	40 CFR 264; 33 CFR 320–330; 33 USC 403
CAA (NAAQS)	Discharge to Air	40 CFR 50
SDWA	Underground Injection Control	40 CFR 144, 146, 147, 268
OSWER Directive	Monitored Natural Attenuation	OSWER 9200.4-17
NC Sedimentation Control Act of 1973	Land Disturbing Activities	Chapter 133A
NC Groundwater Corrective Action	Regulations for cleanup of contaminated groundwater	15A NCAC 2L.016
NC Well Construction Standards	Construction and abandonment requirements for water wells	15A NCAC 2C.0100
NC Injection Well Construction Standards	Construction requirements for injection wells.	15A NCAC 2C.0200
NC Water Quality Discharge Requirements	Wastewater requirements for discharges and infiltration galleries	15A NCAC 2H .0100 & .0200

TABLE 2-2 (continued)
POTENTIAL ACTION-SPECIFIC ARARs
OPERABLE UNIT NO. 6, SITES 36, 43, 44 AND 54
FEASIBILITY STUDY, CTO-0219
MCB CAMP LEJEUNE, NORTH CAROLINA

Standard [1]	Action	General Citation
NC Sedimentation Control Rules	Requirements for stormwater management and erosion control	15A NCAC 4B
NC Hazardous Waste Management Rules	Design and treatment requirements for hazardous waste	15A NCAC 13A
NC Solid Waste Management	Design and monitoring requirements for solid waste disposal sites	15A NCAC 13B
NC Air Pollution Control Requirements	Regulates air quality and establishes emissions standards	15A NCAC 2D, 2H .0600, 2Q

Notes:

[1] RCRA = Resource Conservation Recovery Act
CWA = Clean Water Act
CAA = Clean Air Act
NAAQS = National Ambient Air Quality Standards
SDWA = Safe Drinking Water Act

TABLE 2-3
SITE 36 SURFACE SOIL DATA AND COC SELECTION SUMMARY (RESIDENTIAL LAND USE)
OPERABLE UNIT NO. 6, SITES 36, 43, 44 and 54
FEASIBILITY STUDY, CTO-0219
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Screening Criteria	Contaminant Frequency / Range / Location			COC Selection	
	Residential Screening Value	No. of Positive Detects / No. of Samples	Range of Positive Detections	Location of Maximum Detection	Selected as a COC?	Basis for Screening Criteria
VOLATILES (ug/kg)						
Styrene	1,700,000 N	1/61	39 - 39	GS-SB03	No	PRG
Tetrachloroethene	5,700 C	3/61	2 - 3	36-GW12	No	PRG
Toluene	520,000 N	4/61	8 - 98	OF-SB01	No	PRG
Trichloroethene	18.3 C (7)	1/61	4 - 4	FDA-SB03	No	SSL
Xylene (total)	210,000 N	1/61	7 - 7	OF-SB06B	No	PRG
SEMIVOLATILES (ug/kg)						
2-Methylnapthalene	1,600,000 N (2)	2/57	54 - 82	OA-SB01A	No	Region III
Acenaphthene (PAH)	3,700,000 N	1/57	330 - 330	OF-SB04	No	PRG
Anthracene (PAH)	22,000,000 N	1/57	780 - 780	OF-SB04	No	PRG
Benzo(a)anthracene (PAH)	620 C	2/57	46 - 3,900	OF-SB04	Yes	PRG
Benzo(a)pyrene (PAH)	62 C	2/57	40 - 3,300	OF-SB04	Yes	PRG
Benzo(b)fluoranthene (PAH)	620 C	3/57	51 - 3,600	OF-SB04	Yes	PRG
Benzo(g,h,i)perylene (PAH)	230,000 N (3)	1/57	2,400 - 2,400	OF-SB04	No	PRG
Benzo(k)fluoranthene (PAH)	6,200 C	2/57	39 - 1,500	OF-SB04	No	PRG
Butylbenzylphthalate	12,000,000 N	3/57	51 - 290	OA-SB03	No	PRG
Carbazole	24,000 C	1/57	240 - 240	OF-SB04	No	PRG
Chrysene (PAH)	62,000 C	5/57	51 - 4,600	OF-SB04	No	PRG
Dibenz(a,h)anthracene (PAH)	62 C	1/57	720 - 720	OF-SB04	Yes	PRG
Dibenzofuran	290,000 N	1/57	150 - 150	OF-SB04	No	PRG
Fluoranthene (PAH)	2,300,000 N	5/57	54 - 5,500	OF-SB04	No	PRG
Fluorene (PAH)	2,600,000 N	1/57	200 - 200	OF-SB04	No	PRG
Indeno(1,2,3-cd)pyrene (PAH)	620 C	3/57	46 - 2,700	OF-SB04	Yes	PRG
Naphthalene (PAH)	56,000 N	2/57	48 - 120	OF-SB04	No	PRG
n-Nitro-di-n-propylamine	69 C	1/57	320 - 320	DAB-SB03	Yes	PRG
Phenanthrene (PAH)	230,000 N (3)	4/57	59 - 2,500	OF-SB04	No	PRG
Pyrene (PAH)	2,300,000 N	8/57	41 - 11,000	OF-SB04	No	PRG
PESTICIDES/PCBs (ug/kg)						
4-4'-DDD	2,400 C	37/57	2.8 - 550	OA-SB01A	No	PRG
4-4'-DDE	1,700 C	49/57	2.2 - 2,600	OA-SB01A	Yes	PRG
4-4'-DDT	1,700 C	48/57	1.8 - 12,000	OA-SB01A	Yes	PRG
Aldrin	29 C	3/57	5 - 5.1	OF-SB03	No	PRG
alpha-Chlordane	1,600 C (4)	15/57	1.2 - 980	OA-SB05	No	PRG
Aroclor 1248	220 C	9/57	68 - 24,000	OA-SB01I	No (1)	PRG
Aroclor 1254	220 C	3/57	92 - 530	OA-SB01	No (1)	PRG
Dieldrin	30 C	21/57	2 - 16,000	OF-SB03	Yes	PRG
Endosulfan I	370,000 N	3/57	8.3 - 36	OA-SB01E	No	PRG
Endosulfan Sulfate	370,000 N (5)	2/57	2.5 - 4.2	OF-SB06	No	PRG
Endrin	18,000 N	1/57	9.9 - 9.9	OA-SB08	No	PRG
Endrin aldehyde	1,800 N (6)	1/57	12 - 12	OF-SB02	No	PRG
Endrin Ketone	1,800 N (6)	1/57	15 - 15	OF-SB03	No	PRG
gamma-BHC (Lindane)	440 C	1/57	4 - 4	OF-SB06D	No	PRG
gamma-Chlordane	1,600 C (4)	10/57	1.2 - 840	OA-SB05	No	PRG
Heptachlor	110 C	1/57	1.9 - 1.9	FCA-SB12	No	PRG
Heptachlor epoxide	53 C	10/57	2 - 67	OA-SB01I	Yes	PRG

TABLE 2-3 (continued)
SITE 36 SURFACE SOIL DATA AND COC SELECTION SUMMARY (RESIDENTIAL LAND USE)
OPERABLE UNIT NO. 6, SITES 36, 43, 44 and 54
FEASIBILITY STUDY, CTO-0219
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Screening Criteria	Contaminant Frequency / Range / Location			COC Selection	
	Residential Screening Value	No. of Positive Detects / No. of Samples	Range of Positive Detections	Location of Maximum Detection	Selected as a COC?	Basis for Screening Criteria
METALS (mg/kg)						
Aluminum	76,000 N	52/52	1,010 - 17,600	FCA-SB09	No	PRG
Antimony	31 N	7/46	3.3 - 31.7	OA-SB08	Yes	PRG
Arsenic	22 C [8]	43/52	0.39 - 10.4	OA-SB08	No	PRG
Barium	5,400 N	51/52	4.5 - 141	OA-SB08	No	PRG
Beryllium	150 N	1/52	0.18 - 0.18	FCA-SB10	No	PRG
Cadmium	37 N	8/52	0.7 - 6.3	OA-SB08	No	PRG
Calcium	NA	51/52	106 - 103,000	OF-SB06	No	PRG
Chromium	210 C	52/52	1.6 - 51.6	OA-SB08	No	PRG
Cobalt	4,700 N	10/52	0.88 - 9	OA-SB08	No	PRG
Copper	2,900 N	39/52	0.6 - 445	OA-SB08	No	PRG
Iron	23,000 N	52/52	863 - 86,200	OA-SB08	Yes	PRG
Lead	400 N	48/52	4.3 - 836	OA-SB08	Yes	EPA
Magnesium	NA	52/52	52 - 1,020	DAD-SB01	No	PRG
Manganese	1,800 N	52/52	2.1 - 940	OA-SB08	No	PRG
Mercury	23 N	18/52	0.1 - 2.4	OA-SB05	No	PRG
Nickel	1,600 N	26/52	1 - 48.3	OA-SB08	No	PRG
Potassium	NA	32/52	33.7 - 676	FCA-SB05	No	PRG
Selenium	390 N	12/52	0.32 - 0.53	36-SB06D	No	PRG
Silver	390,000 N	8/48	0.6 - 12	OF-SB04	No	PRG
Sodium	NA	31/52	9.6 - 358	DAD-SB01	No	PRG
Vanadium	550 N	50/52	2.9 - 46	OA-SB08	No	PRG
Zinc	23,000 N	50/52	2.1 - 1,320	OA-SB08	No	PRG

Notes:

NA - Not Applicable
COC - Chemical of Concern
RBC - Risk Based Concentration
SSL - Soil Screening Levels
EPA - OSWER Action Level for Lead
PRG - Preliminary Remediation Goal
PAH - Polynuclear Aromatic Hydrocarbon
ug/kg - microgram per kilogram
mg/kg - milligram per kilogram
C - Carcinogenic
N - Non-Carcinogenic

Shaded constituents were identified as COPCs for the Feasibility Study

(1) PCB Contaminated soil was removed during the removal action that OHM conducted in 1997
(2) USEPA Region III RBC
(3) Screening value for pyrene used as a surrogate
(4) Screening value for chlordane used as a surrogate
(5) Screening value for endosulfan used as a surrogate
(6) Screening value for endrin used as a surrogate
(7) Soil contaminants are screened against NC SSLs when they are present in groundwater above State standards
(8) USEPA Region IX pathway-specific concentration for combined exposure in residential soil

TABLE 2-4
SITE 36 SUBSURFACE SOIL DATA AND COC SELECTION SUMMARY (RESIDENTIAL LAND USE)
OPERABLE UNIT NO. 6, SITES 36, 43, 44 and 54
FEASIBILITY STUDY, CTO-0219
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Screening Criteria	Contaminant Frequency / Range / Location			COC Selection	
	Residential Screening Value	No. of Positive Detects / No. of Samples	Range of Positive Detections	Location of Maximum Detection	Selected as a COC?	Basis for Screening Criteria
VOLATILES (ug/kg)						
1,2-Dichloroethene (total)	4,300 N	1/62	4 - 4	OA-SB01	No	PRG
Acetone	1,600,000 N	8/62	12 - 480	GS-SB03	No	PRG
Benzene	670 C	1/62	3 - 3	FDA-SB01	No	PRG
Toluene	520,000 N	5/62	5 - 17	OF-SB06	No	PRG
Trichloroethene	18.3 C (7)	3/62	3 - 5	FDA-SB01	No	SSL
Xylene (total)	210,000 N	8/62	2 - 6	FDA-SB06	No	PRG
SEMIVOLATILES (ug/kg)						
1,4-Dichlorobenzene	3,400 C	1/57	97 - 97	DAB-SB02	No	PRG
2-Methylnaphthalene	1,600,000 N (2)	2/57	65 - 85	FDA-SB02	No	Region III
2-Methylphenol	3,100,000 N	1/58	510 - 510	DAB-SB01	No	PRG
4-Methylphenol	310,000 N	1/58	43 - 43	DAB-SB01	No	PRG
Benzo(a)anthracene (PAH)	620 C	3/57	69 - 140	OA-SB07	No	PRG
Benzo(a)pyrene (PAH)	62 C	4/57	72 - 450	GS-SB03	Yes	PRG
Benzo(b)fluoranthene (PAH)	620 C	5/57	44 - 170	OA-SB07	No	PRG
Benzo(g,h,i)perylene (PAH)	230,000 N (3)	2/57	42 - 89	OA-SB07	No	RBC
Benzo(k)fluoranthene (PAH)	6,200 C	3/57	42 - 68	OA-SB07	No	PRG
Butylbenzylphtalate	12,000,000 N	3/57	42 - 170	OA-SB03	No	PRG
Chrysene (PAH)	62,000 C	5/57	41 - 200	OA-SB07	No	PRG
Di-n-butylphtalate	6,100,000 N	1/58	56 - 56	OA-SB01	No	PRG
Fluoranthene (PAH)	2,300,000 N	3/57	130 - 320	OA-SB07	No	PRG
Indeno(1,2,3-cd)pyrene (PAH)	620 C	3/57	48 - 110	OA-SB07	No	PRG
Isophorone	510,000 C	1/58	2,100 - 2,100	DAB-SB01	No	PRG
Naphthalene (PAH)	56,000 N	1/57	41 - 41	OA-SB01A	No	PRG
Phenanthrene (PAH)	230,000 N (3)	3/57	48 - 190	OA-SB07	No	RBC
Pyrene (PAH)	2,300,000 N	5/57	59 - 320	OA-SB07	No	PRG
PESTICIDES/PCBs (ug/kg)						
4,4'-DDD	2,400 C	30/56	2.3 - 1,300	FDA-SB05	No	PRG
4,4'-DDE	1,700 C	29/56	2.3 - 1,700	OA-SB01A	Yes	PRG
4,4'-DDT	1,700 C	28/56	2.8 - 3,100	OA-SB01A	Yes	PRG
Aldrin	29 C	5/56	1.5 - 16	36-GW11	No	PRG
alpha-Chlordane	1,600 C (4)	12/56	1.6 - 750	36-GW11	No	RBC
Aroclor 1248	220 C	5/56	19 - 850	OA-SB01	No (1)	PRG
Dieldrin	30 C	17/56	2.2 - 1,200	FDA-SB05	Yes	PRG
Endosulfan II	370,000 N (5)	1/56	2 - 2	OF-SB06B	No	PRG
Endrin	18,000 N	5/56	2.4 - 5	OF-SB06B	No	PRG
Endrin Aldehyde	1,800 N (6)	3/56	3.5 - 32	FDA-SB05	No	RBC
gamma-BHC (Lindane)	440 C	1/56	4 - 4	OF-SB06D	No	PRG
gamma-Chlordane	1,600 C	9/56	2.3 - 770	36-GW11	No	PRG
Heptachlor Epoxide	53 C	3/56	3.4 - 14	36-GW11	No	PRG

TABLE 2-4 (continued)
SITE 36 SUBSURFACE SOIL DATA AND COC SELECTION SUMMARY (RESIDENTIAL LAND USE)
OPERABLE UNIT NO. 6, SITES 36, 43, 44 and 54
FEASIBILITY STUDY, CTO-0219
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Screening Criteria	Contaminant Frequency / Range / Location			COC Selection	
	Residential Screening Value	No. of Positive Detects / No. of Samples	Range of Positive Detections	Location of Maximum Detection	Selected as a COC?	Basis for Screening Criteria
METALS (mg/kg)						
Aluminum	76,000 N	51/51	752 - 19,700	FDA-SB05	No	PRG
Antimony	31 N	7/44	4.9 - 21.6	36-GW11	No	PRG
Arsenic	22 C[8]	41/51	0.2 - 25.9	FDA-SB01	Yes	PRG
Barium	5,400 N	50/51	2 - 475	36-GW11	No	PRG
Beryllium	150 N	2/51	0.17 - 0.18	FCA-SB10	No	PRG
Cadmium	37 N	11/51	0.7 - 42.8	36-GW11	Yes	PRG
Calcium	NA	49/51	15 - 46,300	OF-SB06B	No	PRG
Chromium	210 C	50/51	1.4 - 71.9	36-GW11	No	PRG
Cobalt	4,700 N	16/51	0.48 - 9.4	OA-SB07	No	PRG
Copper	2,900 N	31/51	0.5 - 1,320	OF-SB06B	No	PRG
Iron	23,000 N	51/51	408 - 132,000	36-GW11	Yes	PRG
Lead	400 N	50/51	1.2 - 2,680	OA-SB07	Yes	EPA
Magnesium	NA	51/51	20.2 - 2,700	36-GW11	No	PRG
Manganese	1,800 N	47/51	0.85 - 1,260	FDA-SB01	No	PRG
Mercury	23 N	13/51	0.12 - 3.9	OA-SB07	No	PRG
Nickel	1,600 N	24/51	1.1 - 72.1	DAD-SB02	No	PRG
Potassium	NA	32/51	47.2 - 1,640	FDA-SB06	No	PRG
Selenium	390,000 N	4/51	0.4 - 1.2	OF-SB06	No	PRG
Silver	390 N	3/48	0.55 - 0.89	36-GW11	No	PRG
Sodium	NA	34/51	5.2 - 501	FDA-SB06	No	PRG
Vanadium	550 N	49/51	1.6 - 52.6	OF-SB06	No	PRG
Zinc	23,000 N	41/51	0.9 - 2,580	FDA-SB05	No	PRG

Notes:

NA - Not Applicable
COC - Chemical of Concern
RBC - Risk Based Concentration
SSL - Soil Screening Levels
EPA - OSWER Action Level for Lead
PRG - Preliminary Remediation Goal
PAH - Polynuclear Aromatic Hydrocarbon
ug/kg - microgram per kilogram
mg/kg - milligram per kilogram
C - Carcinogenic
N - Non-Carcinogenic

Shaded constituents were identified as COCs for the Feasibility Study

(1) PCB Contaminated soil was removed during the removal action that OHM conducted in 1997
(2) USEPA Region III Residential RBC
(3) Screening value for pyrene used as a surrogate
(4) Screening value for chlordane used as a surrogate
(5) Screening value for endosulfan used as a surrogate
(6) Screening value for endrin used as a surrogate
(7) Soil contaminants are screened against NC SSLs when they are present in groundwater above State standards
(8) USEPA Region IX pathway-specific concentration for combined exposure in residential soil

TABLE 2-5
SITE 36 FINAL SOIL COCs AND REMEDIATION GOALS (RESIDENTIAL LAND USE)
OPERABLE UNIT NO. 6, SITES 36, 43, 44 and 54
FEASIBILITY STUDY, CTO-0219
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Remedial Goal	Basis For Remedial Goal
SEMIVOLATILES (ug/kg)		
Benzo(a)anthracene (PAH)	620 C	PRG
Benzo(a)pyrene (PAH)	62 C	PRG
Benzo(b)fluoranthene (PAH)	620 C	PRG
Dibenz(a,h)anthracene (PAH)	62 C	PRG
Indeno(1,2,3-cd)pyrene (PAH)	620 C	PRG
n-Nitro-di-n-propylamine	69 C	PRG
PESTICIDES/PCBs (ug/kg)		
4-4'-DDE	1,700 C	PRG
4-4'-DDT	1,700 C	PRG
Dieldrin	30 C	PRG
gamma-Chlordane	1,600 C (1)	PRG
Heptachlor epoxide	53 C	PRG
METALS (mg/kg)		
Antimony	31 N (3)	PRG
Arsenic	22 C (2) (3)	RBC
Cadmium	37 N (3)	PRG
Lead	400 N	EPA

ug/kg - microgram per kilogram
mg/kg - milligram per kilogram
C - Carcinogenic
N - Non-Carcinogenic
PRG - USEPA Region IX Preliminary Remediation Goal (Residential)
EPA - OSWER Action Level for Lead
PAH - Polynuclear Aromatic Hydrocarbon
RBC - Risk Based Concentration

(1) Surrogate value for Chlordane used
(2) USEPA Region IX pathway-specific concentration for combined exposure in residential soil
(3) Exceeds USEPA Region IX PRG, but does not generate unacceptable risk at Site 36

TABLE 2-6
SITE 36 GROUNDWATER DATA AND COC SELECTION SUMMARY
OPERABLE UNIT NO. 6, SITES 36, 43, 44 and 54
FEASIBILITY STUDY, CTO-0219
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Screening Criteria [1]		Contaminant Frequency / Range / Location			COC Selection	
	MCL	NCWQS	No. of Positive Detects / No. of Samples	Range of Positive Detections	Location of Maximum Detection	Selected as a COC?	Basis for Screening Criteria
VOLATILES [2] (ug/L)							
1,2-Dichloroethene (total)	NE	70	5/10	3J - 20	36-GW10IW	No	NCWQS
Trichloroethene	5	2.8	6/10	3J - 44	36-GW10IW	Yes	NCWQS
1,1,2,2-Tetrachloroethane	NE	0.17 [3]	3/10	4J - 20	36-GW16IW	Yes	NCWQS
cis-1,2-Dichloroethene	70	70	5/10	3J - 20	36-GW10IW	No	NCWQS
Vinyl Chloride	2	0.015	5/10	1J - 2	36-GW18IW	Yes	NCWQS
METALS [4] (ug/L)							
Aluminum	200 [5]	NE	6/11	6,630 - 6,980	36-GW10IW	Yes	MCL
Antimony	6	NE	1/11	3.7B - 3.7 B	36-GW10	No	MCL
Arsenic	10	50	6/11	2.6 B - 5.4 B	36-GW03	No	MCL
Barium	2,000	2,000	11/11	7.4 B - 104 B	36-GW09	No	NCWQS
Beryllium	4	NE	1/11	0.23 B - 0.23 B	36-GW10IW	No	MCL
Cadmium	5	5	6/11	0.26 B - 1 B	36-GW03	No	NCWQS
Calcium	NE	NE	11/11	1980 B - 188,000	36-GW16IW	No	NA
Chromium	100	50	5/11	1.1 B - 7.9 B	36-GW10	No	NCWQS
Cobalt	NE	NE	1/11	1.3 B - 1.3 B	36-GW03	No	NA
Copper	1,000	1,000	3/11	1.8 B - 3 B	36-GW09	No	NCWQS
Iron	300	300	11/11	146 - 5,620	36-GW13	Yes	NCWQS
Lead	15	15	2/11	5 - 5	36-GW10	No	NCWQS
Magnesium	NE	NE	11/11	509 B - 26,000	36-GW10DW	No	NA
Manganese	50	50	6/11	6.1 B - 222	36-GW09	Yes	NCWQS
Mercury	2	1.1	1/11	0.07 B - 0.07 B	36-GW10	No	NCWQS
Nickel	NE	100	7/11	1.9 B - 5 B	36-GW16IW	No	NCWQS
Potassium	NE	NE	11/11	5,150 - 29,300	36-GW10DW	No	NA
Sodium	NE	NE	11/11	7,790 - 40,300	36-GW13IW	No	NA
Vanadium	NE	NE	5/11	0.83 B - 10.3 B	36-GW10IW	No	NA
Zinc	5,000 [5]	2,100	9/11	0.47 B - 14.1 B	36-GW09	No	NCWQS

Notes:

NE - Not Established
NA - Not Applicable
COC - Chemical of Concern
NCWQS - North Carolina Water Quality 2L Standard
ug/L - microgram per liter
MCL - Maximum Contaminant Level (when NCWQS is not established)
B -The reported value is less than Contract-Required Detection Limits (CRDL), but greater than Instrument Detection Limits (IDC)
J - Analyte present - Reported value is estimated

Shaded constituents were identified as COCs for the Feasibility Study

(1) NCWQS 2L , MCL
(2) Data for volatiles taken from 01/2002 Long-Term Monitoring sampling event
(3) Interim Standard
(4) Data for metals taken from 04/2001 Long-Term Monitoring sampling event
(5) Secondary Drinking Water Standard

TABLE 2-7
SITE 36 FINAL GROUNDWATER COCs AND REMEDIATION GOALS
OPERABLE UNIT NO. 6, SITES 36, 43, 44 and 54
FEASIBILITY STUDY, CTO-0219
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Remedial Goal	Basis for Remedial Goal [1]
VOLATILES [2] (ug/L)		
Trichloroethene	2.8	NCWQS
1,1,2,2-Tetrachloroethane	0.17 [4]	NCWQS
Vinyl Chloride	0.015	NCWQS
METALS [3] (ug/L)		
Aluminum	200	MCL [4]
Iron	300	NCWQS
Manganese	50	NCWQS

Notes:

COC - Chemical of Concern
NCWQS - North Carolina 2L Standard
ug/L - microgram per liter

(1) NCWQS 2L
(2) Data for volatiles taken from 01/2002 Long-Term Monitoring sampling event
(3) Data for metals taken from 04/2001 Long-Term Monitoring sampling event
(4) Interim Standard

TABLE 2-8
SITE 43 SURFACE SOIL DATA AND COC SELECTION SUMMARY (RESIDENTIAL LAND USE)
OPERABLE UNIT NO. 6, SITES 36, 43, 44 and 54
FEASIBILITY STUDY, CTO-0219
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Screening Criteria	Contaminant Frequency / Range / Location			COC Selection	
	Residential Screening Value	No. of Positive Detects / No. of Samples	Range of Positive Detections	Location of Maximum Detection	Selected as a COC?	Basis for Screening Criteria
SEMIVOLATILES (ug/kg)						
2-Methylnapthalene	1,600,000 N (1)	1/28	74 - 74	WA-SB01A	No	Region III
4-Methylphenol	310,000 N	1/28	120 - 120	DA1-SB02	No	PRG
Acenaphthene (PAH)	3,700,000 N	3/28	45 - 2,100	WA-SB01A	No	PRG
Acenaphthylene	3,700,000 N	1/28	71 - 71	WA-SB01A3	No	PRG
Anthracene (PAH)	22,000,000 N	3/28	44 - 820	WA-SB01A	No	PRG
B(g,h,i)perylene (PAH)	230,000 N (2)	9/28	87 - 24,000	WA-SB01A	No	RBC
Benzo(a)anthracene (PAH)	620 C	9/28	51 - 40,000	WA-SB01A	Yes	PRG
Benzo(a)pyrene (PAH)	62 C	9/28	79 - 39,000	WA-SB01A	Yes	PRG
Benzo(b)fluoranthene (PAH)	620 C	10/28	44 - 52,000	WA-SB01A	Yes	PRG
Benzo(k)fluoranthene (PAH)	6,200 C	9/28	57 - 20,000	WA-SB01A	Yes	PRG
Butylbenzylphthalate	12,000,000 N	3/28	50 - 420	OA-SB03	No	PRG
Carbazole	24,000 C	5/28	99 - 350	WA-SB01A	No	PRG
Chrysene (PAH)	62,000 C	9/28	110 - 46,000	WA-SB01A	No	PRG
Dibenz(a,h)anthracene (PAH)	62 C	8/28	47 - 1,200	WA-SB01A	Yes	PRG
Dibenzpfuran	290,000 N	2/28	35 - 870	WA-SB01A	No	PRG
Fluoranthene (PAH)	2,300,000 N	10/28	49 - 60,000	WA-SB01A	No	PRG
Fluorene (PAH)	2,600,000 N	3/28	53 - 1,700	WA-SB01A	No	PRG
Indeno(1,2,3-cd)pyrene (PAH)	620 C	10/28	42 - 27,000	WA-SB01A	Yes	PRG
Phenanthrene (PAH)	230,000 N (2)	8/28	54 - 5,900	WA-SB01A	No	RBC
Pyrene (PAH)	2,300,000 N	10/28	49 - 64,000	WA-SB01A	No	PRG
PESTICIDES/PCBs (ug/kg)						
4-4'-DDD	2,400 C	1/7	3,000 - 3,000	DA1-SB03	Yes	PRG
4-4'-DDE	1,700 C	5/7	5.7 - 1,000	DA1-SB03	No	PRG
4-4'-DDT	1,700 C	4/7	10 - 1,000	DA1-SB03	No	PRG
Endrin aldehyde	1,800 N (3)	1/7	5.4 - 5.4	DA2-SB03	No	RBC
Heptachlor epoxide	53 C	1/7	2 - 2	WA-SB01A	No	PRG
METALS (mg/kg)						
Cadmium	37 N	2/21	0.7 - 1.7	WA-SB02	No	PRG
Chromium	210 C	21/21	1.1 - 106	DA1-SB02	No	PRG
Copper	2,900 N	17/21	0.5 - 55.7	DA2-SB01	No	PRG
Lead	400 N (4)	20/21	4.3 - 246	DA2-SB01	No	EPA
Manganese	1,800 N	21/21	2.8 - 189	DA2-SB01	No	PRG
Mercury	23 N	3/21	0.1 - 0.5	DA1-SB02	No	PRG
Nickel	1,600 N	8/21	1.1 - 5	DA2-SB01	No	PRG
Zinc	23,000 N	21/21	1.5 - 595	DA1-SB02	No	PRG

Notes:

Shaded constituents were identified as COPCs for the Feasibility Study

NA - Not Applicable
COC - Chemical of Concern
RBC - Risk Based Concentration
EPA - OSWER Action Level for Lead
PRG - Preliminary Remediation Goal
PAH - Polynuclear Aromatic Hydrocarbon
ug/kg - microgram per kilogram
mg/kg - milligram per kilogram
C - Carcinogenic
N - Non-Carcinogenic
S - Soil Saturation

(1) USEPA Region III RBC
(2) Screening value for pyrene used as a surrogate
(3) Screening value for endrin used as a surrogate
(4) EPA OSWER Directive for Lead

TABLE 2-9
SITE 43 SUBSURFACE SOIL DATA AND COC SELECTION SUMMARY (RESIDENTIAL LAND USE)
OPERABLE UNIT NO. 6, SITES 36, 43, 44 and 54
FEASIBILITY STUDY, CTO-0219
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Screening Criteria	Contaminant Frequency / Range / Location			COC Selection	
	Residential Screening Value	No. of Positive Detects / No. of Samples	Range of Positive Detections	Location of Maximum Detection	Selected as a COC?	Basis for Screening Criteria
SEMIVOLATILES (ug/kg)						
Benzo(a)anthracene (PAH)	620 C	1/20	390 - 390	WA-SB02	No	PRG
Benzo(a)pyrene (PAH)	62 C	1/20	570 - 570	WA-SB02	Yes	PRG
Benzo(b)fluoranthene (PAH)	620 C	1/20	780 - 780	WA-SB02	Yes	PRG
Benzo(g,h,i)perylene (PAH)	230,000 N (1)	1/20	790 - 790	WA-SB02	No	RBC
Benzo(k)fluoranthene (PAH)	6,200 C	1/20	340 - 340	WA-SB02	No	PRG
Butylbenzylphtalate	12,000,000 N	2/20	39 - 440	OA-SB03	No	PRG
Carbazole	24,000 C	1/20	73 - 73	WA-SB02	No	PRG
Chrysene	62,000 C	1/20	740 - 740	WA-SB02	No	PRG
Fluoranthene (PAH)	2,300,000 N	1/20	850 - 850	WA-SB02	No	PRG
Indeno(1,2,3-cd)pyrene (PAH)	620 C	1/20	890 - 890	WA-SB02	Yes	PRG
Phenanthrene (PAH)	230,000 N	1/20	430 - 430	WA-SB02	No	PRG
Pyrene (PAH)	2,300,000 N	1/20	1,800 - 1,800	WA-SB02	No	PRG
PESTICIDES/PCBs (ug/kg)						
4,4'-DDD	2,400 C	1/7	1,200 - 1,200	DA1-SB03	No	PRG
4,4'-DDE	1,700 C	1/7	9 - 9	DA1-SB03	No	PRG
4,4'-DDT	1,700 C	1/7	45 45	DA1-SB03	No	PRG
METALS (mg/kg)						
Copper	2,900 N	6/20	0.4 - 3.6	OA-SB01	No	PRG

Notes:

NA - Not Applicable
COC - Chemical of Concern
PAH - Polynuclear Aromatic Hydrocarbon
RBC - Risk Based Concentration
PRG - Preliminary Remediation Goal
C = Carcinogenic
S = Soil Saturation
N = Non-Carcinogenic
ug/kg - microgram per kilogram
mg/kg - milligram per kilogram

Shaded constituents were identified as COPCs for the Feasibility Study

(1) Screening value for pyrene used as a surrogate

TABLE 2-10
SITE 43 FINAL SOIL COCs AND REMEDIATION GOALS (RESIDENTIAL LAND USE)
OPERABLE UNIT NO. 6, SITES 36, 43, 44 and 54
FEASIBILITY STUDY, CTO-0219
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Remedial Goal	Basis For Remedial Goal
SEMIVOLATILES (ug/kg)		
Benzo(a)anthracene (PAH)	620 C	PRG
Benzo(a)pyrene (PAH)	62 C	PRG
Benzo(b)fluoranthene (PAH)	620 C	PRG
Benzo(k)fluoranthene (PAH)	6,200 C	PRG
Dibenz(a,h)anthracene (PAH)	62 C	PRG
Indeno(1,2,3-cd)pyrene (PAH)	620 C	PRG

ug/kg - microgram per kilogram
C - carcinogenic
PRG - USEPA Region IX Preliminary Remediation Goal (Residential)
PAH - Polynuclear Aromatic Hydrocarbon

TABLE 3-1
POTENTIAL REMEDIAL ACTION TECHNOLOGIES AND PROCESS OPTIONS
OPERABLE UNIT NO. 6, SITES 36, 43, 44, and 54
FEASIBILITY STUDY, CTO-0219
MCB CAMP LEJEUNE, NORTH CAROLINA

Media	General Response Action	Remedial Action Technology Type	Process Option	Applicable Sites
Soil/Sediment	No Action	No Action	No Action	36, 43, 44, 54
	Institutional Controls	Land Use Restrictions (Intrusive Activities)	Deed restrictions/ LUCIP	36, 43, 44, 54
	Containment/Removal Actions	Capping	Clay/Soil Cap	36, 43
			Asphalt/Concrete Cap	36, 43
			Multi-layered Cap	36, 43
		Excavation	Excavation	36, 43
		Disposal	Landfill Disposal	36, 43
	Treatment Actions (Ex-Situ)	Thermal Treatment	Incineration	36, 43
			Thermal Desorption	43
			Pyrolysis	43
		Physical/Chemical Treatment	Chemical Reduction /Oxidation	36
			Separation	36
			Soil Washing	36, 43
			Solar Detoxification	43
			Solidification	36,43
			Solvent Extraction	36, 43
	Treatment Actions (In-Situ)	Thermal Treatment	Thermally Enhanced Soil Vapor Extraction	43
		Biological Treatment	Phytoremediation	43
		Physical/Chemical Treatment	Electrokinetic Separation	36
			Soil Flushing	36
			Solidification/Stabilization	36, 43
Groundwater	No Action	No Action	No Action	36, 43, 44, 54
	Institutional Controls	Land Use Restrictions (Aquifer Use and Intrusive Activities)	Deed restrictions / LUCIP	36, 54
	Treatment Actions (Ex-Situ)	Physical/Chemical Treatment	Granular Activated Carbon	36
			Air Stripping	36
		Biological	Bioreactors	36
	Treatment Actions (In-Situ)	Physical/Chemical Treatment	Enhanced Natural Attenuation	36
			Air Sparaging	36
			Chemical Oxidation/Reduction	36
			Monitored Natural Attenuation	36, 54
			Dual Phase Extraction	36
			In-Well Air Stripping	36

TABLE 3-2
PRELIMINARY SCREENING OF REMEDIAL ACTION TECHNOLOGIES AND PROCESS OPTIONS
OPERABLE UNIT NO. 6, SITES 36, 43, 44 AND 54
FEASIBILITY STUDY, CTO-0219
MCB CAMP LEJEUNE, NORTH CAROLINA

Media	General Response Action	Remedial Action Technology Type	Process Option	Description	Site-Specific Applicability	Screening Results	Applicable Sites
Soil	No Action	No Action	No Action	Contaminated soils and sediments remain on site. No institutional controls.	▪ Potentially Applicable	**Retained**	36, 43, 44, 54
	Institutional Controls	Land Use Restrictions (Intrusive Activities)	Deed Restrictions / LUCIP	Contaminated areas have permanent land use restrictions implemented that would limit future development and restrict future land use.	▪ Potentially Applicable	**Retained**	36, 43, 44, 54
	Containment/ Removal Actions	Capping	Clay/Soil Cap Asphalt/Concrete Cap Multi-layered Cap	A cap reduces potential for direct exposure to the contaminated soil and minimizes further migration of contaminated soils/sediments due to runoff/erosion.	▪ Potentially Applicable	**Retained**	36, 43
		Excavation	Excavation	Soil and sediments contaminated above cleanup levels will be excavated for subsequent treatment or disposal.	▪ Potentially Applicable	**Retained**	36, 43
		Disposal	Off-Site Landfill	Permitted off-site landfill disposal facilities accept the contaminated soils and sediments for disposal.	▪ Potentially Applicable	**Retained**	36, 43
	Treatment Actions (Ex-Situ)	Thermal Treatment	Incineration	Established technology for treatment of organic contaminants via combustion. Off-gas treatment required. Metals in soil may limit applicability.	▪ Volatile metals in the soil such as arsenic, lead, cadmium and mercury require the installation of gas cleaning systems	Eliminated	
			Thermal Desorption	Wastes are heated to volatilize water and organic contaminants. A carrier gas or vacuum system transports volatilized water and organics to the gas treatment system.	▪ Heavy metals in the feed may produce a reside that requires stabilization	Eliminated	
			Pyrolysis	Chemical decomposition is induced in organic materials by heat, and transformed into gaseous components and a solid residue containing fixed carbon and ash.	▪ Moisture content of <1% required ▪ Media with heavy metals may require stabilization	Eliminated	

TABLE 3-2 (continued)
PRELIMINARY SCREENING OF REMEDIAL ACTION TECHNOLOGIES AND PROCESS OPTIONS
OPERABLE UNIT NO. 6, SITES 36, 43, 44 AND 54
FEASIBILITY STUDY, CTO-0219
MCB CAMP LEJEUNE, NORTH CAROLINA

Media	General Response Action	Remedial Action Technology Type	Process Option	Description	Site-Specific Applicability	Screening Results	Applicable Sites
Soil (continued)	Treatment Actions (Ex-Situ) (continued)	Physical/ Chemical Treatment	Chemical Reduction/Oxidation	Hazardous compounds are converted into non-hazardous contaminants through an oxidizing agent such as chlorine, hydrogen peroxide or ozone.	▪ Target group is inorganics, may not be as effective for SVOCs or VOCs	Eliminated	
			Separation	Different sized sieves are used to concentrate contaminants into smaller volumes in a physical separation process	▪ May not be as effective for SVOCs as it is for inorganics ▪ Soil contamination may not meet cleanup goals	Eliminated	
			Soil Washing	Contaminants attached to fine soil particles are separated from coarse-grained soil in order to reduce the volume of soil to be treated.	▪ Potentially Applicable	**Retained**	36, 43
			Solar Detoxification	Ultraviolet light activates the catalyst, resulting in the formation of reactive radicals that break down contaminants into non-toxic by-products.	▪ Effective during daylight hours only ▪ May only practically remove heavy metals from water and not soil	Eliminated	
			Solidification	Mobility of contaminants is reduced when they are bound in a stabilized mass	▪ May result in a significant increase in volume ▪ Organics are generally not immobilized	Eliminated	
			Solvent Extraction	Contaminated soil and extractant are mixed together, and the extracted solution is separated for treatment and future use.	▪ Traces of solvent remains in treated soils ▪ May not meet remediation goals	Eliminated	
	Treatment Actions (In-Situ)	Thermal Treatment	Thermally Enhanced Soil Vapor Extraction	Many heating options are available to increase the volatilization rate of semi-volatiles and facilitate extraction of contaminants.	▪ Limited by high moisture content ▪ Must also regulate air emissions	Eliminated	

TABLE 3-2 (continued)
PRELIMINARY SCREENING OF REMEDIAL ACTION TECHNOLOGIES AND PROCESS OPTIONS
OPERABLE UNIT NO. 6, SITES 36, 43, 44 AND 54
FEASIBILITY STUDY, CTO-0219
MCB CAMP LEJEUNE, NORTH CAROLINA

Media	General Response Action	Remedial Action Technology Type	Process Option	Description	Site-Specific Applicability	Screening Results	Applicable Sites
Soil (continued)	Treatment Actions (In-Situ) (continued)	Biological	Phyto-accumulation	Contaminants are accumulated in aboveground biomass of plants though uptake in the root systems.	▪ Not proven for arsenic ▪ May not meet remediation goals	Eliminated	
			Phytoremediation	Phytoremediation processes include the removal, transfer, destruction or stabilization of plants in soil.	▪ Not a proven technology for SVOCs ▪ May be seasonal	Eliminated	
		Physical/ Chemical Treatment	Electrokinetic Separation	This process separates contaminats though the use of a direct current that separates positively charged organic compounds and inorganic ions from clean soil and water.	▪ Effective for a limited range of moisture content ▪ Technoilogy is most effective in clays	Eliminated	
			Soil Flushing	Contaminants are removed from soil when an in-situ extraction fluid is passed though soils via an infiltration or injection process.	▪ This technology is not as effective for PAHs and pesticides as it is for inorganics	Eliminated	
			Solidification/ Stabilization	An in-situ physical and chemical technology that immobilizes contaminants within their host medium	▪ Future site use may be hindered by the solidified contaminants remaining on site ▪ Target contaminant group is inorganics	Eliminated	
Groundwater	No Action	No Action	No Action	Contaminated groundwater remains on-site untreated.	▪ Potentially Applicable	**Retained**	36, 43, 44, 54
	Institutional Controls	Land Use Restrictions (Aquifer Use and Intrusive Activities)	Deed restrictions / LUCIP	Restrictions are placed within 1000 feet of the contaminated plume	▪ Potentially Applicable	**Retained**	36,54
	Treatment Actions (Ex-Situ)	Physical/ Chemical Treatment	Granular Activated Carbon	A series of columns containing granular activated carbon adsorbs dissolved organic contaminants.	▪ Target contaminant groups include VOCs	**Retained**	36

TABLE 3-2 (continued)
PRELIMINARY SCREENING OF REMEDIAL ACTION TECHNOLOGIES AND PROCESS OPTIONS
OPERABLE UNIT NO. 6, SITES 36, 43, 44 AND 54
FEASIBILITY STUDY, CTO-0219
MCB CAMP LEJEUNE, NORTH CAROLINA

Media	General Response Action	Remedial Action Technology Type	Process Option	Description	Site-Specific Applicability	Screening Results	Applicable Sites
Groundwater (continued)	Treatment Actions (Ex-Situ) (continued)	Physical/ Chemical Treatment (continued)	Air Stripping	Volatile organics are partitioned from ground water by increasing the surface area of the water though packed towers, diffused aeration, tray aeration, or spray aeration.	▪ High organic content may result in frequent column cleaning or pre-treatment	Eliminated	
		Biological	Bioreactors	Bioreactors degrade contaminants in water with microorganisms through attached or suspended biological systems.	▪ Air pollution controls may need to be implemented for volatilization ▪ Residual sludges require treatment or disposal	Eliminated	
	Treatment Actions (In-Situ)	Physical/ Chemical Treatment	Enhanced Natural Attenuation (HRC)	The injection of a Hydrogen Release Compound (HRC) into the groundwater for the enhancement of natural attenuation	▪ Potentially Applicable	**Retained**	36
			Air Sparaging	Air is injected into the aquifer and travels horizontally and vertically to volatilize VOCs	▪ Potentially Applicable	**Retained**	36
			Chemical Oxidation/Reduction	Oxidizing agents convert hazardous contaminants into less toxic compounds	• Incomplete oxidation or intermediate products may occur	Eliminated	
			Monitored Natural Attenuation	Natural attenuation relies of natural processes to remove contaminants from the groundwater. Site conditions will be monitored quarterly to ensure effective clean-up.	• Potentially Applicable	**Retained**	36, 54
			Dual Phase Extraction	A high vacuum system is used to remove liquid or gas low permeability or heterogeneous formations.	• Requires both water and vapor treatment	Eliminated	
			In-Well Air Stripping	Injection of air into a double screened well transfers VOCs from the dissolved phase to the vapor phase by air bubbles for volatilization.	• Shallow aquifers may limit process effectiveness	Eliminated	

TABLE 3-3
SUMMARY OF THE PROCESS OPTION EVALUATION
OPERABLE UNIT NO. 6, SITES 36, 43, 44, AND 54
FEASIBLITY STUDY, CTO-0219
MCB CAMP LEJEUNE, NORTH CAROLINA

Media	General Response Action	Remedial Action Technology Type	Process Option	Evaluation			Evaluation Results
				Effectiveness	Implementability	Relative Cost	
Soil	**No Action**	No Action	No Action	▪ Not effective for managing risks or protecting the environment ▪ Relies on long-term natural attenuation processes	▪ Easily implemented ▪ No means to monitor site conditions	No cost	**Retained** as per the requirements of the NCP for Sites 36, 43, 44, and 54
	Institutional Controls	Land Use Restrictions (Intrusive Activities)s	Deed restrictions / LUCIP	▪ Limits future development and land use at the site ▪ Limits human exposure and protects human health ▪ Not effective for limiting ecological exposure ▪ Contaminants still present in soil ▪ Not effective in limiting contaminant migration due to runoff, erosion, and flooding ▪ Equally effective for inorganics and PAH contamination	Easily Implemented	Negligible cost	**Retained** for Sites 36, 43, 44, 54
	Containment/ Removal Actions	Capping	Clay/Soil Cap Asphalt/Concrete Cap Multi-layered Cap	▪ Prevents direct contact with contaminated soils ▪ Contaminants still present in soil ▪ Minimizes migration due to runoff and erosion ▪ May not limit contaminant migration in floodplain ▪ Equally effective for inorganics and PAH contamination	▪ Standard construction equipment required ▪ Permanent erosion, sediment and flood controls required ▪ Soils containing hazardous compounds must first be transported to a permitted facility	▪ Low to moderate capital costs ▪ Low O & M costs	**Retained** for Sites 36, 43

TABLE 3-3 (continued)
SUMMARY OF THE PROCESS OPTION EVALUATION
OPERABLE UNIT NO. 6, SITES 36, 43, 44, AND 54
FEASIBLITY STUDY, CTO-0219
MCB CAMP LEJEUNE, NORTH CAROLINA

Media	General Response Action	Remedial Action Technology Type	Process Option	Evaluation			Evaluation Results
				Effectiveness	Implementability	Relative Cost	
Soil (Cont'd)	**Containment/ Removal Actions (Cont'd)**	Excavation	Excavation	▪ Effective in removal of contaminated soil and sediment for subsequent treatment or disposal	▪ Pre- and post-excavation sampling may be required ▪ Soil dewatering may be required for wet soils/sediments ▪ Difficult to implement in wetland/wooded areas	▪ Low to moderate capital costs ▪ No O&M costs	**Retained** for Sites 36, 43
		Disposal	Landfill Disposal	▪ Contaminants removed from site and placed away from human and ecological exposure pathways ▪ Equally effective for inorganics and PAH contamination	▪ Excavation required ▪ Landfill must be permitted to accept contaminants ▪ On-site pre-screening or dewatering may be required ▪ Easily implemented	▪ Moderate to high capital costs ▪ No O & M costs ▪ More cost effective if material can be disposed in Base landfill	**Retained** for Sites 36, 43
	Treatment Actions (Ex-Situ) *Assuming excavation*	Thermal Treatment	Thermal Desorption	▪ Proven to be effective for inorganics and SVOCs	▪ On-site or off-site technology ▪ On-site pre-screening and dewatering may be necessary ▪ Heavy metals in the soil may result in a treated solid residue that requires stabilization ▪ Liquid and baghouse waste requires treatment ▪ Long distance transport required for off-site treatment	▪ Moderate to high capital costs ▪ Moderate O & M costs	Eliminated due to high cost. Not cost effective for low levels of organic contamination. Off-site thermal desorption may be effective for treatment process residuals, but not as a primary treatment method.
		Physical/ Chemical Treatment	Soil Washing	▪ Target contaminant groups include SVOCs and heavy metals ▪ Effectively reduces the volume of soil to be treated	▪ Complex mixtures of inorganics with organics make formulating a washing fluid difficult ▪ Generated contaminated water will require treatment	▪ Moderate capital costs ▪ Moderate O & M costs	Eliminated due to elevated costs associated with the determination and implementation of an effective washing fluid.

TABLE 3-3 (continued)
SUMMARY OF THE PROCESS OPTION EVALUATION
OPERABLE UNIT NO. 6, SITES 36, 43, 44, AND 54
FEASIBLITY STUDY, CTO-0219
MCB CAMP LEJEUNE, NORTH CAROLINA

Media	General Response Action	Remedial Action Technology Type	Process Option	Evaluation			Evaluation Results
				Effectiveness	Implementability	Relative Cost	
Groundwater	**No Action**	No Action	No Action	▪ Not effective for managing risks or protecting the environment ▪ Relies on long-term natural attenuation processes	▪ Easily implemented ▪ No means to monitor site conditions	▪ No cost	**Retained** as per the requirements of the NCP for Sites 36, 43, 44, and 54
	Institutional Controls	Land Use Restrictions (Aquifer Use and Intrusive Activities)	Deed restrictions / LUCIP	▪ Reduces exposure pathways to contaminated groundwater	▪ Easily Implemented	▪ Negligible costs	**Retained** for Site 36, 54
	Treatment Actions (In-Situ)	Physical/ Chemical Treatment	Enhanced Natural Attenuation (HRC)	▪ Previous studies document effectiveness for TCE ▪ Monitoring will determine effectiveness	▪ Easily Implemented	▪ Moderate capital costs ▪ Moderate O & M costs	**Retained** for Site 36
			Air Sparaging	• VOCs are target contaminant group ▪ Produces residual vapors	▪ Involves implementation of a vapor extraction system ▪ May take an extended amount of time to reach clean-up goals	▪ Moderate capital costs ▪ Moderate O & M costs	Eliminated because treatment option may be too costly for site clean-up
			Monitored Natural Attenuation	▪ Quarterly monitoring will determine the effectiveness of this process option	▪ Easily Implemented	▪ Low Capital Costs ▪ Moderate O & M costs	**Retained** for Site 36, 54

TABLE 3-4
FINAL REMEDIAL ACTION TECHNOLOGIES AND PROCESS OPTIONS
OPERABLE UNIT NO. 6, SITES 36, 43, 44, and 54
FEASIBILITY STUDY, CTO-0219
MCB CAMP LEJEUNE, NORTH CAROLINA

Site	Media	General Response Action	Remedial Action Technology Type	Process Option
Site 36	Soil/Sediment	No Action	No Action	No Action
		Institutional Controls	Land Use Restrictions (Intrusive Activities)	Deed restrictions / LUCIP
		Containment/Removal Actions	Capping	Clay/Soil Cap
			Excavation	Excavation
			Disposal	Landfill Disposal
	Groundwater	No Action	No Action	No Action
		Institutional Controls	Land Use Restrictions (Aquifer Use and Intrusive Activities)	Deed restrictions / LUCIP
		Treatment Actions (In-Situ)	Physical/ Chemical Treatment	Enhanced Natural Attenuation
				Monitored Natural Attenuation
Site 43	Soil/Sediment	No Action	No Action	No Action
		Containment/Removal Actions	Capping	Capping for Future Residential Use
			Excavation	Excavation
			Disposal	Landfill Disposal
	Groundwater	No Action	No Action	No Action
Site 44	Soil/Sediment	No Action	No Action	No Action
	Groundwater	No Action	No Action	No Action
Site 54	Soil/Sediment	No Action	No Action	No Action
	Groundwater	Institutional Controls	Land Use Restrictions (Aquifer Use and Intrusive Activities)	Deed restrictions / LUCIP
		Treatment Actions (In Situ)	Physical/Chemical Treatment	Monitoring

TABLE 4-1
REMEDIAL ACTION ALTERNATIVE SUMMARY TABLE
OPERABLE UNIT NO. 6, SITES 36, 43, 44 AND 54
FEASIBILITY STUDY, CTO-0219
MCB CAMP LEJEUNE, NORTH CAROLINA

Alternative	Media	Description / Components	Land Use Controls Needed	Screening Criteria	Cost
Site 36					
36S RAA 1) No Action	Soil	No remedial action or institutional controls	None	NA	$0
36S RAA 2) Capping and Institutional Controls for Lead Contaminated Areas [1]	Soil	Soil cover over contaminated areas exceeding cleanup goals; site restoration	Excavation Restrictions Land Use Restrictions	Region IX Residential PRGs	$187,951
36S RAA 3) Excavation and Off-Site Disposal and Institutional Controls for Lead Contaminated Areas [1]	Soil	Excavate all soils above cleanup levels; disposal of waste in appropriate landfills; site restoration	Excavation Restrictions Land Use Restrictions	Region IX Residential PRGs	$200,302
36GW RAA 1) No Action	Groundwater	No remedial action or institutional controls	None	NA	$0
36GW RAA 2) Enhanced Natural Attenuation [1]	Groundwater	Injection of HRC; monitoring of progress toward cleanup goals	Aquifer Use Restrictions Excavation Restrictions	NCWQS (2L)	$690,818
36GW RAA 3) Monitored Natural Attenuation [1]	Groundwater	Monitoring of natural attenuation progress toward cleanup goals	Aquifer Use Restrictions Excavation Restrictions	NCWQS (2L)	$409,966
Site 43 [2]					
43S RAA 1) No Action	Soil	No remedial action or institutional controls	None	NA	$0
43S RAA 2) Capping	Soil	Soil cover over contaminated areas exceeding cleanup goals; site restoration	Excavation Restrictions	Region IX Residential PRGs	$169,463
43S RAA 3) Excavation and Off-Site Disposal	Soil	Excavate all soils above cleanup levels; disposal of waste in appropriate landfills; site restoration	None	Region IX Residential PRGs	$119,180
43GW RAA 1) No Action	Groundwater	No remedial action or institutional controls	None	NA	$0
Site 44 [2]					
44S RAA 1) No Action	Soil	No remedial action or institutional controls	None	NA	$0
44GW RAA 1) No Action	Groundwater	No remedial action or institutional controls	None	NA	$0
Site 54					
54S RAA 1) No Action	Soil	No remedial action or institutional controls	None	NA	$0
54GW RAA 1) No Action	Groundwater	No remedial action or institutional controls	None	NA	$0
54GW RAA 2) Institutional Controls and Monitoring [1]	Groundwater	Monitoring of lead until cleanup goals are demonstrated	Aquifer Use Restrictions Excavation Restrictions	NCWQS (2L)	$43,790

(1) Land use controls in place until remedial cleanup goals are achieved

(2) Note that institutional controls (i.e.,Excavation Restrictions) will be in effect at Sites 43 and 44 since these two sites were former disposal areas

TABLE 5-1
36S RAA 2 - SITE 36 CAPPING AND INSTITUTIONAL CONTROLS FOR LEAD CONTAMINATED AREAS
BUDGETARY COST ESTIMATE [1]
OPERABLE UNIT No. 6, SITES 36, 43, 44 and 54
FEASIBILITY STUDY CTO-0219
MCB, CAMP LEJEUNE, NORTH CAROLINA

Cost Item	Quantity	Units	Unit Cost	Total Cost	Assumptions (Basis of Cost Estimate)
DIRECT CAPITAL COSTS					
I. Site Preparation					
A. Mobilization/Demobilization	1	LS	$10,000	$10,000	Engineering Judgement
B. Erosion Protection (Silt Fence)	820	LF	$0.93	$763	Means Site Work 2002 (02370-550-1000)
C. Clearing and Grubbing	0.28	AC	$2,150	$603	Means Site Work 2002 (02200-200-0010)
Subtotal				$11,365	
II. Capping and Site Restoration					
A. Decontamination Of Equipment	1	LS	$500	$500	Engineering Estimate
B. Capping (12" soil cap)	400	CY	$15.52	$6,208	Means Site Work 2002 (02320-200-0540) (G1030-210-1350), Assume borrow source is within 3 miles of site, includes placement/compaction
C. Top Soil (6-inches)	200	CY	$29.63	$5,926	Means Site Work 2002 (02315-200-7000) (02320-200-0550) (02315-300-8200), Assume source is within 5 miles of site, includes delivery, placement, compaction
D. Fine Grading/Stormwater Controls	1	LS	$500	$500	Engineering Estimate
E. Revegetation	0.28	AC	$8,000	$2,243	Engineering Estimate
Subtotal				$15,377	
III. LUCIP					
A. Plat Map	1	LS	$3,000	$3,000	Includes survey crew cost
Subtotal				$3,000	
TOTAL - DIRECT CAPITAL COSTS				**$29,700**	
INDIRECT CAPITAL COSTS & CONTINGENCY [3]					
I. Scope & Bid Contingency Allowance	1	LS	$7,425	$7,425	Assume 25% of total direct capital cost
II. Design/Engineering Support	1	LS	$15,940	$15,940	Assume 20% of total direct capital cost, additional cost added for Design/SPECS
III. Construction Management	1	LS	$19,455	$19,455	Assume 15% of total direct capital cost, additional cost for Work Plan, HASP
IV. Project Management	1	LS	$7,970	$7,970	Assume 10% of total direct capital cost, additional cost for mgmt of plans, etc.
V. Institutional Controls	1	LS	$10,000	$10,000	Institutional Controls: Intrusive boundaries, legal fees, land use controls, etc.
TOTAL - INDIRECT CAPITAL COSTS				**$60,790**	
ANNUAL OPERATION & MAINTENANCE COSTS					
A. Cap Inspection and Maintenance	1	LS	$3,538	$3,538	Assumes annual inspection (10% of cap to be replaced) / periodic minor maintenance
B. Annual LUCIP Review	1	LS	$2,500	$2,500	Engineering Estimate
TOTAL - ANNUAL O&M COSTS				**$6,038**	
TOTAL PROJECT COST SUMMARY					
DIRECT CAPITAL COSTS				$29,700	
INDIRECT CAPITAL COSTS				$60,790	
PRESENT WORTH OF ANNUAL O&M COSTS				$97,461	Present worth over 30 Years @ 5% discount rate
TOTAL PROJECT COST				**$187,951**	

Notes:
(1) Estimated accuracy of cost estimate is -30% to +50%. Cost estimate is to be used primarily for comparison of costs relative to other response action alternatives.
(2) Includes SVOC and pesticide areas
(3) USEPA 2000, "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study", EPA 540-R-00-002, OSWER 9355.0-75, July 2000

TABLE 5-2
36S RAA 3 - SITE 36 EXCAVATION AND OFF-SITE DISPOSAL AND INSTITUTIONAL CONTROLS FOR LEAD CONTAMINATED AREAS
BUDGETARY COST ESTIMATE [1]
OPERABLE UNIT No. 6, SITES 36, 43, 44 and 54
FEASIBILITY STUDY CTO-0219
MCB, CAMP LEJEUNE, NORTH CAROLINA

Cost Item	Quantity	Units	Unit Cost	Total Cost	Assumptions (Basis of Cost Estimate)
DIRECT CAPITAL COSTS					
I. Site Preparation					
A. Mobilization/Demobilization	1	LS	$10,000	$10,000	Engineering Judgement
B. Erosion Protection	1090	LF	$0.93	$1,014	Means Site Work 2002 (02370-550-1000)
C. Clearing and Grubbing	0.40	AC	$2,150	$860	Means Site Work 2002 (02200-200-0010)
Subtotal				$11,874	
II. Excavation and Site Restoration					
A. Excavation of Contaminated Soil [2]	950	CY	$3.33	$3,168	Means Site Work 2002 (02315-400-1250) (02315-400-0020) Add 10% for Level D
B. Confirmatory Sampling	62	EA	$304	$18,833	Analysis for SVOCs & Pesticides. Includes $50/sample for collection/handling. Assume 20' grid and 72-hour turnaround
C. Base Landfill Disposal	1,430	Ton	$10	$14,300	Transport to Base Landfill, distance of 10 miles each way (estimate)
D. Decontamination Of Equipment	1	LS	$500	$500	Engineering Estimate
E. Backfill (bring site to within 6" of original grade)	710	CY	$15.52	$11,019	Means Site Work 2002 (02320-200-0540) (G1030-210-1350), Assume borrow source is within 3 miles of site, includes placement/compaction
F. Top Soil (6-inches)	240	CY	$29.63	$7,111	Means Site Work 2002 (02315-200-7000) (02320-200-0550) (02315-300-8200), Assume source is within 5 miles of site, includes delivery, placement, compaction
G. Fine Grading/Stormwater Controls	1	LS	$500	$500	Engineering Estimate
H. Revegetation	0.40	AC	$8,000	$3,200	Engineering Estimate
Subtotal				$58,631	
III. LUCIP					
A. Plat Map	1	LS	$3,000	$3,000	Includes survey crew cost
Subtotal				$3,000	
TOTAL - DIRECT CAPITAL COSTS				**$73,500**	
INDIRECT CAPITAL COSTS & CONTINGENCY [4]					
I. Scope & Bid Contingency Allowance	1	LS	$18,375	$18,375	Assume 25% of total direct capital cost
II. Design/Engineering Support	1	LS	$24,700	$24,700	Assume 20% of total direct capital cost, additional cost added for Design/SPECS
III. Construction Management	1	LS	$26,025	$26,025	Assume 15% of total direct capital cost, additional cost for Work Plan, HASP
IV. Project Management	1	LS	$7,350	$7,350	Assume 10% of total direct capital cost
V. Institutional Controls	1	LS	$10,000	$10,000	Institutional Controls: Intrusive boundaries, legal fees, land use controls, etc.
TOTAL - PROFESSIONAL & CONTINGENCY COSTS				**$86,450**	
ANNUAL OPERATION & MAINTENANCE COSTS					
A. Annual LUCIP Review	1	LS	$2,500	$2,500	Engineering Estimate
TOTAL - ANNUAL O&M COSTS				**$2,500**	
TOTAL PROJECT COST SUMMARY					
DIRECT CAPITAL COSTS				$73,500	
PROFESSIONAL & CONTINGENCY COSTS				$86,450	
PRESENT WORTH OF ANNUAL O&M COSTS				$40,352	
TOTAL PROJECT COST				**$200,302**	

Notes:
(1) Estimated accuracy of cost estimate is -30% to +50%. Cost estimate is to be used primarily for comparison of costs relative to other response action alternatives.
(2) Includes SVOC and pesticide areas
(3) Confirmatory Sampling will be conducted on a 20' by 20' grid on the bottom of the excavation and at 20' spacing along the side walls
(4) USEPA 2000, "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study", EPA 540-R-00-002, OSWER 9355.0-75, July 2000

TABLE 5-3
36GW RAA 2 -SITE 36 ENHANCED NATURAL ATTENUATION
BUDGETARY COST ESTIMATE [1]
OPERABLE UNIT No. 6, SITES 36, 43, 44 and 54
FEASIBILITY STUDY CTO-0219
MCB, CAMP LEJEUNE, NORTH CAROLINA

Cost Item	Quantity	Units	Unit Cost	Total Cost	Assumptions (Basis of Cost Estimate)
DIRECT CAPITAL COSTS					
I. Site Preparation					
A. Mobilization/Demobilization	1	LS	$15,000	$15,000	Engineering Estimate
B. Clearing/Grubbing	2	acre	$2,150	$4,300	Means Site Work 2002 (02200-200-0010)
SUBTOTAL				$19,300	
II. Enhanced In-Situ Biodegradation					
A. HRC Grid Installation [2]	1	LS	$274,000	$274,000	Regenesis Cost Model - Includes Geoprobe, HRC equipment/materials, etc.
B. Construction Oversight of HRC Installation	1	LS	$15,000	$15,000	Engineering Estimate
SUBTOTAL				$289,000	
TOTAL - DIRECT CAPITAL COSTS				**$308,300**	
INDIRECT CAPITAL COSTS & CONTINGENCY [3]					
I. Contingency Allowance	1	LS	$77,075	$77,075	Assume 25% of total direct capital cost
II. Design/Engineering Support	1	LS	$46,245	$46,245	Assume 15% of total direct capital cost
III. Construction Oversight	1	LS	$30,830	$30,830	Assume 10% of total direct capital cost
IIII. Legal Fees/Administration	1	LS	$24,664	$24,664	Assume 8% of total direct capital cost
V. Institutional Controls	1	LS	$3,000	$3,000	Temporary Aquifer Use Restrictions / Intrusive Activity Restrictions
TOTAL - INDIRECT CAPITAL COSTS				**$181,814**	
ANNUAL OPERATION & MAINTENANCE COSTS					
I. Groundwater Monitoring Program					
A. Groundwater Sampling - Labor	4	event	$9,700	$38,800	2 geologists @$45/hr; 10 hrs per day; for 3 days, plus travel expenses
B. Sample Analysis	80	Ea	$300	$24,000	TCL VOC analysis, NA parameters; 14 samples plus 1 MS/MSD and 1 duplicate, and trip blanks
C. Reporting	1	Ea	$40,000	$40,000	Engineering Judgement - Reporting and analysis of data
TOTAL - ANNUAL O&M COSTS				**$102,800**	
TOTAL PROJECT COST SUMMARY					
DIRECT CAPITAL COSTS				$308,300	
INDIRECT CAPITAL COSTS				$181,814	
PRESENT WORTH OF ANNUAL O&M COSTS				$200,704	Assume O&M for 2 years @ 5% discount rate
TOTAL PROJECT COST				**$690,818**	

Notes:
(1) Cost estimate to be used for budgetary information as well as for comparison of costs relative to other response action alternatives.
(2) See Table 5-5a for Regenesis cost estimates table
(3) USEPA 2000, "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study", EPA 540-R-00-002, OSWER 9355.0-75, July 2000

TABLE 5-3a
36GW RAA 2 -SITE 36 ENHANCED NATURAL ATTENUATION (HRC)
CONTRACTOR COST ESTIMATE
OPERABLE UNIT No. 6, SITES 36, 43, 44 and 54
FEASIBILITY STUDY CTO-0219
MCB, CAMP LEJEUNE, NORTH CAROLINA

REGENESIS **HRC Grid Design**
Version 1
Technical Support (949) 366-8000

Site Name: Operable Unit No.6, Site 36
Location: MCB Camp Lejeune
Consultant: Baker Environmental

Basic Site Characteristics

Width of plume (intersecting flow)	300	ft
Length of plume	300	ft
Depth to contaminated zone	7	ft
Thickness of contaminated saturated zone	25	ft
Nominal aquifer soil (gravel, sand, silty sand, silt, clay)	silty sand	
Porosity	0.3	
Hydraulic conductivity, Kh	2.4	ft/day
Hydraulic gradient	0.009	ft/ft
Seepage velocity	0.072 ft/day = 26.3	ft/yr
Treatment Zone Pore Volume (cu. ft.)	675,000	ft^3

Dissolved Phase Groundwater VOC Concentrations: Cgw in mg/L

PCE	0.000
TCE	0.050
DCE	0.020
VC	0.002
Carbon tetrachloride	0.000
Chloroform	0.000
TCA	0.000
DCA	0.000

Sorbed Phase VOC Mass:

Soil bulk density	1.37	kg/L
Fraction of organic carbon: foc	0.005	

(Values are estimated using Soil Conc=foc*Koc*Cgw) (Adjust Koc as nec. to provide realistic estimates)	Koc (L/kg)	Soil Conc. (mg/kg)
PCE	263	0.00
TCE	107	0.03
DCE	80	0.01
VC	2.5	0.00
Carbon tetrachloride	110	0.00
Chloroform	34	0.00
TCA	183	0.00
DCA	40	0.00

Competing Electron Acceptor (CEA) Concentrations:

	(mg/L)
Oxygen	1.50
Nitrate	1.00
Manganese reduction potential	3.18
Iron reduction (potential amount of Fe2+ that can be formed)	0.70
Sulfate reduction	15.06

Microbial Demand Factor	3	Recommend 3-4x
Additional Demand Factor	2	Recommend 2-3x

Injection Point Spacing	**Rec.**	Min.	Max.
Nominal injection spacing (ft)	15.0	5	15
# points in row(w/desired spacing)	20	60	20
Actual spacing between columns (ft)	15.0	5.0	15.0
# rows (w/desired spacing)	20	60	20
Actual spacing between rows (ft)	15.0	5.0	15.0
Advective travel time bet. rows (days)	208	69	208
Number of points in grid	400	3600	400

HRC Injection Amount

Minimum req. HRC per foot (lbs/ft)	2.0	2.0	2.0
Feasibility of above HRC per foot:	(ok)	(ok)	(ok)

Proposed HRC Grid Specifications			
Proposed number of HRC delivery points (adjust as nec. for site)			600
Proposed HRC applic. rate lbs/foot (adjust as nec. for site)			2.0
Corresponding amount of HRC per point (lbs)			50
Buckets per injection point			1.7
Total Buckets			1000
Total Amt of HRC (lbs)			30,000
Unit cost of HRC		$	6.00
Total Material Cost		**$**	**180,000**
Shipping and/or Tax Estimate			
HRC ($0.1 to $0.4/lb, call for exact rate)	cost per lb: 0.2	$	6,000
Sales tax (call for exact rate)	rate: 5%	$	9,000.00
Total Regenesis Material Cost		**$**	**195,000**

Injection length >20 ft may require multiple holes to prevent preferential injection-adjust cost

HRC Installation Cost Estimate (responsibility of customer to contract work)		
Footage for each inj. point = uncontaminated + HRC inj. interval (feet)		32
Total vertical feet for project (feet)		19,200
Estimated production rate (feet per hour: 50 for push, 25 for drilling)		50
Estimated hole completion rate (holes per hour)		1.6
Time per day spent pushing/drilling (hrs)		10
Required number of days		39
Mob/demob cost for injection subcontrator	$	1,000
Daily rate for inj. Sub. ($1-2K for geoprobe or $3-4K for drill rig)	$	2,000
Total injection subcontrator cost for application	$	79,000
Total Project Cost(not including consultant oversight, GWM, etc.)	**$**	**274,000**

TABLE 5-4
36GW RAA 3 -SITE 36 MONITORED NATURAL ATTENUATION
BUDGETARY COST ESTIMATE [1]
OPERABLE UNIT No. 6, SITES 36, 43, 44 and 54
FEASIBILITY STUDY CTO-0219
MCB, CAMP LEJEUNE, NORTH CAROLINA

Cost Item	Quantity	Units	Unit Cost	Total Cost	Assumptions (Basis of Cost Estimate)
DIRECT CAPITAL COSTS					
I. Base-Line Monitoring					
A. Well Installation	1	LS	$21,500	$21,500	3 Shallow wells @ $2500, 4 Intermediate wells @ $3500
B. Well Installation Oversight - Labor	1	LS	$4,500	$4,500	1 geologist @ 10 days, 10 hours/day, $45/hour
SUBTOTAL				$26,000	
TOTAL - DIRECT CAPITAL COSTS				**$26,000**	
INDIRECT CAPITAL COSTS & CONTINGENCY [2]					
I. Contingency Allowance	1	LS	$6,500	$6,500	Assume 25% of total direct capital cost
II. Design/Engineering Support	1	LS	$3,900	$3,900	Assume 15% of total direct capital cost
III. Construction Oversight	1	LS	$3,900	$3,900	Assume 15% of total direct capital cost
IIII. Legal Fees/Administration	1	LS	$3,900	$3,900	Assume 15% of total direct capital cost
V. Institutional Controls	1	LS	$5,000	$5,000	Aquifer Use Restrictions
TOTAL - INDIRECT CAPITAL COSTS				**$23,200**	
ANNUAL OPERATION & MAINTENANCE COSTS					
I. Groundwater Monitoring Program (Semi-Annual First 4 Years)					
A. Groundwater Sampling - Labor	2	event	$9,700	$19,400	2 geologists @$45/hr; 10 hrs per day; for 3 days, plus travel expenses
B. Sample Analysis	40	Ea	$300	$12,000	TCL VOC analysis, NA parameters; 14 samples plus 1 MS/MSD and 1 duplicate and trip blanks
C. Reporting	1	Ea	$20,000	$20,000	Engineering Judgement - Reporting and analysis of data
D. Well Development	5	Well	$800	$4,000	Assume each well to be developed once every 2 years
SUBTOTAL				$55,400	
E. Well Replacement	1	LS	$17,000	$17,000	2 Shallow wells @ $2500, 2 Intermediate wells @ $3500 and 1 deep well @ $5000
PRESENT WORTH OF O&M COSTS				$220,249	Present Value for First 4 Years
I. Groundwater Monitoring Program (Annual Last 6 Years)					
A. Groundwater Sampling - Labor	1	event	$9,700	$9,700	2 geologists @$45/hr; 10 hrs per day; for 3 days, plus travel expenses
B. Sample Analysis	20	Ea	$300	$6,000	TCL VOC analysis, NA parameters; 14 samples plus 1 MS/MSD and 1 duplicate and trip blanks
C. Reporting	1	Ea	$10,000	$10,000	Engineering Judgement - Reporting and analysis of data
D. Well Development	5	Well	$800	$4,000	Assume each well to be developed once every 2 years
SUBTOTAL				$29,700	
E. Well Replacement	1	LS	$14,500	$14,500	3 Shallow wells @ $2500, 2 Intermediate wells @ $3500
PRESENT WORTH OF O&M COSTS				$140,516	Present Value for Last 6 Years
TOTAL PROJECT COST SUMMARY					
DIRECT CAPITAL COSTS				$26,000	
INDIRECT CAPITAL COSTS				$23,200	
PRESENT WORTH OF ANNUAL O&M COSTS				$360,766	Assume O&M for 10 years @ 5% discount rate
TOTAL PROJECT COST				**$409,966**	

Notes:
(1) Cost estimate to be used for budgetary information as well as for comparison of costs relative to other response action alternatives.
(2) USEPA 2000, "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study", EPA 540-R-00-002, OSWER 9355.0-75, July 2000

TABLE 5-5
43S RAA 2 - SITE 43 CAPPING
BUDGETARY COST ESTIMATE [1]
OPERABLE UNIT No. 6, SITES 36, 43, 44 and 54
FEASIBILITY STUDY CTO-0219
MCB, CAMP LEJEUNE, NORTH CAROLINA

Cost Item	Quantity	Units	Unit Cost	Total Cost	Assumptions (Basis of Cost Estimate)
DIRECT CAPITAL COSTS					
I. Site Preparation					
A. Mobilization/Demobilization	1	LS	$10,000	$10,000	Engineering Judgement
B. Erosion Protection (Silt Fence)	370	LF	$0.93	$344	Means Site Work 2002 (02370-550-1000)
C. Clearing and Grubbing	0.19	AC	$2,150	$416	Means Site Work 2002 (02200-200-0010)
Subtotal				$10,760	
II. Capping and Site Restoration					
A. Decontamination Of Equipment	1	LS	$500	$500	Engineering Estimate
B. Capping (bring site back to acceptable grade plus 12" soil cap)	277	CY	$15.52	$4,293	Means Site Work 2002 (02320-200-0540) (G1030-210-1350), Assume borrow source is within 3 miles of site, includes placement/compaction
C. Top Soil (6-inches), delivered, spread, compacted	138	CY	$29.63	$4,098	Means Site Work 2002 (02315-200-7000) (02320-200-0550) (02315-300-8200), Assume source is within 5 miles of site, includes delivery, placement, compaction
D. Fine Grading/Stormwater Controls	1	LS	$500	$500	Means Site Work 2002 (02310-440-0010)
E. Revegetation	0.19	AC	$8,000	$1,548	Engineering Estimate
Subtotal				$10,938	
TOTAL - DIRECT CAPITAL COSTS				**$21,700**	
INDIRECT CAPITAL COSTS & CONTINGENCY [2]					
I. Scope & Bid Contingency Allowance	1	LS	$5,425	$5,425	Assume 25% of total direct capital cost
II. Design/Engineering Support	1	LS	$14,340	$14,340	Assume 20% of total direct capital cost, additional cost added for Design/SPECS
III. Construction Management	1	LS	$18,255	$18,255	Assume 15% of total direct capital cost, additional cost for Work Plan, HASP
IV. Project Management	1	LS	$7,170	$7,170	Assume 10% of total direct capital cost, additional cost for mgnt of plans, etc.
V. Institutional Controls	1	LS	$10,000	$10,000	Institutional Controls: Intrusive boundaries, legal fees, land use controls, etc.
TOTAL - INDIRECT CAPITAL COSTS				**$55,190**	
ANNUAL OPERATION & MAINTENANCE COSTS					
A. Cap Inspection and Maintenance	1	LS	$3,235	$3,235	Assumes annual inspection (10% of cap to be replaced) / periodic minor maintenance
B. Annual LUCIP Review	1	LS	$2,500	$2,500	Engineering Estimate
TOTAL - ANNUAL O&M COSTS				**$5,735**	
TOTAL PROJECT COST SUMMARY					
DIRECT CAPITAL COSTS				$21,700	
INDIRECT CAPITAL COSTS				$55,190	
PRESENT WORTH OF ANNUAL O&M COSTS				$92,573	Present worth over 30 Years @ 5% discount rate
TOTAL PROJECT COST				**$169,463**	

Notes:
(1) Estimated accuracy of cost estimate is -30% to +50%. Cost estimate is to be used primarily for comparison of costs relative to other response action alternatives.
(2) USEPA 2000, "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study", EPA 540-R-00-002, OSWER 9355.0-75, July 2000

TABLE 5-6
43S RAA 3 - SITE 43 EXCAVATION
BUDGETARY COST ESTIMATE [1]
OPERABLE UNIT No. 6, SITES 36, 43, 44 and 54
FEASIBILITY STUDY CTO-0219
MCB, CAMP LEJEUNE, NORTH CAROLINA

Cost Item	Quantity	Units	Unit Cost	Total Cost	Assumptions (Basis of Cost Estimate)
DIRECT CAPITAL COSTS					
I. Site Preparation					
A. Mobilization/Demobilization	1	LS	$10,000	$10,000	Engineering Judgement
B. Erosion Protection	405	LF	$0.93	$376.65	Means Site Work 2002 (02370-550-1000)
C. Clearing and Grubbing	0.19	AC	$2,150	$400.03	Means Site Work 2002 (02200-200-0010)
Subtotal				$10,777	
II. Excavation and Site Restoration					
A. Excavation of Contaminated Soil	752	CY	$3.33	$2,506	Means Site Work 2002 (02315-400-1250) (02315-400-0020) Add 10% for Level D
B. Confirmatory Sampling [2]	31	EA	$304	$9,416	Analysis for SVOCs & Pesticides. Includes $50/sample for collection/handling.Assume 72-hour turnaround
C. Base Landfill Disposal	1,551	Ton	$10	$15,513	Transport to Base Landfill, distance of 10 miles each way (estimate)
D. Decontamination Of Equipment	1	LS	$500	$500	Engineering Estimate
E. Backfill (bring site to within 6" of original grade)	646	CY	$15.52	$10,030	Means Site Work 2002 (02320-200-0540) (G1030-210-1350), Assume borrow source is within 3 miles of site, includes placement/compaction
F. Top Soil (6-inches)	159	CY	$29.63	$4,719	Means Site Work 2002 (02315-200-7000) (02320-200-0550) (02315-300-8200), Assume source is within 5 miles of site, includes delivery, placement, compaction
G. Fine Grading/Stormwater Controls	1	LS	$500	$500	Engineering Estimate
H. Revegetation	0.19	AC	$8,000	$1,488	Engineering Estimate
Subtotal				$44,673	
TOTAL - DIRECT CAPITAL COSTS				**$55,400**	
INDIRECT CAPITAL COSTS & CONTINGENCY [3]					
I. Scope & Bid Contingency Allowance	1	LS	$13,850	$13,850	Assume 25% of total direct capital cost
II. Design/Engineering Support	1	LS	$21,080	$21,080	Assume 20% of total direct capital cost, additional cost added for Design/SPECS
III. Construction Management	1	LS	$23,310	$23,310	Assume 15% of total direct capital cost, additional cost for Work Plan, HASP
IV. Project Management	1	LS	$5,540	$5,540	Assume 10% of total direct capital cost
TOTAL - PROFESSIONAL & CONTINGENCY COSTS				**$63,780**	
ANNUAL OPERATION & MAINTENANCE COSTS					
TOTAL - ANNUAL O&M COSTS				**$0**	
TOTAL PROJECT COST SUMMARY					
DIRECT CAPITAL COSTS				$55,400	
PROFESSIONAL & CONTINGENCY COSTS				$63,780	
PRESENT WORTH OF ANNUAL O&M COSTS				$0	
TOTAL PROJECT COST				**$119,180**	

Notes:
(1) Estimated accuracy of cost estimate is -30% to +50%. Cost estimate is to be used primarily for comparison of costs relative to other response action alternatives.
(2) Confirmatory Sampling will be conducted on a 20' by 20' grid on the bottom of the excavation and at 20' spacing along the side walls
(3) USEPA 2000, "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study", EPA 540-R-00-002, OSWER 9355.0-75, July 2000

TABLE 5-7
54GW RAA 2 -SITE 54 INSTITUTIONAL CONTROLS AND MONITORING
BUDGETARY COST ESTIMATE [1]
OPERABLE UNIT No. 6, SITES 36, 43, 44 and 54
FEASIBILITY STUDY CTO-0219
MCB, CAMP LEJEUNE, NORTH CAROLINA

Cost Item	Quantity	Units	Unit Cost	Total Cost	Assumptions (Basis of Cost Estimate)
INDIRECT CAPITAL COSTS & CONTINGENCY [2]					
V. Institutional Controls	1	LS	$5,000	$5,000	Aquifer Use Restrictions
TOTAL - INDIRECT CAPITAL COSTS				**$5,000**	
ANNUAL OPERATION & MAINTENANCE COSTS					
I. Groundwater Monitoring Program (Quarterly First Year)					
A. Groundwater Sampling - Labor	4	event	$1,225	$4,900	1 geologist @$45/hr; 5 hrs per day; for 1 day, plus travel expenses
B. Sample Analysis	16	Ea	$20	$320	Lead analysis, 12 samples plus 1 MS/MSD and 1 duplicate and trip blanks
C. Reporting	1	Ea	$20,000	$20,000	Engineering Judgement - Reporting and analysis of data
D. Well Development	1	Well	$800	$800	Assume each well to be developed once every 2 years
SUBTOTAL				$26,020	
I. Groundwater Monitoring Program (Semi-Annual Second Year)					
A. Groundwater Sampling - Labor	2	event	$1,225	$2,450	1 geologist @$45/hr; 5 hrs per day; for 1 day, plus travel expenses
B. Sample Analysis	8	Ea	$20	$160	Lead analysis, 1 sample plus 1 MS/MSD and 1 duplicate and trip blanks
C. Reporting	1	Ea	$10,000	$10,000	Engineering Judgement - Reporting and analysis of data
D. Well Development	1	Well	$800	$800	Assume well to be developed once every 2 years
SUBTOTAL				$13,410	
PRESENT WORTH OF O&M COSTS				$12,770	Present Value for Second Year
TOTAL PROJECT COST SUMMARY					
INDIRECT CAPITAL COSTS				$5,000	
PRESENT WORTH OF ANNUAL O&M COSTS				$38,790	Assume O&M for 2 years @ 5% discount rate
TOTAL PROJECT COST				**$43,790**	

Notes:
(1) Cost estimate to be used for budgetary information as well as for comparison of costs relative to other response action alternatives.
(2) USEPA 2000, "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study", EPA 540-R-00-002, OSWER 9355.0-75, July 2000

FIGURES

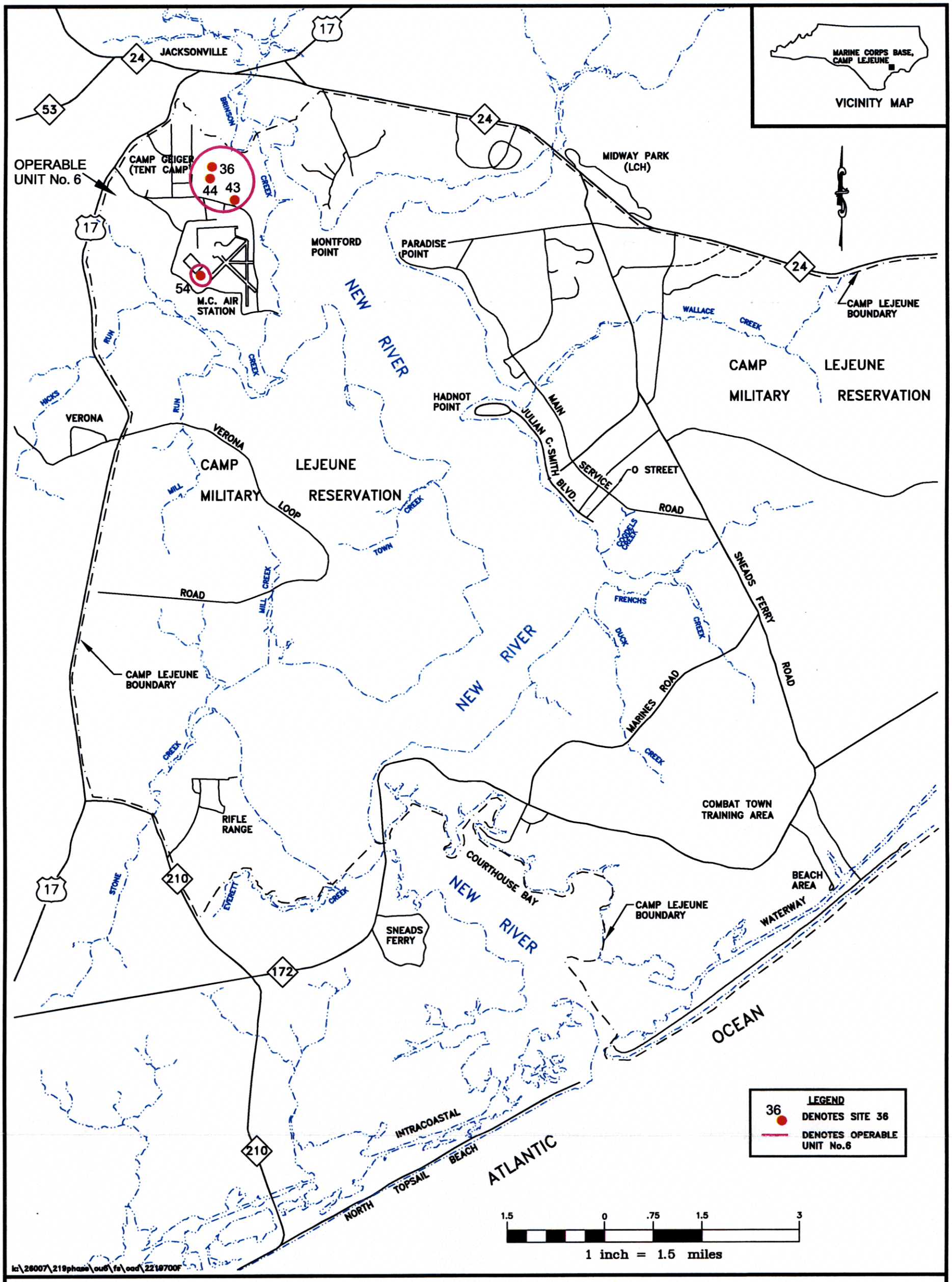
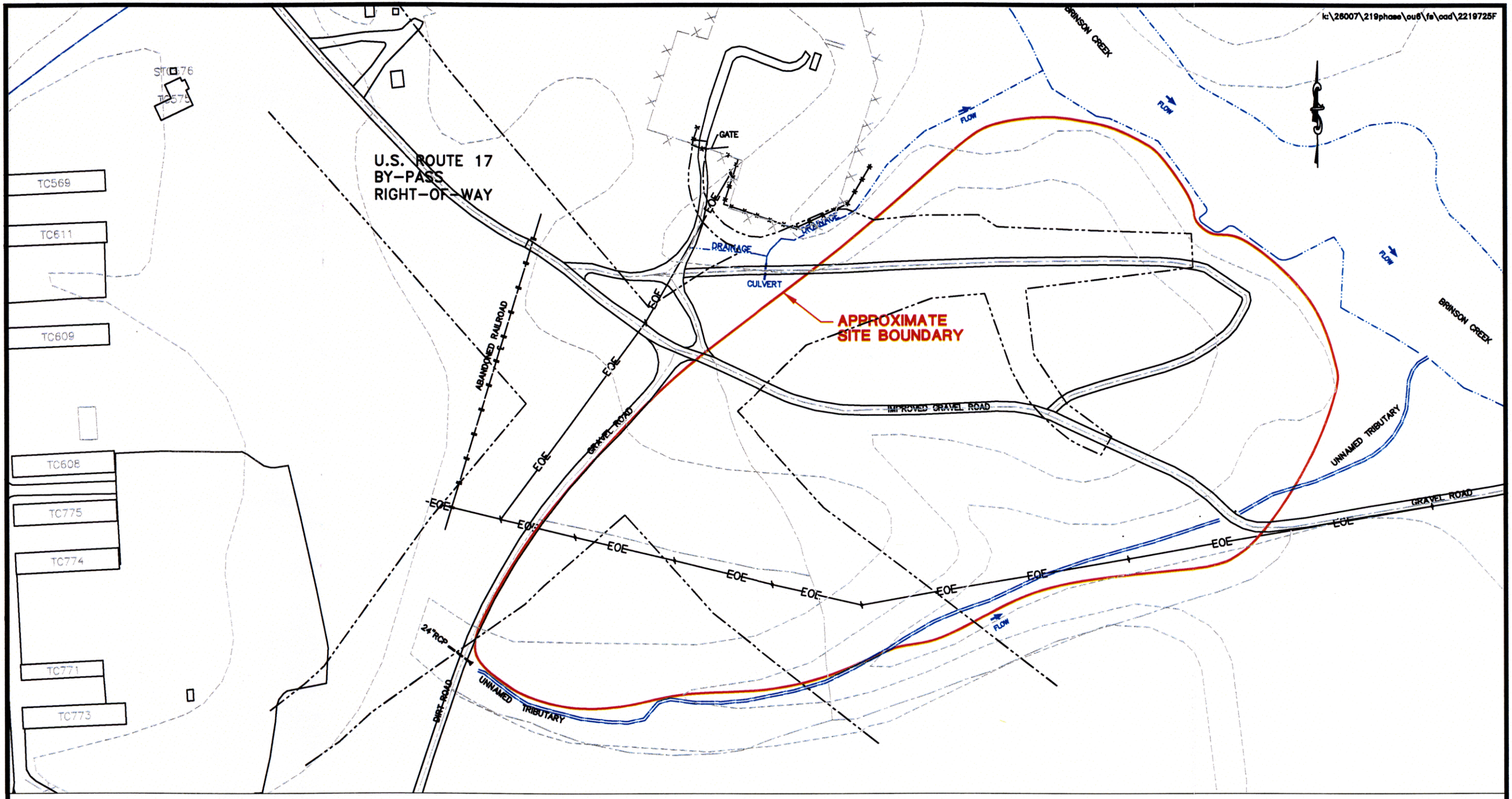


FIGURE 1-1
SITE LOCATION MAP
OPERABLE UNIT NO. 6
OPERABLE UNIT No. 6 - SITES 36, 43, 44 AND 54
CTO - 0219
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA



LEGEND

- FLOW — DIRECTION OF SURFACE WATER FLOW
- EOE — OVERHEAD ELECTRIC LINE & UTILITY POLE
- FENCE
- ASPHALT ROAD
- GRAVEL ROAD
- STREAM
- US 17 JACKSONVILLE BYPASS EASEMENT LIMITS

SOURCE: LANTDIV, MARCH 2000

FIGURE 1-2
SITE FEATURES MAP
FEASIBILITY STUDY, OPERABLE UNIT NO. 6
SITE 36, CAMP GEIGER DUMP AREA
CTO - 0219
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

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FLOW

EDWARDS CREEK

FLOW

STRAWHORN CREEK

APPROXIMATE SITE BOUNDARY

DRAINAGE DITCH

SOIL PATH

MARSH

ABANDONED SEWAGE DISPOSAL FACILITY

GRAVEL ROAD

AGAN STREET

EOE

SEWAGE PUMP/LIFT STATION

GRAVEL ROAD

SOIL PATH

MARSH

DRAINAGE DITCH

STRAWHORN CREEK

FLOW

36"RCP

FLOW

STRAWHORN CREEK

AGAN STREET

DAYCARE/ MINISCHOOL

LEGEND

- FLOW — DIRECTION OF SURFACE WATER FLOW
- MARSH
- EOE — OVERHEAD ELECTRIC LINE & UTILITY POLE
- FENCE
- ASPHALT ROAD
- GRAVEL ROAD OR SOIL PATH
- EDGE OF CREEK, DRAINAGE DITCH OR MARSH
- TREE LINE
- STRUCTURE

120 0 60 120

1 inch = 120 ft.

Baker

FIGURE 1-3
SITE FEATURES MAP
FEASIBILITY STUDY, OPERABLE UNIT NO. 6
SITE 43, AGAN STREET DUMP
CTO - 0219
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

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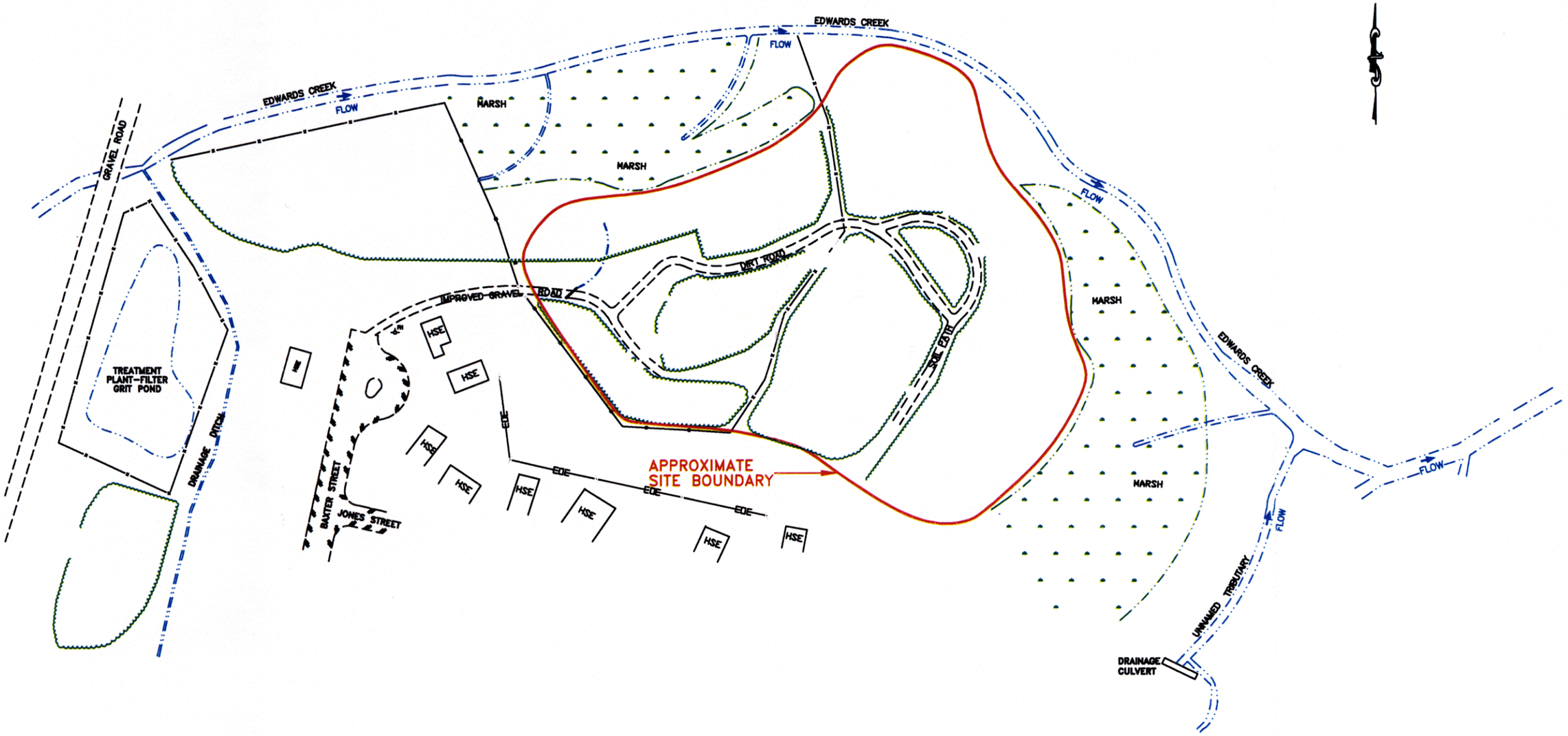
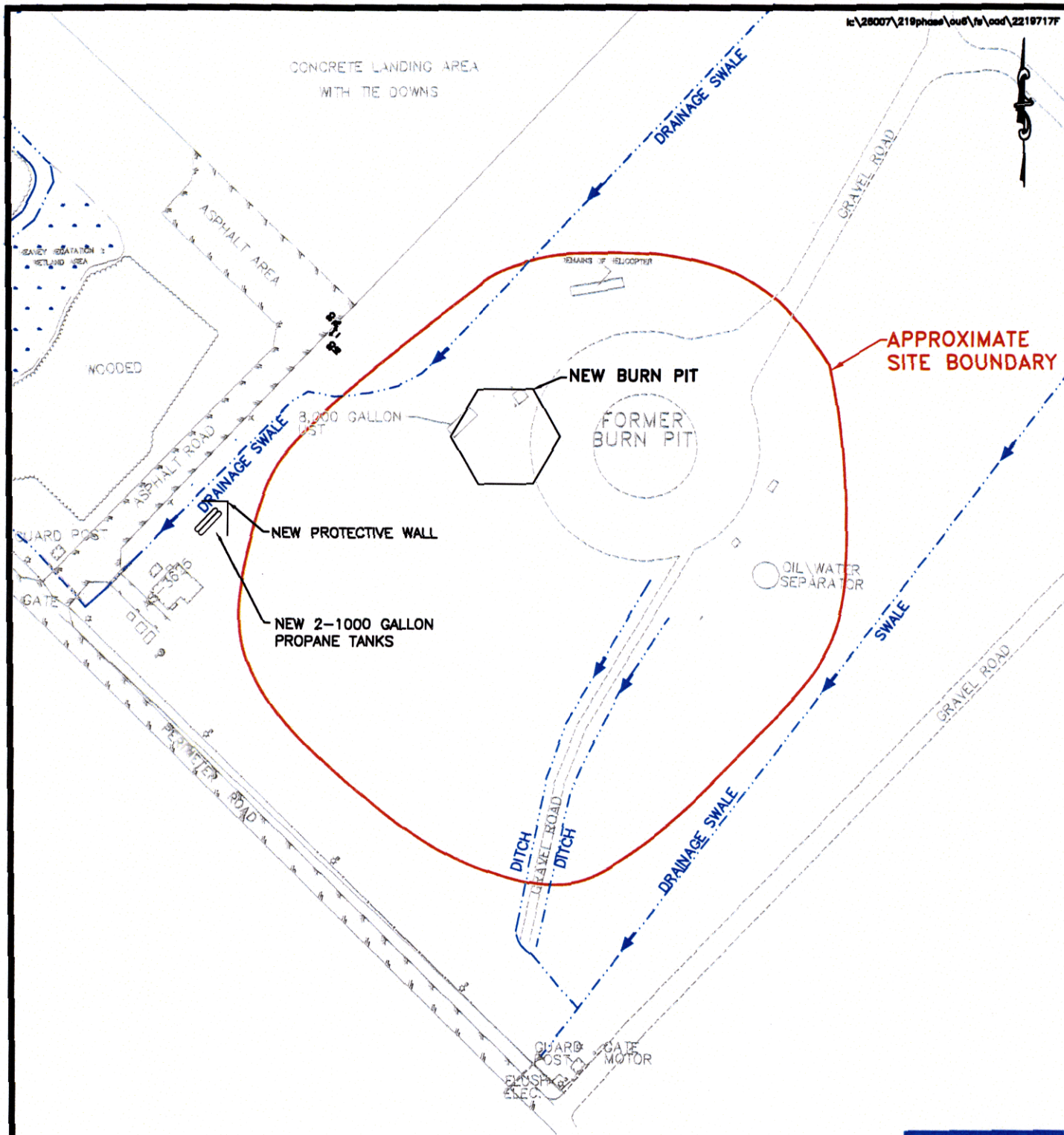


LEGEND

- FLOW — DIRECTION OF SURFACE WATER FLOW
- MARSH
- EOE — OVERHEAD ELECTRIC LINE & UTILITY POLE
- FENCE
- ASPHALT ROAD
- GRAVEL OR DIRT ROAD
- EDGE OF CREEK, DRAINAGE DITCH, MARSH OR POND
- TREE LINE
- HSE — BASE HOUSING UNIT

FIGURE 1-4
SITE FEATURES MAP
FEASIBILITY STUDY, OPERABLE UNIT NO.6
SITE 44, JONES STREET DUMP
CTO- 0219
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA



LEGEND

- MARSH
- FENCE
- ASPHALT ROAD OR AREA
- GRAVEL ROAD
- EDGE OF CREEK OR MARSH
- CENTERLINE OF DRAINAGE SWALE
- LIGHT POLE
- ELECTRIC BOX
- STRUCTURE

FIGURE 1-5
SITE FEATURES MAP
FEASIBILITY STUDY, OPERABLE UNIT NO. 6
SITE 54, CRASH CREW FIRE TRAINING BURN PIT
CTO - 0219

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

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U.S. ROUTE 17
BY-PASS
RIGHT-OF-WAY

BRINSON CREEK

FLOW

GATE

DRAINAGE

CULVERT

EOE

APPROXIMATE
SITE BOUNDARY

IMPROVED GRAVEL ROAD

GRAVEL ROAD

DIRT ROAD

UNNAMED TRIBUTARY

36-GW14
36-GW12IW
36-GW06DW
36-GW06
36-GW15
36-GW16IW
36-GW13
36-GW10
36-GW10IW
36-GW10DW
36-GW12
36-GW17
36-GW08
36-GW07
36-GW07DW
36-GW04
36-GW09
36-GW11
36-GW11DW
36-GW02
36-GW01
36-GW03
36-GW05

36-SW/SD07
36-BN07
36-SD09
36-SD08
36-SW/SD06
36-BN08
36-SW/SD05
36-BN05
36-SW/SD04
36-SW/SD03
36-SW/SD01
36-SW/SD02

GS-SB04
GS-SB03
GS-SB02
GS-SB01
GS-SB05
GS-SB06

OA-SB06
OA-SB01A
OA-SB01
OA-SB01B
OA-SB01C
OA-SB01D
OA-SB04
OA-SB08
OA-SB02
OA-SB03
OA-SB05
OA-SB07

EDA-SB03
EDA-SB06
EDA-SB02
EDA-SB01
EDA-SB04
EDA-SB05

TP04
TP03
TP05
TP06A
TP06B
TP01
TP02
TP07

OF-SB01
OF-SB03
OF-SB05
OF-SB06A
OF-SB06
OF-SB06D
OF-SB06B
OF-SB06C
OF-SB02
OF-SB04

DAB-SB04
DAB-SB03
DAB-SB01
DAB-SB02
DAD-SB01
DAD-SB02
SG01
36-TW01

BB-SB02
BB-SB01

FCA-SB04
FCA-SB10
FCA-SB12
FCA-SB07
FCA-SB13
FCA-SB01
FCA-SB08
FCA-SB05
FCA-SB14
FCA-SB02
FCA-SB09
FCA-SB11
FCA-SB06
FCA-SB03

AREA SHOWN ENLARGED ON FIGURES 2-1 AND 2-2

36-GW14	SHALLOW MONITORING WELL
36-GW12IW	INTERMEDIATE MONITORING WELL
36-GW06DW	DEEP MONITORING WELL
36-TW01	TEMPORARY MONITORING WELL
SG01	STAFF GAUGE
OA-SB02	SOIL BORING LOCATION
36-SW/SD01	SURFACE WATER AND SEDIMENT SAMPLE LOCATION
36-SW/SD05 36-BN05	SURFACE WATER, SEDIMENT AND BENTHIC SAMPLE LOCATION

NOTE:
THE FOLLOWING WELLS HAVE BEEN ABANDONED: 36-GW04, 36-GW06, 36-GW06DW, 36-GW08, 36-GW12, 36-GW12IW, 36-GW14, 36-GW15, AND 36-GW17.

200 0 100 200
1 inch = 200 ft.

Baker

LEGEND

FLOW — DIRECTION OF SURFACE WATER FLOW	EDGE OF DRAINAGE DITCH
FENCE	US 17 JACKSONVILLE BYPASS EASEMENT LIMITS
TP01 — EXPLORATORY TEST PIT LOCATION	
GRAVEL ROAD	

SOURCE: LANTDIV, MARCH 2000

FIGURE 1-6
REMEDIAL INVESTIGATION SAMPLING LOCATIONS
FEASIBILITY STUDY, OPERABLE UNIT NO. 6
SITE 36, CAMP GEIGER DUMP AREA
CTO - 0219
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

k:\26007\219phase\ou6\fe\cad\2219719F

EC-SW/SD01
EC-SW/SD02
EDWARDS CREEK
FLOW
FLOW
STRAWHORN CREEK
43-TW04
SHC-SW/SD04
APPROXIMATE SITE BOUNDARY
OA-SB01
OA-SB02
DA1-SB01
DA1-SB02
DA1-SB03
OA-SB04
DA2-SB02
DA2-SB01
43-TP03
AREA SHOWN ENLARGED ON FIGURE 2-5
43-TP04
OA-SB03
43-GW03
43-TW03
43-TP02
WA-SB01
43-TP01
WA-SB02
43-GW01DW
43-GW01
WA-SB03
ABANDONED SEWAGE DISPOSAL FACILITY
(BB-SB02)
43-GW04DW
43-GW04
OA-SB05
SHC-SW/SD03
43-TW02
OA-SB06
43-TP05
BB-SB01
SEWAGE PUMP/LIFT STATION
43-PZ01
GRAVEL ROAD
SOIL PATH
OA-SB07
MA-SB02
MA-SB01
MA-SB03
43-GW02
BB-SB03
43-TW01
MA-SB04
MA-SB05
SHC-SW/SD01
SHC-SW/SD02
AGAN STREET
DAYCARE/ MINISCHOOL
MARSH
DRAINAGE DITCH

LEGEND

- 43-GW01 — SHALLOW MONITORING WELL
- 43-GW01DW — DEEP MONITORING WELL
- 43-TW01 — TEMPORARY MONITORING WELL
- 43-PZ01 — PIEZOMETER
- OA-SB01 — SOIL BORING LOCATION
- SHC-SW/SD01 — SURFACE WATER AND SEDIMENT SAMPLING LOCATION
- 43-TP01 — TEST PIT LOCATION
- FLOW — DIRECTION OF SURFACE WATER FLOW
- MARSH
- OHE — OVERHEAD ELECTRIC LINE & UTILITY POLE
- FENCE
- ASPHALT ROAD
- GRAVEL ROAD OR SOIL PATH
- EDGE OF CREEK, DRAINAGE DITCH OR MARSH
- TREE LINE
- STRUCTURE

120 0 60 120
1 inch = 120 ft.

Baker
Baker Environmental, Inc.

FIGURE 1-7
REMEDIAL INVESTIGATION SAMPLING LOCATIONS
FEASIBILITY STUDY, OPERABLE UNIT NO. 6
SITE 43, AGAN STREET DUMP
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

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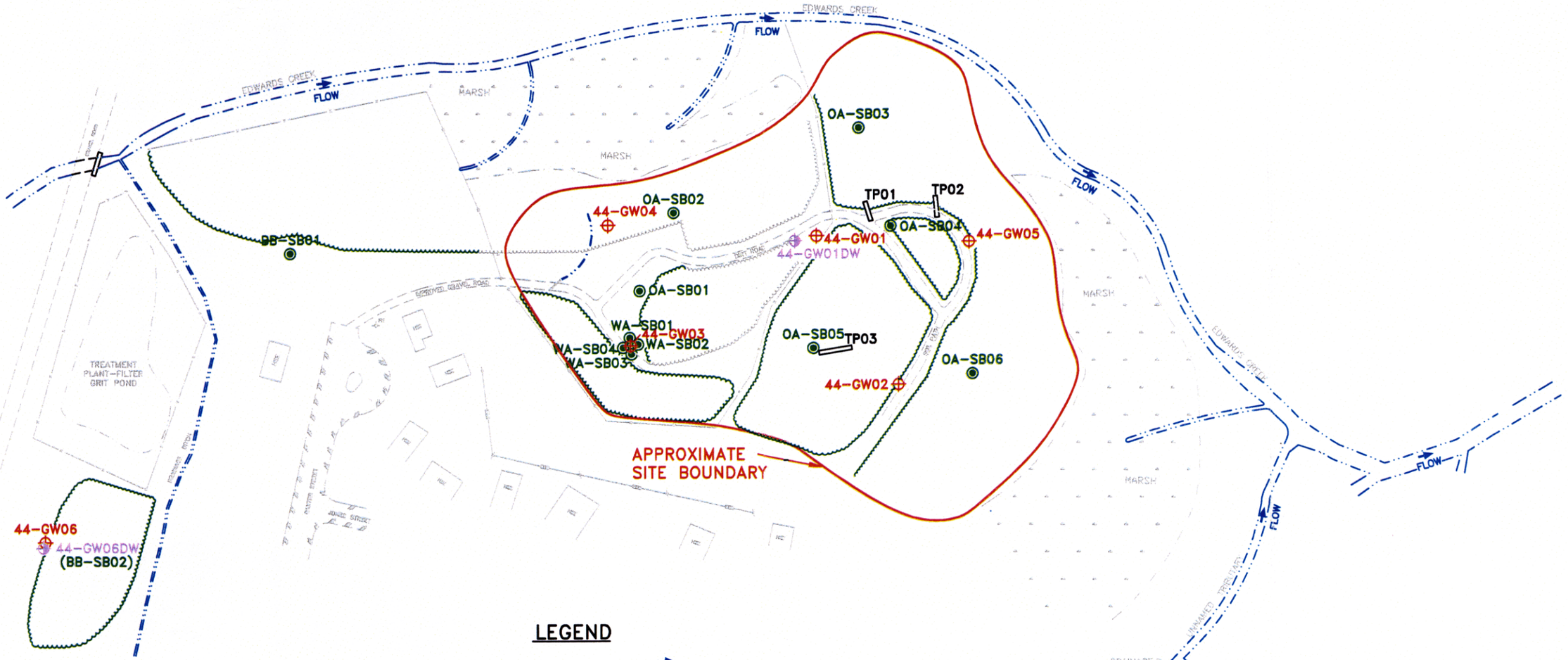

LEGEND

- 44-GW06 — SHALLOW MONITORING WELL
- 44-GW06DW — DEEP MONITORING WELL
- OA-SB02 — SOIL BORING LOCATION
- TP01 — EXPLORATORY TEST PIT
- FLOW — DIRECTION OF SURFACE WATER FLOW
- MARSH
- E OE — OVERHEAD ELECTRIC LINE & UTILITY POLE
- FENCE
- ASPHALT ROAD
- GRAVEL OR DIRT ROAD
- EDGE OF CREEK, DRAINAGE DITCH, MARSH OR POND
- TREE LINE
- HSE — BASE HOUSING UNIT

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FIGURE 1-8
REMEDIAL INVESTIGATION SAMPLING LOCATIONS
FEASIBILITY STUDY, OPERABLE UNIT NO. 6
SITE 44, JONES STREET DUMP
CTO - 0219
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

k:\26007\219phase\ou6\fe\dgd\2219737F

54-GW02
GRAVEL ROAD
54-GW12
NEW BURN PIT
ES07
ES08
54-GW07
SB01
SB07
SB06
APPROXIMATE SITE BOUNDARY
ES06
TW01
ES10
SB02
ES05
TW06
TW05
TW07
TW04
ES13
BURN PIT
ES12
SB05
TW03
CONCRETE PAD
54-GW10
ES11
54-GW06
54-GW08
ES15
TW02
ES16
54-GW01
ES14
54-GW11
SB03
54-GW09
54-GW05
ES17
ES18
SB08
ES01
ES02
ES04
ES03
SB04
SB09
54-GW13
54-GW04
DD-SB01
DD-SB02
FLOW
ASPHALT ROAD
PERIMETER ROAD
DD-SB03
DD-SB04
DITCH
DITCH
GRAVEL ROAD
DRAINAGE SWALE
NOTE: MONITORING WELLS 54-GW11, 54-GW12, AND 54-GW13 WERE INSTALLED DURING THE POST-RI FIELD INVESTIGATION.
DD-SB05
54-GW03
100 0 50 100
1 inch = 100 ft.
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LEGEND

- 54-GW07 — SHALLOW MONITORING WELL
- TW01 — TEMPOARY MONITORING WELL
- SB09 — SOIL BORING LOCATION
- ES09 — IMMUNOASSAY FIELD SCREENING SOIL BORING
- FLOW — DIRECTION OF SURFACE WATER FLOW
- MARSH
- FENCE
- ASPHALT ROAD OR AREA
- GRAVEL ROAD
- EDGE OF CREEK OR MARSH
- CENTERLINE OF DRAINAGE SWALE
- LIGHT POLE
- ELECTRIC BOX
- STRUCTURE

SOURCE: LANTDIV, MARCH 2000

FIGURE 1-9
REMEDIAL INVESTIGATION SAMPLING LOCATIONS
FEASIBILITY STUDY, OPERABLE UNIT NO. 6
SITE 54, CRASH CREW FIRE TRAINING BURN PIT
CTO - 0219
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

REGION IX PRELIMINARY REMEDIATION GOALS (PRGs) - RESIDENTIAL

SEMIVOLATILE ORGANIC COMPOUNDS	REGION IX PRGs – RESIDENTIAL
NAPHTHALENE	56,000
2–METHYLNAPHTHALENE	NE
ACENAPHTHENE	3,700,000
DIBENZOFURAN	290,000
DIETHYLPHTHALATE	49,000,000
FLUORENE	2,600,000
N–NITROSO–DI–N–PROPYLAMINE	69
PHENANTHRENE	NE
ANTHRACENE	22,000,000
CARBAZOLE	24,000
FLUORANTHENE	2,300,000
PYRENE	2,300,000
BENZO(A)ANTHRACENE	620
CHRYSENE	62,000
BIS(2–ETHYLHEXYL)PHTHALATE	NE
BENZO(B)FLUORANTHENE	620
BENZO(K)FLUORANTHENE	6,200
BENZO(A)PYRENE	62
INDENO(1,2,3–CD)PYRENE	620
BUTYLBENZYLPHTHALATE	12,000,000
DIBENZO(A,H)ANTHRACENE	62
BENZO(G,H,I,)PERYLENE	NE
PESTICIDES	**REGION IX PRGs – RESIDENTIAL**
ALDRIN	29
DIELDRIN	30
4,4'–DDE*	1,700
4,4'–DDD*	2,400
4,4'–DDT*	1,700
ENDRIN KETONE	1,800
ALPHA–CHLORDANE	1,800

NOTES:
1. CONCENTRATIONS PRESENTED IN MICROGRAMS PER KILOGRAM.
2. EXCEED REGION IX PRG – RESIDENTIAL IN RED.

LOCATION	36–OF–SB03–00
DATE SAMPLED	02/21/95
PESTICIDES (ug/kg)	
ALDRIN	1400
DIELDRIN	16000
4,4'–DDE	11 J
4,4'–DDD	16 J
4,4'–DDT	2.3 J
ENDRIN KETONE	15 J
ALPHA–CHLORDANE	2.3 J

LOCATION	36–OF–SB04D–00
DATE SAMPLED	05/31/96
SEMIVOLATILE (ug/kg)	
DIETHYLPHTHALATE	160 J
PHENANTHRENE	76 J
FLUORANTHENE	160 J
PYRENE	170 J
BENZO(A)ANTHRACENE	120 J
CHRYSENE	160 J
BENZO(B)FLUORANTHENE	180 J
BENZO(K)FLUORANTHENE	80 J
BENZO(A)PYRENE	110 J
INDENO(1,2,3–CD)PYRENE	71 J
BENZO(G,H,I)PERLYENE	70 J

LOCATION	36–OF–SB04A–00
DATE SAMPLED	05/31/96
SEMIVOLATILE (ug/kg)	
ACENAPHTHENE	150 J
DIBENZOFURAN	100 J
FLUORENE	100 J
PHENANTHRENE	2800
ANTHRACENE	740
FLUORANTHENE	3400
PYRENE	3800
BUTYLBENZYLPHTHALATE	99 J
BENZO(A)ANTHRACENE	2100
CHRYSENE	1900
BENZO(B)FLUORANTHENE	3000
BENZO(K)FLUORANTHENE	990
BENZO(A)PYRENE	1900
INDENO(1,2,3–CD)PYRENE	1300
DIBENZO(A,H)ANTHRACENE	360 J
BENZO(G,H,I)PERLYENE	980

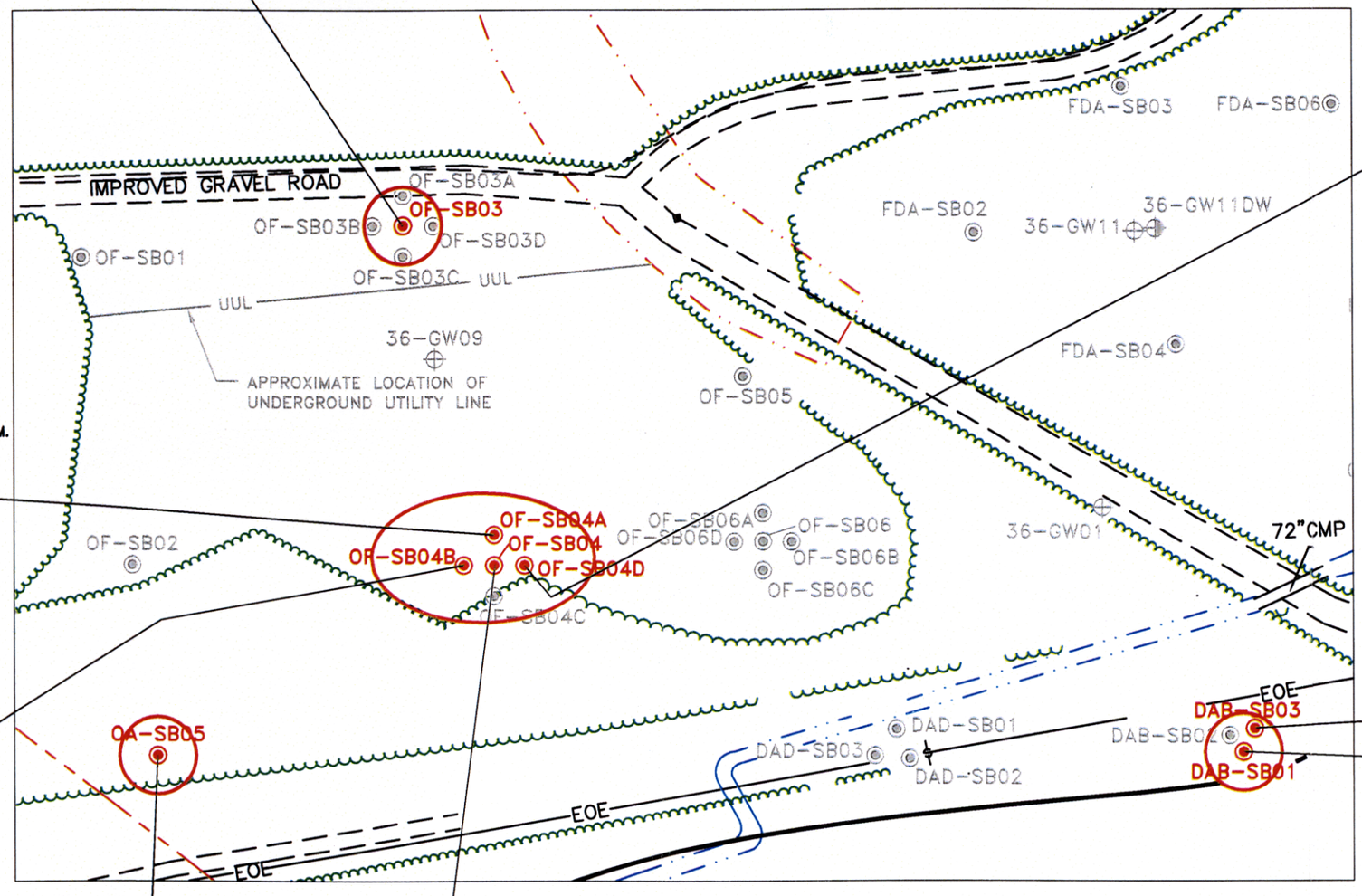
LOCATION	36–OF–SB04B–00
DATE SAMPLED	05/31/96
SEMIVOLATILE (ug/kg)	
NAPHTHALENE	820 J
2–METHYLNAPHTHALENE	1000 J
ACENAPHTHENE	4200
DIBENZOFURAN	2400
FLUORENE	2200
PHENANTHRENE	29000
ANTHRACENE	8400
CARBAZOLE	2600
FLUORANTHENE	52000
PYRENE	58000
BENZO(A)ANTHRACENE	39000
CHRYSENE	44000
BENZO(B)FLUORANTHENE	64000
BENZO(K)FLUORANTHENE	12000
BENZO(A)PYRENE	43000
INDENO(1,2,3–CD)PYRENE	35000
DIBENZO(A,H)ANTHRACENE	5700
BENZO(G,H,I)PERLYENE	31000

LOCATION	36–OA–SB05–00
DATE SAMPLED	02/28/95
PESTICIDES/PCBs (ug/kg)	
HEPTACHLOR EPOXIDE	24 J
DIELDRIN	160 J
4,4'–DDE	1000
4,4'–DDD	230 J
4,4'–DDT	420
ALPHA–CHLORDANE	980
GAMMA–CHLORDANE	840

LOCATION	36–OF–SB04–00
DATE SAMPLED	02/22/95
SEMIVOLATILES (ug/kg)	
NAPHTHALENE	120 J
2–METHYLNAPHTHALENE	54 J
ACENAPHTHENE	330 J
DIBENZOFURAN	150 J
FLUORENE	200 J
PHENANTHRENE	2500
ANTHRACENE	780
CARBAZOLE	240 J
FLUORANTHENE	5500
PYRENE	11000 J
BENZO(A)ANTHRACENE	3900 J
CHRYSENE	4800 J
BENZO(B)FLUORANTHENE	3600
BENZO(K)FLUORANTHENE	1500
BENZO(A)PYRENE	3300
INDENO(1,2,3–CD)PYRENE	2700
DIBENZO(A,H)ANTHRACENE	720
BENZO(G,H,I)PERYLENE	2400
PESTICIDES (ug/kg)	
DIELDRIN	47 J

LOCATION	36–DAB–SB03–00
DATE SAMPLED	02/24/95
SEMIVOLATILES (ug/kg)	
N–NITROSO–DI–N–PROPYLAMINE	320 J
PHENANTHRENE	68 J
FLUORANTHENE	88 J
PYRENE	120 J
BENZO(A)ANTHRACENE	46 J
CHRYSENE	51 J
INDENO(1,2,3–CD)PYRENE	58 J
PESTICIDES/PCBs (ug/kg)	
4,4'–DDE	55 J
4,4'–DDD	6.1 J
4,4'–DDT	17

LOCATION	36–DAB–SB01–00
DATE SAMPLED	02/24/95
SEMIVOLATILES (ug/kg)	
PYRENE	41 J
BENZO(K)FLUORANTHENE	39 J
PESTICIDES/PCBs (ug/kg)	
4,4'–DDE	960
4,4'–DDD	120 J
4,4'–DDT	3300 J



80 0 40 80
1 inch = 80 ft.

Baker
Baker Environmental, Inc.

LEGEND

- SHALLOW MONITORING WELL
- INTERMEDIATE MONITORING WELL
- DEEP MONITORING WELL
- SOIL BORING LOCATION (SURFACE SAMPLE)
- UUL UNDERGROUND UTILITY LINE
- AREA OF CONCERN
- GRAVEL ROAD
- DRAINAGE DITCH
- TREE LINE
- US 17 JACKSONVILLE BYPASS EASEMENT LIMITS

FIGURE 2–1
AREA OF CONCERN: REGION IX RESIDENTIAL PRGs
FEASIBILITY STUDY, OPERABLE UNIT NO. 6
SITE 36, CAMP GEIGER AREA DUMP
CTO – 0219
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

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U.S. ROUTE 17
BY-PASS
RIGHT-OF-WAY

GATE

DRAINAGE

DRAINAGE

CULVERT

APPROXIMATE
SITE BOUNDARY

IMPROVED GRAVEL ROAD

GRAVEL ROAD

UNNAMED TRIBUTARY

FLOW

EOE

36-GW13IW 36-GW13 GS-SB04
GS-SB03
GS-SB02
GS-SB01
36-GW10IW
GS-SB05
36-GW10DW
36-GW10
ND
10 (5-7')
GS-SB06
36-GW12IW 36-GW12
36-GW03
OA-SB06
35.6J
112 (3-5')
30.2 (1-3')
OA-SB04
OA-SB01B
OA-SB04
477J
1.4 (3-5')
138
76.2 (1-3')
433
519 (1-3')
SB04
SB03
OA-SB08
836J
7.7 (1-3')
SB02
36-WP08
FDA-SB03
14.5
TP04
FDA-SB06
51.9J
143J (13-15')
FDA-SB02 1.2 (7-9')
23.7
190J (7-9')
TP03
TP05
FDA-SB01
97.1J
433J (3-5')
36-GW11
35.3
1980 (7-9')
5.7 (11-13')
36-GW11DW
36-GW02
OF-SB01
4.5
3.3 (7-9')
OF-SB03
41
5.1 (5-7')
FDA-SB04
8.3
33.8J (1-3')
FDA-SB05
14.5
424J (1-3')
OA-SB07
2680J (1-3')
OA-SB07R
OA-SB03
7.1
289J (5-7')
TP06A
TP06B
36-GW09
ND
151 (7-9')
OF-SB05
43.5
37.6 (11-13')
36-GW01
OF-SB06A
ND
871 (1-3')
OF-SB06D
18.1
555 (3-5')
OF-SB06C
112
12.8 (3-5')
TP01
TP02
OF-SB06
21.7
11.2 (5-7')
OF-SB06B
29.7
1210 (3-5')
OF-SB02
69
2.1J (3-5')
OF-SB04
234
17.4 (7-9')
TP07
OA-SB05
116
2.8 (3-5')
86.7 (0-6")
23.4 (6-12")
DAD-SB01
111J
DAB-SB03
91.8J
37.6J (1-3')
DAD-SB03
222J
DAB-SB01
71.3J
158J (1-3')
DAD-SB02
86.3J
60.1J (1-3')
DAB-SB02
33.4J
82.8J (3-5')
FCA-SB14
3.9 (1-3')

36-GW14 SHALLOW MONITORING WELL
36-GW12IW INTERMEDIATE MONITORING WELL
36-GW06DW DEEP MONITORING WELL
OA-SB02 SOIL BORING LOCATION
36-SB01 BORING FROM JANUARY 2001
TP01 EXPLORATORY TEST PIT LOCATION

19.2 SURFACE CONCENTRATION mg/kg
400 SURFACE CONCENTRATION EXCEEDING THE 400 MAX FEDERAL LEVEL mg/kg (OSWER VALUE)
8.7 (3-5') SUBSURFACE CONCENTRATION (SAMPLE DEPTH) mg/kg
1980 (7-9') SUBSURFACE CONCENTRATION (SAMPLE DEPTH) EXCEEDING THE 400 MAX FEDERAL LEVEL mg/kg (OSWER VALUE)

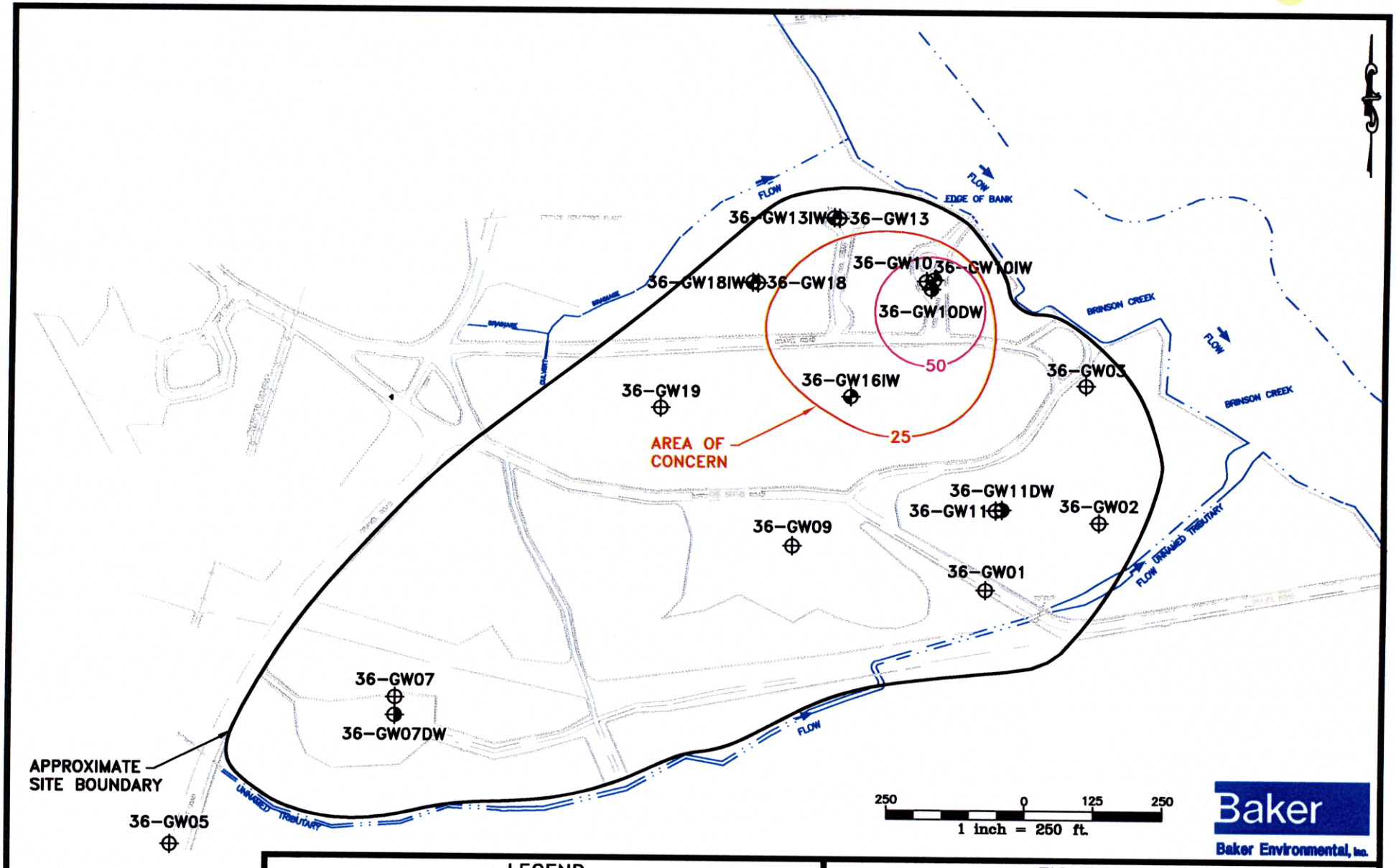
FLOW DIRECTION OF SURFACE WATER FLOW
GRAVEL ROAD
EDGE OF DRAINAGE DITCH
US 17 JACKSONVILLE BYPASS EASEMENT LIMITS
AREA OF CONCERN

SOURCE: LANTDIV, MARCH 2000

150 0 75 150
1 inch = 150 ft.

Baker
Baker Environmental, Inc.

FIGURE 2-2
AREA OF CONCERN: 400 PPM LEAD
FEASIBILITY STUDY, OPERABLE UNIT NO. 6
SITE 36, CAMP GEIGER DUMP AREA
CTO - 0219
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA



LEGEND

- 36-GW02 – SHALLOW MONITORING WELL
- 36-GW13 – INTERMEDIATE MONITORING WELL
- 36-GW10DW – DEEP MONITORING WELL
- 50 – TOTAL VOC ISOCONCENTRATION CONTOUR (ug/L)

FIGURE 2-3
AREA OF CONCERN, GROUNDWATER VOC PLUME FEASIBILITY STUDY, OPERABLE UNIT NO. 6 SITE 36, CAMP GEIGER AREA DUMP

CTO – 0219

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

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LOCATION 43-WA-SB01A2-00	
DATE SAMPLED	05/01/95
SEMIVOLATILE (ug/kg)	
ACENAPHTHENE	45 J
FLUORENE	53 J
PHENANTHRENE	1000
CARBAZOLE	260 J
FLUORANTHENE	2200
PYRENE	2100
BUTYLBENZYLPHTHALATE	50 J
BENZO(A)ANTHRACENE	980
CHRYSENE	1500
BENZO(B)FLUORANTHENE	2300
BENZO(K)FLUORANTHENE	700
BENZO(A)PYRENE	1300
INDENO(1,2,3-CD)PYRENE	1300
DIBENZO(A,H)ANTHRACENE	280 J
BENZO(G,H,I)PERYLENE	1200

LOCATION 43-WA-SB01A1-00	
DATE SAMPLED	05/01/95
SEMIVOLATILE (ug/kg)	
PHENANTHRENE	610
CARBAZOLE	120 J
FLUORANTHENE	1500
PYRENE	1200
BENZO(A)ANTHRACENE	560
CHRYSENE	890
BENZO(B)FLUORANTHENE	1100
BENZO(K)FLUORANTHENE	420
BENZO(A)PYRENE	690
INDENO(1,2,3-CD)PYRENE	590
DIBENZO(A,H)ANTHRACENE	110 J
BENZO(G,H,I)PERYLENE	560

LOCATION 43-WA-SB01B-00	
DATE SAMPLED	03/14/95
SEMIVOLATILE (ug/kg)	
FLUORANTHENE	130 J
PYRENE	150 J
BENZO(A)ANTHRACENE	67 J
CHRYSENE	120 J
BENZO(B)FLUORANTHENE	600
BENZO(K)FLUORANTHENE	280 J
BENZO(A)PYRENE	770
INDENO(1,2,3-CD)PYRENE	590
DIBENZO(A,H)ANTHRACENE	110 J
BENZO(G,H,I)PERYLENE	380 J

LOCATION 43-WA-SB01C-00	
DATE SAMPLED	03/14/95
SEMIVOLATILE (ug/kg)	
PHENANTHRENE	54 J
FLUORANTHENE	350
PYRENE	430
BENZO(A)ANTHRACENE	260 J
CHRYSENE	340 J
BENZO(B)FLUORANTHENE	500
BENZO(K)FLUORANTHENE	200 J
BENZO(A)PYRENE	480
INDENO(1,2,3-CD)PYRENE	550
DIBENZO(A,H)ANTHRACENE	47 J
BENZO(G,H,I)PERYLENE	480

LOCATION 43-WA-SB01-00	
DATE SAMPLED	02/28/95
SEMIVOLATILE (ug/kg)	
PHENANTHRENE	260 J
FLUORANTHENE	530
PYRENE	470
BENZO(A)ANTHRACENE	190 J
CHRYSENE	370 J
BENZO(B)FLUORANTHENE	410
BENZO(K)FLUORANTHENE	200 J
BENZO(A)PYRENE	260 J
INDENO(1,2,3-CD)PYRENE	270 J
DIBENZO(A,H)ANTHRACENE	73 J
BENZO(G,H,I)PERYLENE	280 J

LOCATION 43-WA-SB02-01	
DATE SAMPLED	02/28/95
SEMIVOLATILE (ug/kg)	
PHENANTHRENE	430
CARBAZOLE	73 J
FLUORANTHENE	850
PYRENE	1800 J
BUTYLBENZYLPHTHALATE	39 J
BENZO(A)ANTHRACENE	390 J
CHRYSENE	740 J
BENZO(B)FLUORANTHENE	780
BENZO(K)FLUORANTHENE	340 J
BENZO(A)PYRENE	570
INDENO(1,2,3-CD)PYRENE	890
DIBENZO(A,H)ANTHRACENE	170 J
BENZO(G,H,I)PERYLENE	790

LOCATION 43-WA-SB01A-00	
DATE SAMPLED	03/14/95
SEMIVOLATILE (ug/kg)	
2-METHYLNAPHTHALENE	74 J
ACENAPHTHENE	2900
DIBENZOFURAN	870
FLUORENE	1700
PHENANTHRENE	5900 J
ANTHRACENE	820
CARBAZOLE	350 J
FLUORANTHENE	60000
PYRENE	64000
BENZO(A)ANTHRACENE	41000
CHRYSENE	46000
BENZO(B)FLUORANTHENE	52000
BENZO(K)FLUORANTHENE	20000
BENZO(A)PYRENE	39000
INDENO(1,2,3-CD)PYRENE	27000
DIBENZO(A,H)ANTHRACENE	1200
BENZO(G,H,I)PERYLENE	24000

LOCATION 43-WA-SB01A3-00	
DATE SAMPLED	05/01/95
SEMIVOLATILE (ug/kg)	
ACENAPHTHYLENE	71 J
ACENAPHTHENE	63 J
DIBENZOFURAN	35 J
FLUORENE	59 J
PHENANTHRENE	1300
ANTHRACENE	210 J
CARBAZOLE	300 J
FLUORANTHENE	6400
PYRENE	6500
BUTYLBENZYLPHTHALATE	100 J
BENZO(A)ANTHRACENE	3200
CHRYSENE	4500
BENZO(B)FLUORANTHENE	6800
BENZO(K)FLUORANTHENE	1300
BENZO(A)PYRENE	4700
INDENO(1,2,3-CD)PYRENE	3600
DIBENZO(A,H)ANTHRACENE	710
BENZO(G,H,I)PERYLENE	3400

LOCATION 43-GW01DW-00	
DATE SAMPLED	02/28/95
SEMIVOLATILE (ug/kg)	
PHENANTHRENE	720
ANTHRACENE	44 J
CARBAZOLE	99 J
FLUORANTHENE	1400
PYRENE	1100
BENZO(A)ANTHRACENE	570
CHRYSENE	1000
BENZO(B)FLUORANTHENE	1500
BENZO(K)FLUORANTHENE	580
BENZO(A)PYRENE	760
INDENO(1,2,3-CD)PYRENE	500
DIBENZO(A,H)ANTHRACENE	110 J
BENZO(G,H,I)PERYLENE	420

LOCATION 43-WA-SB01A4-00	
DATE SAMPLED	05/01/95
SEMIVOLATILE (ug/kg)	
PHENANTHRENE	67 J
FLUORANTHENE	230 J
PYRENE	170 J
BENZO(A)ANTHRACENE	51 J
CHRYSENE	110 J
BENZO(B)FLUORANTHENE	170 J
BENZO(K)FLUORANTHENE	57 J
BENZO(A)PYRENE	79 J
INDENO(1,2,3-CD)PYRENE	90 J
BENZO(G,H,I)PERYLENE	87 J

WA-SB01C
WA-SB01B
WA-SB01A1
WA-SB01A2
WA-SB01A
WA-SB01
WA-SB01A4
WA-SB01A3
WA-SB02 (1'-3')
43-GW01DW
OA-SB02
WA-SB03
APPROXIMATE SITE BOUNDARY
AREA OF CONCERN
GRAVEL ROAD

LEGEND

- 43-GW01DW — PILOT TEST BORING FOR DEEP MONITORING WELL
- OA-SB01 — SOIL BORING LOCATION
- WA-SB01A — SURFACE SOIL SAMPLE LOCATION
- GRAVEL ROAD OR SOIL PATH
- TREE LINE
- AREA OF CONCERN

RESIDENTIAL REGION IX PRELIMINARY REMEDIATION GOALS (PRGs)

SEMI VOLATILE ORGANIC COMPOUNDS	REGION IX PRGS-RESIDENTIAL
2-METHYLNAPHTHALENE	NE
ACENAPHTHENE	3,700,000
ACENAPHTHYLENE	NE
DIBENZOFURAN	290,000
CARBAZOLE	24,000
FLUORENE	2,600,000
PHENANTHRENE	NE
FLUORANTHENE	2,300,000
PYRENE	2,300,000
BUTYLBENZYLPHTHALATE	12,000,000
BENZO(A)ANTHRACENE	620
CHRYSENE	62,000
BENZO(B)FLUORANTHENE	620
BENZO(K)FLUORANTHENE	6,200
BENZO(A)PYRENE	62
INDENO(1,2,3-CD)PYRENE	620
BENZO(G,H,I)PERYLENE	NE
DIBENZO(A,H)ANTHRACENE	62

NOTE:
1. CONCENTRATIONS PRESENTED IN MICROGRAMS PER KILOGRAM.
2. EXCEEDANCE OF REGION IX RESIDENTIAL PRG SHOWN IN RED.

30 0 15 30
1 inch = 30 ft.

Baker
Baker Environmental, Inc.

FIGURE 2-4
AREA OF CONCERN:
REGION IX RESIDENTIAL PRGs
FEASIBILITY STUDY, OPERABLE UNIT NO. 6
SITE 43, AGAN STREET DUMP
CTO - 0219
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

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OA-SB04

APPROXIMATE LOCATION OF CAP

IMPROVED GRAVEL ROAD

OF-SB03A

OF-SB03

OF-SB03B

OF-SB03D

OF-SB03C

OF-SB01

UUL

UUL

APPROXIMATE LOCATION OF UNDERGROUND UTILITY LINE

OA-SB03

36-GW09

OF-SB05

FDA-SB03

FDA-SB06

OA-SB08

SB03

FDA-SB02

36-GW11

36-GW11DW

FDA-SB01

36-GW02

FDA-SB05

FDA-SB04

FLOW

UNNAMED TRIBUTARY

OA-SB07

OF-SB02

OF-SB04B

OF-SB04A

OF-SB04

OF-SB04D

OF-SB04C

OF-SB06A

OF-SB06D

OF-SB06

OF-SB06B

OF-SB06C

36-GW01

72"CMP

APPROXIMATE LOCATION OF CAP

EOE

OA-SB05

APPROXIMATE LOCATION OF CAP

EOE

DAD-SB01

DAD-SB03

DAD-SB02

DAB-SB03

DAB-SB02

DAB-SB01

APPROXIMATE LOCATION OF CAP

80 0 40 80

1 inch = 80 ft.

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NOTE:
SOIL BORINGS IN RED EXCEED REGION IX RESIDENTIAL PRGs.
SAMPLE LOCATIONS IN BLUE EXCEED USEPA OSWER DIRECTIVE FOR LEAD (400 ppm).

LEGEND

- SHALLOW MONITORING WELL
- INTERMEDIATE MONITORING WELL
- DEEP MONITORING WELL
- SOIL BORING LOCATION
- UUL UNDERGROUND UTILITY LINE
- GRAVEL ROAD
- DRAINAGE DITCH
- TREE LINE
- US 17 JACKSONVILLE BYPASS EASEMENT LIMITS
- INSTITUTIONAL CONTROL BOUNDARY FOR LEAD

FIGURE 4-1
36S RAA 2: CAPPING AND INSTITUTIONAL CONTROLS FOR LEAD
FEASIBILITY STUDY, OPERABLE UNIT NO. 6
SITE 36, CAMP GEIGER AREA DUMP
CTO - 0219
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

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OA-SB04

EXCAVATE TO DEPTH OF 2 FEET

IMPROVED GRAVEL ROAD

OF-SB03A

OF-SB03B

OF-SB03

OF-SB03D

OF-SB03C

OF-SB01

UUL

UUL

APPROXIMATE LOCATION OF UNDERGROUND UTILITY LINE

OA-SB03

36-GW09

OF-SB05

EXCAVATE TO DEPTH OF 2 FEET

OF-SB04A

OF-SB04

OF-SB04B

OF-SB04D

OF-SB04C

OF-SB02

OF-SB06A

OF-SB06D

OF-SB06

OF-SB06B

OF-SB06C

36-GW01

EXCAVATE TO DEPTH OF 2 FEET

OA-SB05

FDA-SB03

FDA-SB06

OA-SB08

SB03

FDA-SB02

36-GW11

36-GW11DW

FDA-SB01

36-GW02

FDA-SB05

FDA-SB04

FLOW

UNNAMED TRIBUTAR

OA-SB07

72"CMP

EOE

DAD-SB01

DAD-SB03

DAD-SB02

DAB-SB02

DAB-SB03

DAB-SB01

EOE

EXCAVATE TO DEPTH OF 2 FEET

EOE

EOE

80 0 40 80

1 inch = 80 ft.

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Baker Environmental, Inc.

NOTE:
SOIL BORINGS IN RED EXCEED REGION IX RESIDENTIAL PRGs.
SAMPLE LOCATIONS IN BLUE EXCEED USEPA OSWER DIRECTIVE FOR LEAD (400 ppm).

LEGEND

- SHALLOW MONITORING WELL
- INTERMEDIATE MONITORING WELL
- DEEP MONITORING WELL
- SOIL BORING LOCATION
- UUL UNDERGROUND UTILITY LINE
- GRAVEL ROAD
- DRAINAGE DITCH
- TREE LINE
- US 17 JACKSONVILLE BYPASS EASEMENT LIMITS
- INSTITUTIONAL CONTROL BOUNDARY FOR LEAD

FIGURE 4-2
36S RAA 3: EXCAVATION AND OFF-SITE DISPOSAL AND INSTITUTIONAL CONTROLS FOR LEAD
FEASIBILITY STUDY, OPERABLE UNIT NO. 6
SITE 36, CAMP GEIGER AREA DUMP
CTO - 0219
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

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36-SW01 (1000 FEET UPSTREAM)

36-SW02

BRINSON CREEK

FLOW

36-GW13IW

36-GW13

36-GW18IW

36-GW18

36-GW10

36-GW10IW

36-GW10DW

36-SW03

FLOW

BRINSON CREEK

36-GW16IW

36-GW03

36-GW19

APPROXIMATE SITE BOUNDARY

ESTIMATED EXTENT OF PLUME

36-SW04

IMPROVED GRAVEL ROAD

36-GW11

36-GW11DW

36-GW09

36-GW02

UNNAMED TRIBUTARY

36-GW01

GRAVEL ROAD

EOE

36-TW01

36-TW02

36-GW07

36-GW07DW

24"ROP

DIRT ROAD

UNNAMED TRIBUTARY

36-GW05

FLOW

GATE

DRAINAGE

DRAINAGE

CULVERT

U.S. ROUTE 17
BY-PASS
RIGHT-OF-WAY

STC576

TC575

TC572

TC569

TC611

TC609

TC608

TC775

TC774

TC771

TC773

NOTE
WELLS AND SURFACEWATER LOCATIONS SHOWN IN RED ARE TO BE INCLUDED IN THE MONITORING PROGRAM.

200 0 100 200
1 inch = 200 ft.

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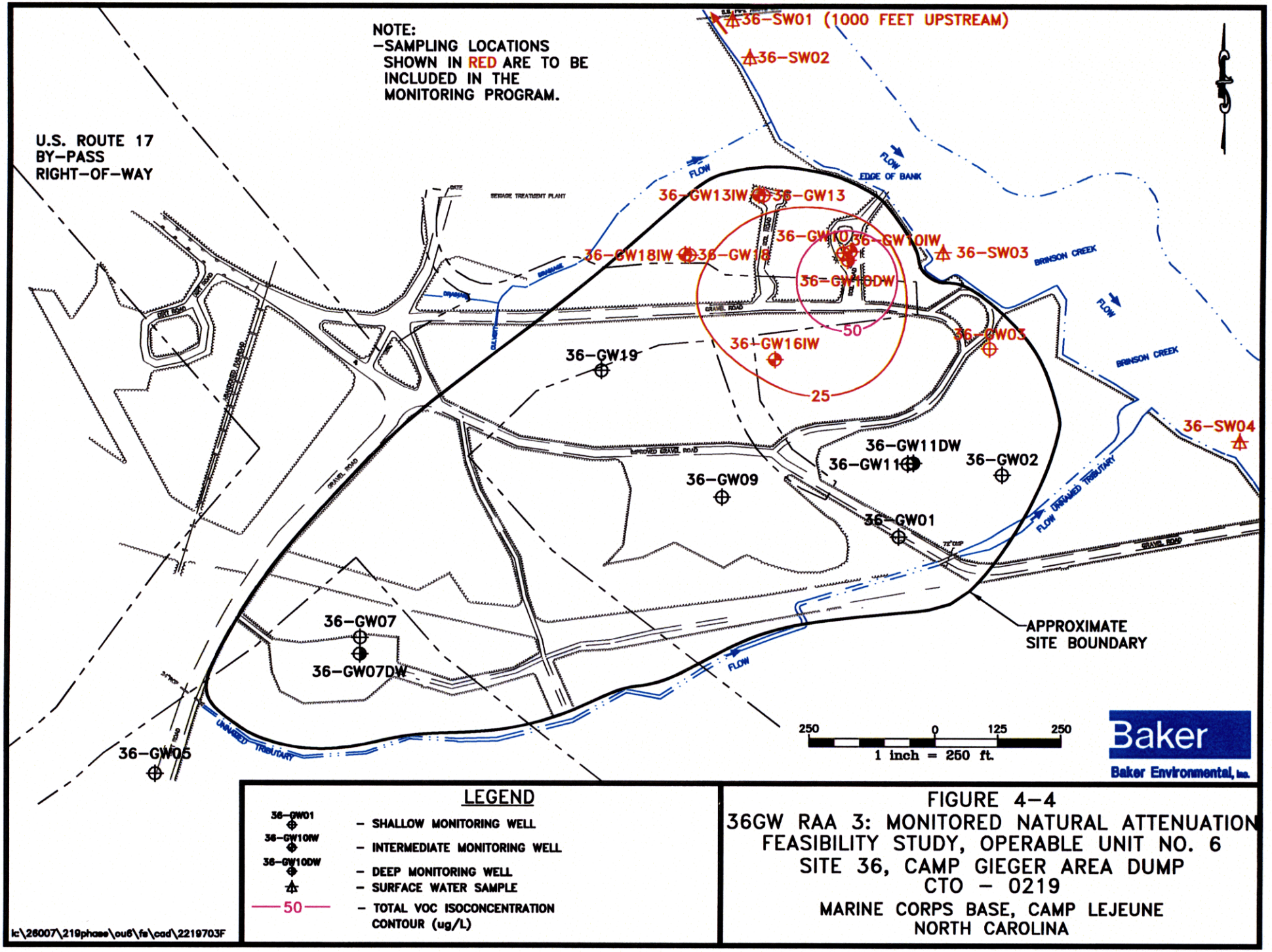
LEGEND:

- 36-GW02 — SHALLOW MONITORING WELL
- 36-GW10IW — INTERMEDIATE MONITORING WELL
- 36-GW10DW — DEEP MONITORING WELL
- SURFACE WATER SAMPLE LOCATION
- DIRECTION OF GROUNDWATER FLOW IN THE VICINITY OF THE VOC AREA OF CONCERN
- FLOW — DIRECTION OF SURFACE WATER FLOW
- GRAVEL ROAD
- EDGE OF CREEK, RIVER, OR DRAINAGE
- US 17 JACKSONVILLE BYPASS EASEMENT LIMITS
- HRC INJECTION GRID

SOURCE: LANTDIV, MARCH 2000

FIGURE 4-3
36GW RAA 2: ENHANCED NATURAL ATTENUATION (HRC)
FEASIBILITY STUDY, OPERABLE UNIT NO. 6
SITE 36, CAMP GEIGER AREA DUMP
CTO - 0219
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA



LEGEND

- 36-GW01 – SHALLOW MONITORING WELL
- 36-GW10W – INTERMEDIATE MONITORING WELL
- 36-GW10DW – DEEP MONITORING WELL
- 36-SW01 – SURFACE WATER SAMPLE
- 50 – TOTAL VOC ISOCONCENTRATION CONTOUR (ug/L)

FIGURE 4-4
36GW RAA 3: MONITORED NATURAL ATTENUATION FEASIBILITY STUDY, OPERABLE UNIT NO. 6
SITE 36, CAMP GIEGER AREA DUMP
CTO - 0219
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

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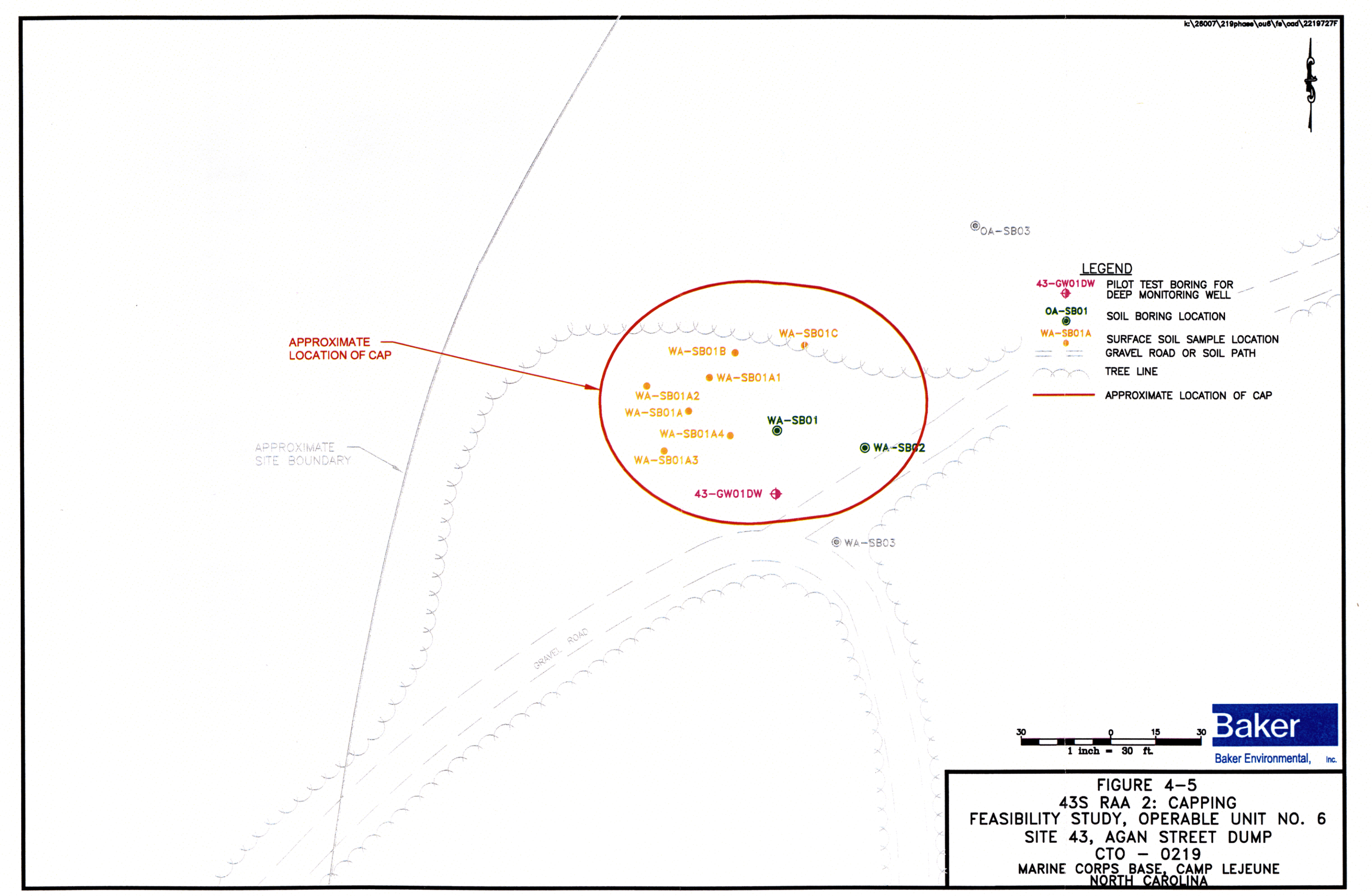

FIGURE 4-5
43S RAA 2: CAPPING
FEASIBILITY STUDY, OPERABLE UNIT NO. 6
SITE 43, AGAN STREET DUMP
CTO - 0219
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

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EXCAVATE TO DEPTH
OF 3 FEET

OA-SB03

WA-SB01C

WA-SB01B

WA-SB01A1

WA-SB01A2

WA-SB01A

WA-SB01

WA-SB01A4

WA-SB02

WA-SB01A3

43-GW01DW

WA-SB03

APPROXIMATE
SITE BOUNDARY

GRAVEL ROAD

LEGEND

43-GW01DW — PILOT TEST BORING FOR DEEP MONITORING WELL

OA-SB01 — SOIL BORING LOCATION

WA-SB01A — SURFACE SOIL SAMPLE LOCATION

GRAVEL ROAD OR SOIL PATH

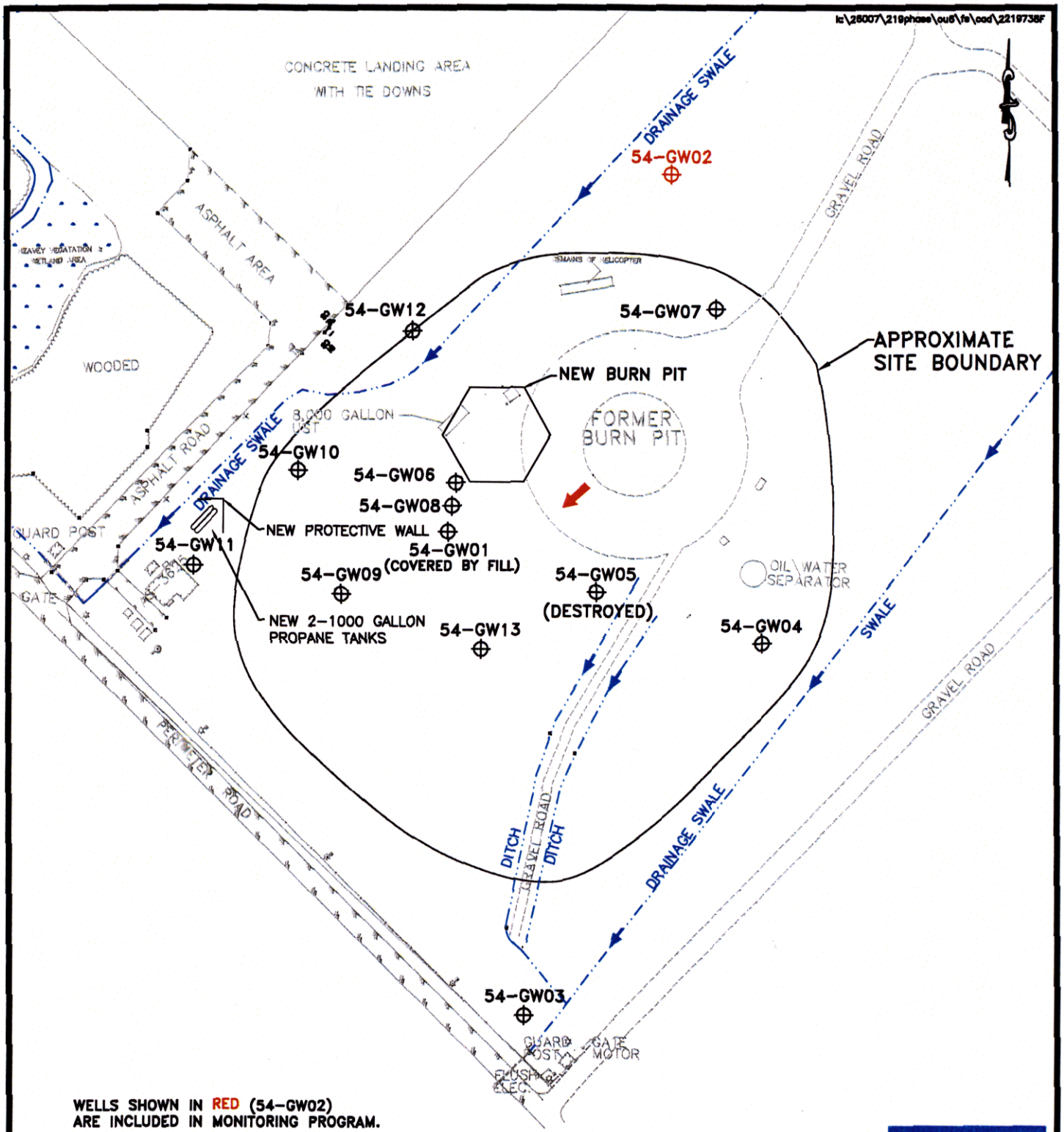
TREE LINE

30 0 15 30
1 inch = 30 ft.

Baker

Baker Environmental, Inc.

FIGURE 4-6
43S RAA 3: EXCAVATION AND OFF-SITE DISPOSAL
FEASIBILITY STUDY, OPERABLE UNIT NO. 6
SITE 43, AGAN STREET DUMP
CTO - 0219
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA



LEGEND

- 54-GW07 — SHALLOW MONITORING WELL
- CENTERLINE OF DRAINAGE SWALE
- SHALLOW GROUNDWATER FLOW DIRECTION

SURVEY: BRENT A. LANIER AND ASSOCIATES, 1995.

FIGURE 4-7

54GW RAA 2: INSTITUTIONAL CONTROLS AND GROUNDWATER MONITORING
FEASIBILITY STUDY, OPERABLE UNIT NO 6
SITE 54, CRASH CREW FIRE TRAINING BURN PIT
CTO - 0219
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA