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FINAL

ENGINEERING EVALUATION/COST ANALYSIS
SITE 85 - THE CAMP JOHNSON BATTERY DUMP

MARINE CORPS BASE
CAMP LEJEUNE, NORTH CAROLINA

CONTACT TASK ORDER 0314

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LIST OF ACRONYMS AND ABBREVIATIONS

AOCs	Areas of Concern
ARARs	Applicable or Relevant and Appropriate Requirements
Baker	Baker Environmental, Inc.
BRA	Baseline Risk Assessment
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CLEAN	Comprehensive Long-Term Environmental Action Navy
COPCs	Chemicals of Potential Concern
COC	Contaminant of Concern
CSF	Cancer Slope Factor
CTO	Contract Tak Order
DEM	Division of Environmental Management
DoN	Department of the Navy
DOT	Department of Transportation
EE/CA	Engineering Evaluation/Cost Analysis
EMD	Environmental Management Division
FS	Feasibility Study
FWS	Fish and Wildlife Service
HA	Health Advisories
HI	Hazard Index
ICR	Incremental Lifetime Cancer Risk
IR	Installation Restoration
IRP	Installation Restoration Program
kg	kilogram
LANTDIV	Atlantic Division, Naval Facilities Engineering Command
MCB	Marine Corps Base
MCLs	Maximum Contaminant Levels
mg/L	Milligrams per Liter
μg/L	Micrograms per Liter
NAVFAC	Naval Facilities Engineering Command
NC DENR	North Carolina Department Environmental and Natural Resources
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NCWQS	North Carolina Water Quality Standards
NWI	National Wetlands Inventory

LIST OF ACRONYMS AND ABBREVIATIONS
(continued)

OSHA	Occupational Safety and Health Administration
PAH	Polynuclear Aromatic Hydrocarbons
PCB	Polychlorinated biphenyl
PPE	Personal Protective Equipment
QA/QC	Personal Protective Equipment
RAGS	Risk Assessment Guidance for Superfund
RBCs	Risk-Based Concentrations
RCRA	Resource Conservation and Recovery Act
RfD	Reference Dose
RRRS	Relative Risk Ranking System
SARA	Superfund Amendments and Reauthorization Act
TAL	Total Analyte List
TCLP	Toxicity Characteristic Leaching Procedure
USC	United States Code
USEPA	U.S. Environmental Protection Agency
USGS	United States Geological Survey
USMC	United States Marine Corps
WQS	Water Quality Standards

1.0 INTRODUCTION

This report presents the Engineering Evaluation/Cost Analysis (EE/CA) of removal action options for Site 85, the Camp Johnson Battery Dump, at Marine Corps Base (MCB), Camp Lejeune, North Carolina. This EE/CA has been prepared by Baker Environmental, Inc. (Baker) under contract to the Atlantic Division Naval Facilities Engineering Command (LANTDIV, NAVFAC). The development of this EE/CA is based on the Scope of Work for Contract Task Order (CTO) 0314, under the Comprehensive Long-Term Environmental Action Navy (CLEAN) Contract N62470-89-D-4814.

This EE/CA has been prepared in accordance with the removal program requirements defined by the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), the Superfund Amendments and Reauthorization Act of 1986 (SARA), the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), and the U.S. Environmental Protection Agency's (USEPA) Guidance on Conducting Non-Time Critical Removal Actions Under CERCLA dated August 1993.

The Department of the Navy (DoN) has broad authority under CERCLA Section 104 and Executive Order 12580 to carry out removal actions when the release is on, or the sole source of the release is from the DoN installation. The Navy/Marine Corps Installation Restoration Program (IRP) was initiated to identify, assess, characterize, and clean-up or control contamination from past hazardous waste disposal operations and hazardous material spills at Navy and Marine Corps Activities. This EE/CA follows the guidelines published in the Navy/Marine Corps Installation Restoration (IR) Manual dated February 1992 and addresses a non-time-critical removal action for soil contaminated with inorganics as a result of former operations at Site 85.

A non-time-critical removal action allows for an analysis of removal alternatives for a site where action may be delayed for six months or more before clean-up is initiated. Potential remediation alternatives are evaluated for effectiveness in minimizing or stabilizing the threat to public health, consistency with the anticipated final remedial actions, consistency with applicable or relevant and appropriate requirements (ARARs), and cost effectiveness. Non-time-critical removal actions may

be interim or final actions, they may be the first and only action at a site, or one of a series of planned response actions.

This EE/CA is based on a Pre-Remedial Investigation Screening Study conducted by Baker in 1996.

This EE/CA Report is organized into the following sections:

- Section 1.0 - Introduction
- Section 2.0 - Site Characterization
- Section 3.0 - Baseline Risk Assessment
- Section 4.0 - Identification of Removal Action Objectives
- Section 5.0 - Identification of Removal Action Alternatives
- Section 6.0 - Analysis of Removal Action Alternatives
- Section 7.0 - Comparative Analysis
- Section 8.0 - Proposed Removal Action
- Section 9.0 - References

2.0 SITE CHARACTERIZATION

This section discusses environmental setting, previous investigations, the current investigation, and the detected contaminants that necessitated the preparation of this EE/CA.

2.1 Site Description and History

The following subsections detail the general history and describe the features of Site 85.

2.1.1 Setting

Site 85 is located within the Camp Johnson support operations area. The site is located to the south of Coolidge Road using a network of improved and unimproved roads. The area is heavily vegetated and contains downed trees from previous hurricanes and storms. The approximate size of the area of concern is 4.5 acres. Currently the roads surrounding Site 85 are used for vehicle training and support operations. Figure 2-1 shows the location of Site 85 within MCB Camp Lejeune.

The site's terrain is relatively flat with some mounded soil and excavated open holes. No pavement exists at the site. Some surface water runoff does collect in the excavated open holes. No permanent groundwater monitoring wells exist at Site 85, but 12 potable water supply wells have been identified within a one-mile radius of the study area.

2.1.2 History - Site 85

Site 85 was used as a battery dump during the 1950s. Battery remnants, possibly from the Korean War, were uncovered during road grading and remain visible in selected areas. The batteries are generally in piles along the side of the unimproved roads. The battery piles are composed of severely corroded and/or burned individual batteries and battery packs. The battery packs are approximately 10 inches long and 5 inches wide. The piles of batteries range in size from 2 feet wide by 2 feet long, to 10 feet wide by 20 feet long. The battery piles range in height from one to three feet. Currently there have been 16 battery piles identified at the site. The battery piles are identified on the Site Map, Figure 2-2.

2.1.3 Surface Drainage

The site is flat and unpaved. Standing water occurs after heavy rains in low areas which have been graded for roads and other vehicle training. Due to the absence of paved roads or sewer installation, overland runoff is expected to be minimal.

2.1.4 General Geology

MCB, Camp Lejeune is located within the Atlantic Coastal Plain physiographic province. The sediments of this province consist primarily of sand, silt, and clay. Other sediments may be present, including shell beds and gravel. Sediments may be of marine or continental origin. These sediments are found in interfingering beds and lenses that gently dip and thicken to the southeast. Sediments of this type range in age from early Cretaceous to Quaternary time and overlie igneous and metamorphic rocks of pre-Cretaceous age. Table 2-1 presents a generalized stratigraphic column for the Atlantic Coastal Plain of North Carolina (Harned et. Al., 1989).

United States Geological Survey (USGS) studies at MCB, Camp Lejeune indicate that the base is underlain by sand, silt, clay, calcareous clay and partially cemented limestone. The combined thickness of these sediments beneath the base is approximately 1,500 feet.

2.1.5 General Hydrogeology

The aquifers of primary interest are the surficial aquifer and the underlying Castle Hayne aquifer. Other aquifers that occur beneath the facility include the Beaufort, Pedee, Black Creek, and upper and lower Cape Fear aquifers. The following summary is a compilation of information which pertains to aquifer characteristics within the MCB, Camp Lejeune area. The location of three generalized hydrogeologic cross-sections are shown on Figure 2-3. The cross-sections are shown on Figure 2-4.

The surficial aquifer consists of interfingering beds of sand, clay, sandy clay, and silt that contain some peat and shells. The thickness of the surficial aquifer ranges from 0 to 73 feet and averages nearly 25 feet over the MCB, Camp Lejeune area. It is generally thickest in the interstream divide

areas and presumed absent where it is cut by the New River and its tributaries. The beds are thin and discontinuous, and have limited lateral continuity. This aquifer is not used for water supply at MCB, Camp Lejeune.

The general lithology of the surficial aquifer and the absence of any thick, continuous clay beds are indications of relatively high vertical conductivity within the aquifer. The estimated lateral hydraulic conductivity of the surficial aquifer in the MCB, Camp Lejeune area is 50 feet per day, and is based on a general composition of fine sand mixed with some silt and clay (Cardinell et al., 1993).

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

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

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

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

Onslow County and MCB, Camp Lejeune lie in an area where the Castle Hayne aquifer generally contains freshwater; however, the proximity of saltwater in deeper layers just below the aquifer and in the New River estuary is of concern in managing water withdrawals. Over-pumping of the deeper parts of the aquifer could cause encroachment of saltwater. The aquifer generally contains water having less than 250 milligrams per liter (mg/L) chloride throughout the base, except for one USGS well in the southern portion of the base that is screened in the lower portion of the aquifer. Chloride was measured at 960 mg/L in a sample collected in 1989 from this well.

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

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

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

2.1.6 Surface Water Hydrology

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

Water quality criteria for surface waters in North Carolina have been published under Title 15 of the North Carolina Administrative Code. At MCB, Camp Lejeune, the New River falls into two classifications: SC (estuarine waters not suited for body-contact sports or commercial shellfishing); and SA (estuarine waters suited for commercial shellfishing). The SC classification applies to only three areas of the New River at MCB, Camp Lejeune; the rest of the New River at MCB, Camp Lejeune falls into the SA classification (ESE, 1990).

2.1.7 Natural Resources and Ecological Features

The ecology at MCB Camp Lejeune is discussed in three sections that include ecological communities, sensitive environments and threatened and endangered species.

2.1.7.1 Ecological Communities

MCB, Camp Lejeune is located on North Carolina's coastal plain. A number of natural ecological communities are present within this region. In addition, variations of natural communities have occurred in response to disturbance and intervention (e.g., forest clearing, urbanization). The natural communities found in the area are summarized as follows:

- Mixed Hardwood Forest - Found generally on slopes of ravines. Beech, white oak, tulip, sweetgum, and holly are indicator species.

- Southeastern Evergreen Forest - Dominated by pines, especially longleaf pine.

- Loblolly Pine/Hardwoods Community - Second growth forest that includes loblolly pine with a mix of hardwoods (i.e., oak, hickory, sweetgum, sour gum, red maple, and holly).

- Southern Floodplain Forest - Occurs on the floodplains of rivers. Hardwoods dominate with a variety of species present. Composition of species varies with the amount of moisture.

- Maritime Forest - Develops on the lee side of stable sand dunes protected from the ocean. Live oak is an indicator species along with pine, cedar, yaupon, holly, and laurel oak. Deciduous hardwoods may be present where forest is mature.

- Pocosins - Lowland forest community that develops on highly organic soils that are seasonally flooded. Characterized by plants adapted to drought and shrubs. Strongly influenced by fire.

- Cypress Tupelo Swamp Forest - Occurs in the lowest and wettest areas of floodplains. Dominated by bald cypress and tupelo.

- Freshwater Marsh - Occurs upstream from tidal marshes and downstream from non-tidal freshwater wetlands. Cattails, sedges, and rushes are present.

- Salt Marsh - Regularly flooded, tidally influenced areas dominated by salt-tolerant grasses. Saltwater cordgrass is a characteristic species. Tidal mud flats may be present during low tide.

- Salt Shrub Thicket - High areas of salt marshes and beach areas behind dunes. Subjected to salt spray and periodic saltwater flooding. Dominated by salt resistant shrubs.

- Dunes/Beaches - Zones from the ocean shore to the maritime forest. Subjected to sand, salt, wind, and water.

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

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

MCB, Camp Lejeune covers approximately 111,000 acres or 234 square miles. Marine and estuarine open water account for 26,000 acres and terrestrial and palustrine land account for 85,000 acres. Forests are predominant as terrestrial cover and pine forest is the dominant habitat type. A total of 21,000 acres of the pine forest is loblolly pine; 7,700 acres are dominated by longleaf pine forest; and 3,600 acres are dominated by pond pine forest. These pine forests include natural subcommunities that are maintained by fire.

In addition to the pine forest, mixed pine\hardwood forest is present on MCB, Camp Lejeune and accounts for 15,900 acres. An additional 12,100 acres are covered by hardwood forest. Of the wetlands present, estuarine marsh accounts for 700 acres; open freshwater accounts for 200 acres; and dune, beach, and brackish marsh accounts for 2200 acres. Industrial, infrastructure, and administrative areas make up 10,000 acres and artillery impact areas and buffer zones account for 11,000 acres (LeBlond, 1994). The base contains 80 miles of tidal streams, 21 miles of marine shoreline, and 12 freshwater ponds. The soil types range from sandy loams to fine sand and muck, with the dominant series being sandy loam (USMC,1987).

The base drains primarily to the New River via its tributaries. These tributaries include Northeast Creek, Southwest Creek, Cogdels Creek, Wallace Creek, Frenchs Creek, Bear Head Creek, Brinson Creek, Edwards Creek, and Duck Creek. Site-specific information regarding surface water and drainage features will be presented later in this report.

Forested areas within the military reservation are actively managed for timber. Game species are also managed for hunting and ponds are maintained for fishing. Game species managed include wild turkey, white-tailed deer, black bear, grey and fox squirrels, bobwhite quail, eastern cottontail and marsh rabbits, raccoons, and wood ducks. About 150 acres are maintained for wildlife food plots.

2.1.7.2 Sensitive Environments

Two areas on MCB, Camp Lejeune have been registered as designated Natural Areas within the North Carolina Natural Heritage Program. These two areas, which encompass 141 acres, are the Longleaf Pine Natural Area and the Wallace Creek Swamp Natural Area. In addition, 12 other Natural Areas have been recommended for inclusion in the registry.

These Natural Areas contain some of the finest examples of natural communities in North Carolina and support many rare species. A few of these community types are globally rare. The Calcareous Coastal Fringe Forest on the 100-acre midden at Corn Landing is the only known extant example of this community type. Camp Lejeune contains some of the best examples of the following globally-rare, natural community types: Cypress Savanna, Depression Meadow, and Small

Depression Pond. The Maritime Evergreen Forest hammocks between Cedar Point and Shell Point are connected by shell tombolas and appear to be a very rare geological formation.

The North Carolina Department of Environmental and Natural Resources (NC DENR's) Division of Environmental Management (DEM) has developed guidance pertaining to activities that may impact wetlands (NC DENR, 1992). In addition, certain activities affecting wetlands are also regulated by the U.S. Army Corps of Engineers.

The U.S. Fish and Wildlife Service (FWS) has prepared National Wetlands Inventory (NWI) maps for the MCB, Camp Lejeune area. Through stereoscopic analysis of high altitude aerial photographs, wetlands were identified based upon vegetation, visible hydrology, and geography in accordance with Classification of Wetland and Deep-Water Habitats of the United States (Cowardin, et al., 1979). The NWI maps are intended for an initial identification of wetland areas and are not meant to replace an actual wetland delineation survey that may be required by Federal, state and local regulatory agencies.

2.1.7.3 Threatened and Endangered Species

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

Surveys have been conducted to identify threatened and endangered species at MCB, Camp Lejeune and several programs are underway to manage and protect them. Of these species, the red-cockaded woodpecker, American alligator, and sea turtles are protected by specific regulatory programs.

The red-cockaded woodpecker requires a mature, living longleaf or loblolly pine environment. The birds live in family groups and young are raised cooperatively. At MCB, Camp Lejeune, 2,512 acres of habitat have been identified and marked for protection. Approximately 3,300 acres are in actively managed red-cockaded woodpecker colonies. Research on the bird at MCB, Camp Lejeune began in 1985 and information has been collected to determine home ranges, population size and composition, reproductive success, and habitat use. An annual roost survey is conducted and 36 colonies of birds have been located.

The American alligator is considered a state special concern specie. It is found in freshwater, estuarine, and saltwater wetlands in MCB, Camp Lejeune. Base wetlands are maintained and protected for alligators; signs have been posted where alligators are known to live. Annual surveys of Wallace, Southwest, French, Duck, Mill, and Stone Creeks have been conducted since 1977 to identify alligators and their habitats on base.

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

Three bird species, piping plover, Bachmans sparrow, and peregrine falcon have also been identified during surveys at MCB, Camp Lejeune. The piping plover is a shore bird. Piping plovers prefer beaches with broad open sandy flats above the high tide line and feed along the edge of incoming waves. Like the piping plover, Bachmans sparrows have very specific habitat requirements. The sparrows live in open stretches of pines with grasses and scattered shrubs for ground cover. Bachmans sparrows were observed at numerous locations throughout southern portion MCB, Camp Lejeune.

In addition to the protected species that breed or forage at MCB, Camp Lejeune, several protected whales migrate through the coastal waters off the base during spring and fall. These include the Atlantic right whale, finback whale, sei whale, and sperm whale. Before artillery or bombing

practice is conducted in the area, aerial surveys are made to assure that whales are not present in the impact areas.

A natural heritage resource study was conducted at MCB, Camp Lejeune (LeBlond, 1994) to identify threatened or endangered plants and areas of significant natural interest. During the resource study 55 rare plant species were documented from Camp Lejeune. These include 1 specie that is classified as Federal Endangered, 1 specie that is classified as Federally Threatened, 9 that are candidates for federal listing as Endangered or Threatened, 4 that are listed as Endangered or Threatened in the State of North Carolina, and 27 species that are State Rare or State Special Concern.

2.2 Previous Investigations

The only study to be conducted at Site 85 was a Pre-Remedial Investigation Screening Study (Baker, 1996). Baker collected soil and groundwater samples as part of the Relative Risk Ranking System (RRRS) in September 1995. The results, along with some additional analyses conducted in 1996 were published in the Pre-Remedial Investigation Screening Study.

Surface soil, subsurface soil, and groundwater samples were collected as part of the Pre-Remedial Investigation Screening Study. The soil samples were analyzed for Total Analyte List (TAL) metals, cyanide, Toxicity Characteristic Leaching Procedure (TCLP) metals, and pH. The sample points were concentrated around the visible battery piles. To sample groundwater, three temporary monitoring wells were installed using direct push technology. The groundwater was analyzed for TAL metals (total and dissolved). Table 2-2 summarizes the analytical results. Figure 2-5 presents the analytical results. Also, the complete analytical results are shown in Appendix A.

Five surface soil samples were collected and analyzed. Fifteen TAL metals were detected in the surface soil. All of the metals detected in the surface soil, with the exception of aluminum and cyanide, either exceeded established screening values or were twice the average base background levels.

Ten subsurface (greater than one foot below the ground surface) soil samples were collected and analyzed. Thirteen TAL metals were detected in the subsurface soil. None of the metals detected in the subsurface soil exceeded established screening values, but ten of the metals had concentrations which exceeded base-specific background levels.

Three groundwater samples were collected from temporary monitoring wells. Nineteen TAL metals were detected in the groundwater samples. Aluminum, cadmium, chromium, iron, lead, manganese, mercury, nickel, and zinc were detected at concentrations which exceeded North Carolina Water Quality Standards (WQS) and/or Federal Maximum Contaminant Levels (MCLs).

Three composite soil samples were collected at Site 85 and analyzed for TCLP metals. One sample, collected during temporary monitoring well installation, did not detect any analytes. Two other composite samples collected from the battery piles indicated concentrations of lead, barium, and cadmium. Only lead exceeded its screening standard (500 micrograms per liter [μg/L]).

2.3 Source, Nature, and Extent of Contamination

This section provides an assessment of the nature and extent of constituent migration resulting from prior disposal practices or activities at Site 85. The media of interest include surface soil and subsurface soil. Information from the Pre-Remedial Investigation Screening Study serves as the basis for this evaluation.

This evaluation will focus on the following significant elements:

- Identification of the concentrations of constituents of interest in surface soils and subsurface soils.

- Definition of the horizontal and, where applicable, vertical extent of contamination in site soils.

The source area at Site 85 has been defined through visual observations and previous analytical results. The primary constituents of contamination have been identified as TAL metals. The source area has been identified as the 16 battery piles as shown on Figure 2-6. The piles of batteries range in size from 2 feet wide by 2 feet long, to 15 feet wide by 20 feet long. The battery piles range in height from one to three feet.

A total of five surface soil samples were obtained at Site 85 and submitted for TAL inorganics analyses only. Seventeen of 23 TAL metals were detected among the five surface soil samples obtained from Site 85 (antimony, beryllium, silver, selenium, and thallium were not detected). Each of the metals exceeded the established screening value and/or twice the average base background levels. Only aluminum and cyanide were detected at concentrations less than the screening values or base background levels.

A total of ten subsurface soil samples were collected at Site 85 and submitted for TAL inorganic analyses only. Thirteen of 23 TAL metals were detected among the 10 samples obtained form Site 85 (antimony, beryllium, silver, selenium, thallium, and cyanide were not detected). None of the inorganics detected exceeded the screening standard; however, ten of the metals had concentrations which exceeded their base-specific background levels.

Three composite soil samples were collected at Site 85 and analyzed for TCLP metals. One sample was collected as a composite soil sample from the borings advanced at Site 85. This sample did not detect any analytes above the method detection limit. Two other composite samples were collected from the waste battery piles themselves. Three metals were detected as part of the TCLP metals analysis on the waste material and included lead, barium, and cadmium. Of these only lead exceeded the screening standard of 500 μg/L with concentrations of 1,110 μg/L and 3,640 μg/L for the two waste material samples.

Three groundwater samples were collected from temporary monitoring wells at Site 85 and analyzed for TAL inorganics. Nineteen of the 23 TAL inorganics were detected in the groundwater samples (antimony, silver, selenium, and thallium were not detected). Aluminum, cadmium, chromium, iron, lead, manganese, mercury, nickel, and zinc were detected at concentrations which exceeded North Carolina WQS and/or Federal MCLs.

3.0 BASELINE RISK ASSESSMENT

The USEPA's guidance document on conducting non-time-critical removal actions (USEPA, 1993) requires that, as part of the EE/CA, a streamlined risk evaluation be performed. The goals of the streamlined risk evaluation are to: (1) identify Chemicals of Potential Concern (COPCs) at the site, (2) identify potential current and future human exposures that should be prevented and (3) estimate potential human health risks associated with exposures to the COPCs if no remedial action is taken. The streamlined risk evaluation is defined as "... a new type of evaluation, intermediate in scope between the limited risk evaluation undertaken for emergency removal actions and the conventional baseline risk assessment normally conducted for remedial actions." The guidance also recommends that the risk evaluation follow USEPA's Risk Assessment Guidance for Superfund (RAGS), Part A, Human Health Evaluation Manual (USEPA, 1989a).

A baseline risk assessment (BRA) was conducted for Site 85 during the Pre-Remedial Investigation Screening Study. Therefore, only the portions of the baseline risk assessment relative to the items mentioned in the previous paragraph will be discussed in the following sections.

3.1 Summary of the Baseline Risk Assessment

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

The BRA for MCB, Camp Lejeune Site 85 has been conducted in accordance with current USEPA Risk Assessment Guidance (USEPA, 1989a and USEPA, 1991a) and USEPA Region IV Supplemental Risk Guidance (USEPA, 1991b).

3.1.1 Selection of COPCs

COPCs are site-related contaminants used to qualitatively estimate the potential for human exposure and associated potential health effects. The selection of COPCs is the most complicated and subjective task in the risk evaluation process. The COPC selection is based upon the information provided in USEPA's Risk Assessment Guidance for Superfund (RAGS), Part A, Human Health Evaluation Manual (USEPA, 1989a).

3.1.1.1 Criteria for Selecting Contaminants of Potential Concern

As recommended in the Region IV Bulletin (USEPA, 1995), criteria used in selecting COPCs from constituents detected during the field sampling and analytical phase of the investigation are:

- Comparison to USEPA Region III Risk-Based Concentrations (RBCs)
- Comparison to field and laboratory blank data

In addition, some criteria used in the general assessment of COPCs selected from the media investigated during the Pre-RI include:

- Historical information
- Persistence
- Mobility
- Comparison to anthropogenic levels
- Toxicity
- Comparison to background or naturally occurring levels
- State and federal standards and criteria

Federal and state criteria and standards are not used to select human health risk-based COPCs. They are, however, used in the Pre-RI Screening Study quantitative and qualitative RA to determine if further investigation is necessary. In other words, COPCs selected as a result of a comparison to criteria and standards are not risk-based COPCs, and are not used as such to evaluate human health risk. An explanation of the federal and state criteria and standards used for qualitative evaluation of contaminants is presented below.

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

USEPA Region III RBCs - RBC values are derived using conservative USEPA promulgated default values and the most recent toxicological criteria available. The RBCs for potentially carcinogenic chemicals are based on a target ICR of $1x10^{-6}$. The RBCs for noncarcinogens are based on a target hazard quotient of 1.0. In order to account for cumulative risk from multiple chemicals in a medium, it is necessary to derive the RBCs based on a target hazard quotient of 0.1. Re-derivation of the noncarcinogenic RBCs based on a target hazard quotient of 0.1, while using the most recent toxicological criteria available, results in a set of values that can be used as screening values. In order to provide the accurate screening values, the noncarcinogenic RBCs were divided by a factor of ten. For potential carcinogens, the toxicity criteria applicable to the derivation of RBC values are oral and inhalation cancer slope factors (CSFs); for noncarcinogens, they are chronic oral and inhalation reference doses (RfDs). These toxicity criteria are subject to change as more updated information and results from the most recent toxicological/epidemiological studies become available. Therefore, the use of toxicity criteria in the derivation of RBC values requires that the screening concentrations be updated periodically to reflect changes in the toxicity criteria. The RBC table is issued on a semi-annual basis. It should be noted that the most recent update was published in April of 1998.

Contaminant Concentrations in Blanks - If a chemical is detected in both the environmental sample and a blank sample, it may not be retained as a COPC in accordance with RAGS depending on the concentration of the chemical in the media (USEPA, 1989b). Therefore, blank data were compared with results from environmental samples. If the blanks contained detectable results for common laboratory contaminants (i.e., acetone, 2-butanone, methylene, chloride, toluene, and phthalate esters), environmental sample results were considered as positive results only if they exceeded 10 times the maximum amount detected in the associated blank. If the chemical detected in the blank(s) is not a common laboratory contaminant, environmental sample results were considered as positive results only if they exceeded five times the maximum amount detected in the associated blank(s) (USEPA, 1991a). Furthermore, the elimination of an environmental sample result would directly correlate to a reduction in the prevalence of the contaminant in that media.

When assessing soil and sediment concentrations, the Contract Required Quantitation Limits (CRQLs) and percent moisture are accounted for in order to correlate solid and aqueous quantitation limits. For example, when assessing semivolatile, pesticide, polychlorinated biphenyl (PCB), and nitramine contaminants, the CRQL for solid samples is 33 to 66 times (depending on the contaminant) that of the aqueous samples; this correction is not necessary for the evaluation of volatile COPCs. Therefore, in order to assess contaminant levels in solid samples using an aqueous blank concentration, the concentration was multiplied by 5 or 10 (noncommon or common laboratory contaminants, respectively) and then multiplied by 33 to correct for the variance in the CRQL. Accounting for multipliers greater than 33 or the percent moisture was not necessary for this data set. Associated blanks for the site included trip blanks and rinsate blanks.

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

Historical Information - Using historical information to associate contaminants with site activities, when combined with the following selection procedures, helps determine contaminant retention for, or elimination from, evaluation in the BRA.

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

Mobility - A contaminant's physical and chemical properties are responsible for its transport in the environment. These properties, in conjunction with site conditions, determine whether a contaminant will have a greater tendency to volatilize into the air, out of surface soils or surface waters, or to relocate via advection or diffusion through soils, groundwaters, and surface waters. Physical and chemical properties also determine tendency for contaminant adsorption onto soil/sediment particles. In summary, environmental mobility factors can increase or decrease contaminant effects on human health and/or the environment.

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

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

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

Background or Naturally Occurring Levels - Naturally occurring levels of chemicals are present under ambient conditions. Generally, a comparison to naturally occurring levels applies only to inorganic analytes, because the majority of organic contaminants are not naturally occurring. Background samples are collected from areas that are known to be uninfluenced by site contamination. Sample concentrations for surface and subsurface soil were compared to base-specific (i.e., twice the base-wide average concentration) background levels. It should be noted that background data was used for qualitative analysis of COPCs only. COPCs were not chosen based on comparison to background data.

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

Regulatory guidelines are used, when necessary, to infer potential health risks and environmental impacts. Health Advisories (HA) are relevant regulatory guidelines. An explanation of the federal and state criteria and standards used for qualitative evaluation of contaminants is presented below.

It should be emphasized that COPCs were not chosen based on comparison to state and federal criteria. However, these standards and criteria were used for a qualitative analysis of the COPCs.

USEPA Soil Screening Levels - These site-specific screening levels apply to soil at sites where contaminants potentially impact groundwater used for drinking water or non-drinking water exposures such as swimming pools or irrigation (USEPA, 1996).

North Carolina Water Quality Standards (NC WQSs) - Groundwater - NC WQSs are the maximum allowable concentrations resulting from any discharge of contaminants to the land or waters of the state, which may be tolerated without creating a threat to human health or which otherwise render the groundwater unsuitable for its intended purpose.

Health Advisories - HAs are guidelines developed by the USEPA Office of Drinking Water for nonregulated constituents in drinking water. These guidelines are designed to consider both acute and chronic toxic effects in children (assumed body weight 10 kilograms [kg]) who consume 1 liter of water per day or in adults (assumed body weight 70 kg) who consume 2 liters of water per day. HAs are generally available for acute (1 day), subchronic (10 days), and chronic (longer-term) exposure scenarios. These guidelines are designed to consider only threshold effects and, as such, are not used to set acceptable levels for potential human carcinogens.

Maximum Contaminant Levels (MCLs) - Federal Groundwater Standards - 40 CFR 161 - MCLs are enforceable standards for public water supplies promulgated under the Safe Drinking Water Act and are designed for the protection of human health. MCLs are based on laboratory or epidemiological studies and apply to drinking water supplies consumed by a minimum of 25 persons. They are designed for prevention of human health effects associated with a lifetime exposure (70-year lifetime) of an average adult (70 kg) consuming 2 liters of water per day. MCLs also consider the technical feasibility of removing the contaminant from the public water supply.

3.1.1.2 Selection of Chemicals of Potential Concern

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

aforementioned selection criteria. The primary criterion used in selecting a chemical as a COPC at each site was comparing the maximum detected sample concentration to the USEPA Region III RBC Table (USEPA, 1998). In conjunction with the concentration comparisons to the USEPA Region III RBCs, evaluation of laboratory contaminants was conducted. Furthermore, calcium, magnesium, potassium, and sodium were detected in almost every sample, regardless of the medium; however, these constituents were considered to be essential nutrients (USEPA, 1995) and were therefore, not retained as COPCs in any medium under investigation at Site 85.

Tables 3-1 through 3-3 present the selection of COPCs for each environmental medium based on the maximum detected concentration with the USEPA Region III RBC values, and other applicable criteria. Constituents retained ~~as COPCs~~ for ~~the~~ human health risk assessment are indicated by the shaded areas in the tables. Information is presented in these tables only for those constituents detected at least once, in the medium of interest.

Surface Soil

Five surface soil samples were analyzed for inorganic analytes only. Inorganics were detected in all Site 85 surface soil samples. The following analytes were detected at maximum concentrations that exceeded respective soil COC screening values: arsenic, cadmium, chromium, copper, iron, lead, manganese, mercury, and zinc. Consequently, these analytes were retained as surface soil COPCs. Table 3-1 presents the COPC selection results for inorganic analytes for Site 85 surface soil.

Subsurface Soil

Five subsurface soil samples were analyzed for inorganic analytes only. Inorganics were detected in all Site 85 subsurface soil samples. The following analytes were detected at maximum concentrations that exceeded respective soil COC screening values: aluminum, arsenic, and iron. Consequently, these analytes were retained as subsurface soil COPCs. Table 3-2 presents the COPC selection results for inorganic analytes for Site 85 subsurface soil.

Groundwater

Three groundwater samples were analyzed for inorganic analytes only. Inorganics were detected in all Site 85 groundwater samples. The following analytes were detected at maximum concentrations that exceeded respective soil COC screening values: aluminum, arsenic, barium, cadmium, chromium, copper, iron, lead, manganese, mercury, nickel, vanadium, and zinc. Consequently, these analytes were retained as groundwater COPCs. Table 3-3 presents the COPC selection results for inorganic analytes for Site 85 groundwater.

3.2 Risk Characterization

Potential human health effects considered in the baseline risk assessment include carcinogenic effects and systemic or noncarcinogenic effects. Carcinogenic effects are expressed as ICR while noncarcinogenic effects are expressed as hazard indices (HI). Estimated ICR values are compared to the target risk range of 1×10^{-04} to 1×10^{-06} which USEPA considers to be generally acceptable and protective of human health (USEPA, 1990). These carcinogenic risk levels represent the probability of an individual developing cancer over his or her lifetime if exposed to the COPCs at the site. Noncarcinogenic health effects usually occur subsequent to exposure if a threshold intake level is exceeded. Estimated HI values less than unity (i.e., 1.0) are considered by USEPA to be generally acceptable and protective of public health (USEPA, 1990). ICRs and HIs are not intended as a true indication of actual exposure; they are intended to provide decision makers with useful information regarding the significance of the observed contamination.

The results of these calculations are presented on Table 3-4 for the receptors discussed previously. Risk calculation spreadsheets presenting the exposure parameter inputs and concentrations used in the calculations are presented in Appendix B.

Current Military Personnel

A military personnel receptor was evaluated for potential risk to inorganics in surface soil and subsurface soil. ICR values calculated for current military personnel fell within USEPA's acceptable risk range. These results are presented in Table 3-4. The total site HI exceeded USEPA's

acceptable risk level of 1.0. A break down of this elevated HI is presented in Table 3-4. The HI calculated for exposure to subsurface soil fell below 1.0, the acceptable hazard level. However, the noncarcinogenic hazard level for exposure to surface soil exceeded unity for all pathways evaluated. The ingestion pathway (HI=10.1) contributed approximately 70% of the total surface soil HI, while the dermal (HI=2.2) and inhalation of fugitive dusts (HI=2.0) contributed the remaining 30%. Manganese was the risk driver for these elevated noncarcinogenic hazard values.

Future Residential Child

A child receptor was evaluated for potential risk to inorganics in surface soil and groundwater. Both the ICR and HI values calculated for the future child resident exceeded USEPA's acceptable carcinogenic and noncarcinogenic risk values, respectively. The total site ICR of 2.9×10^{-4} exceeded the USEPA acceptable risk range due primarily to the ingestion of surface soil (ICR=1.3×10^{-4}) and the ingestion of groundwater (ICR=1.6×10^{-4}). Arsenic is responsible for the unacceptable surface soil and groundwater ingestion ICRs. Likewise, the surface soil and groundwater ingestion pathways (HI=134 and 180, respectively) are primarily responsible for the total site HI of 334. It should also be noted that all exposure pathways evaluated for surface soil and groundwater exceed 1.0. Manganese was the risk driver in surface soil, while iron and aluminum drove the risk in groundwater. Although groundwater poses a potential risk to the future residential child, this medium will not be addressed in this document. Additional groundwater monitoring wells will be installed at Site 85 after completion of the removal action. These wells will be monitored to determine if the source removal has affected the metals concentrations in the groundwater.

Future Residential Adult

An adult receptor was evaluated for potential risk from exposure to inorganics in surface soil and groundwater. As with the future residential child, both the ICR and HI values calculated for the future adult resident exceeded USEPA's acceptable carcinogenic and noncarcinogenic risk values, respectively. The total site ICR of 4.5×10^{-4} exceeded the USEPA acceptable risk range due primarily to the ingestion of surface soil (ICR=8.8×10^{-5}) and the ingestion of groundwater (ICR=3.6×10^{-4}). Arsenic is responsible for the unacceptable surface soil and groundwater ingestion ICRs. Likewise, the surface soil and groundwater ingestion pathways (HI=14 and 77,

respectively) are primarily responsible for the total site HI of 99. It should also be noted that all exposure pathways evaluated for surface soil and groundwater exceed 1.0. Manganese was the risk driver in surface soil, while iron and aluminum drove the risk in groundwater. These results are presented in Table 3-4. Although groundwater poses a potential risk to the future residential child, this medium will not be addressed in this document.

3.3 Risk-Based Remediation Goals

This section presents the risk-based remediation goals that would be protective of human health and the environment at Site 85 upon exposure to COPCs in the soil in the source area. No risk-based clean up goals were established for this site, therefore, screening levels are to be used to remediate Site 85. The screening levels used were developed using the Region III RBCs, USEPA Soil Screening Guidance, and MCB, Camp Lejeune Base Background concentrations. The non-carcinogenic residential soil screening levels are found by multiplying the RBCs by 0.2. This is a conservative approach to account for potential synergistic effects of multiple contaminants.

The following rationale was used for choosing an appropriate clean up goal. For the metals detected in the Site 85 groundwater at concentrations exceeding the North Carolina 2L Standards and were also detected in the soil, the USEPA soil screening level for transfer from soil to groundwater was chosen as the clean up goal. For the metals detected in the Site 85 groundwater at concentrations that did not exceed the North Carolina 2L Standards but were detected in the soil, the residential soil screening level was chosen. For the metals not detected in the groundwater but detected in the soil at concentrations that exceeded the RBCs or were risk drivers, the residential soil screening level was chosen. Twice the average background was selected as the clean up goal for aluminum, iron and mercury even though the rationale described above indicates that the soil to groundwater screening levels should be selected as the clean up goal. This is because aluminum and iron are prevalent soil constituents, and the mercury soil to groundwater screening level may be technically infeasible. Information concerning the detected concentrations of metals in the soil and groundwater at Site 85 can be found in Tables 3-1 through 3-3. The clean up goals are presented in Table 3-5.

3.4 Conclusion

A removal action is warranted at Site 85 under 40 Code of Federal Regulations (CFR) 300.415(b)(2)(I).

Actual or potential exposure to nearby human populations, animals, or the food chain from hazardous substances of pollutants or contaminants;

40 CFR 300.415(h)(2)(ii)

Actual or potential contamination of drinking water supplies or sensitive ecosystems;

40 CFR 300.415(b)(2)(iv)

High levels of hazardous substances or pollutants or contaminants in soils largely at or near the surface, that may migrate; and

40 CFR 300.415(b)(2)(v)

Weather conditions that may cause hazardous substances or pollutants or contaminants to migrate or be released.

Based upon the concentration, the frequency of detection, and the risk characterization results, the inorganics in the surface soil appear to warrant further actions to prevent or lessen the potential impact to human health and the environment. In order to be protective of human health and the environment, the inorganics should be remediated to levels within the risk based remediation goal ranges presented in Table 3-5.

4.0 IDENTIFICATION OF REMOVAL ACTION OBJECTIVES

Previous investigations have identified approximately 16 piles of batteries at Site 85. In addition, surface soils and subsurface soils with inorganic analytes were detected at maximum concentrations that exceeded respective soil COC screening values. Therefore, the objective of the removal action for this site is to eliminate the potential risks to human health, welfare, and the environment due to contaminants leaching from the batteries into the soil and from the contaminated soil into the groundwater. The removal action for Site 85 must eliminate the source of contamination.

4.1 Statutory Limits on Removal Actions

The NCP (40 CFR Part 300.415) dictates statutory limits of $2 million and 12 months on USEPA fund-financed removal actions, with statutory exemptions for emergencies and actions consistent with the remedial action to be taken. Although this removal action will not be USEPA funded-financed and the Navy/Marine Corps IR Manual does not limit the cost or duration of the removal action, cost effectiveness is a recommended criterion for evaluation of the removal action alternatives.

4.2 Removal Action Scope

The scope of the removal action to be initiated at Site 85 includes the removal of all battery piles and contaminated soil with concentrations in excess of the remediation goals established in Table 3-5. This removal action will be designed to ensure that all surface and subsurface soil with inorganics at levels exceeding the remediation levels in Table 3-5 will be addressed. The estimated soil excavation depth is one foot. The total quantity of soil to be removed is estimated to be 100 CY or 6 tons. The total quantity of batteries to be removed is estimated to be 200 CY. Figure 2-6 shows the approximate locations of the battery piles and contaminated soil.

4.3 Removal Action Schedule

Since the remedial action for Site 85 was previously anticipated, some of the documents typically submitted after the EE/CA have beem completed and are currently being reviewed. The Action Memorandum describing the proposed removal action has been prepared and submitted for review.

The Action Memorandum substantiates the need for the removal action, identifies the proposed action, and explains the rationale for the selected removal action. It should be noted that a Community Information Sheet also has been prepared to provide public notice of the proposed action. These documents will be available for review at the Onslow County Library.

The schedule objective for the Removal Action is to complete the action within 9 months of the approved and signed Action Memorandum. The Removal Action start date will be determined following the completion and acceptance of the final EE/CA and the final Action Memorandum.

The anticipated schedule will follow the general outline below:

- Design preparation following approval of the Action Memorandum - Previously completed
- Mobilization - 1 month
- Removal Action - 3 to 6 months
- Demobilization and Site Restoration - 2 months

4.4 Applicable or Relevant and Appropriate Requirements (ARARs)

4.4.1 Chemical-Specific ARARs

- Site Specific Cleanup Goals for Soil - The cleanup levels for contaminated soil at Site 85 are listed in Table 3-5. Confirmation samples taken after excavation of battery piles and contaminated soil must be lower than these levels for the removal action to be considered complete.

- Identification and Listing of Hazardous Waste Under Resource Conservation and Recovery Act (RCRA) (40 CFR 261) - The criteria for identifying the characteristics of hazardous waste and for listed hazardous wastes are provided in 40 CFR Part 261. RCRA hazardous wastes are not anticipated, but any wastes found to be RCRA hazardous wastes will be stored, treated and/or disposed according to the applicable regulations in these sections.

- Federal Ambient Water Quality Criteria (Clean Water Act) - The objective of the Clean Water Act is to restore and maintain the chemical, physical, and biological integrity of the nation's waters. This EE/CA and the proposed removal action do not include the remediation of any surface water or sediment; therefore, no surface water criteria will be required. The remedial contractor will be required to take all measures necessary to protect surface water from degradation during the removal action.

- National Ambient Air Quality Standards - The Clean Air Act provides the criteria and requirements for ambient air quality monitoring and for reporting ambient air quality data and information. Based on these regulations, air at and around Site 85 will be monitored to ensure compliance with these standards.

- North Carolina Surface Water Quality Standards - The North Carolina Surface Water Standards are set by the Commonwealth of North Carolina and are similar to the standards identified in the Clean Water Act. Surface water quality standards are based on water use and criteria class of surface water. As stated previously, this EE/CA does not include the remediation of surface water. Necessary precautions will be taken to prevent surface water degradation during the removal action.

- North Carolina Groundwater Quality Standards - The North Carolina Groundwater Quality Standards are mandatory and establish groundwater classifications and maximum contaminant concentrations to protect groundwater. Since this EE/CA does not include a remedial alternative which discharges to the groundwater; therefore, no groundwater quality criteria will be required. The remedial contractor

will be required to take necessary precautions to prevent discharge to groundwater during the removal action.

- North Carolina Air Pollution Regulations - These regulations provide for the control of sources emitting toxic air pollutants into the atmosphere, and requires that the best available control technology for toxics, emissions quantification, and human health and safety protection are demonstrated.

4.4.2 Location-Specific ARARs

- Fish and Wildlife Coordination Act (16 United States Code [USC] 661, et. Seq.) - The Fish and Wildlife Coordination Act requires action to protect fish and wildlife from actions modifying streams or areas affection streams. At this time, there are no plans to disturb or modify any streams in the area surrounding Site 85.

- Federal Endangered Species Act (16 USC 153) - The Endangered Species Act requires action to avoid jeopardizing the continued existence of listed endangered or threatened species or modifications to their habitat. Surveys have been conducted to identify threatened and endangered species at MCB, Camp Lejeune and several programs are underway to manage and protect them. The species identified at the Base include the red-cockaded woodpecker, American alligator, and sea turtles which are protected by specific regulatory programs. Three bird species, piping plover, Bachmans sparrow, and peregrine falcon have also been identified as endangered species. The appropriate state agencies will be contacted to determine if there are any other threatened or endangered species in the area and what impact, if any, this has on the removal action.

- Coastal Zone Management Act - The Coastal Zone Management Act requires activities affecting land or water uses in a coastal zone to certify noninterference with coastal zone management. Since Site 85 does not lie within the North Carolina coastal zone, this act will not be considered as an ARAR.

- National Historic Preservation Act - It is believed that there are no buildings listed on the National Register of Historic Places at Site 85, therefore, this act will not be considered as an ARAR.

- Executive Order11990 on Protection of Wetlands - Executive Order 11990 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. There are no wetlands at this site, therefore, this will not be an applicable ARAR.

- Clean Water Act, Section 404 (Wetlands) - Section 404 of the Clean Water Act regulates the discharge of dredged or fill material into certain waters (including wetlands). Dredge or fill material should not be discharged into an aquatic ecosystem unless it can be demonstrated that the discharge will not have an adverse impact on the ecosystem. There are no plans to discharge fill material from the removal action into wetlands, or impact any wetlands as part of this removal action.

4.4.3 Action-Specific ARARs

- Occupational Safety and Health Administration (OSHA) (29 CFR 1910, 1926, 1940) - These regulations provide occupational safety and health requirements applicable to workers engaged in on site field activities. It is required that the regulations be followed for site workers during construction and operation of remedial activities. Therefore, all workers will be made aware of the regulations and they will be enforced by the Site Health and Safety Officer during all remedial activities.

- RCRA Land Disposal Restrictions (40 CFR 268) - 40 CFR Part 268 identifies those RCRA hazardous wastes that are restricted from land disposal. RCRA hazardous wastes are not anticipated at Site 85. Wastes that are land disposal restricted would be shipped off site for disposal with the proper labels, manifests, and notification forms indicating that the waste is land disposal restricted.

- Department of Transportation (DOT) Rules for Hazardous Materials Transport (49 CFR 107, 171.1 - 172.558) - The wastes from the remedial activities will be classified for transportation based on the chemicals present in the material. Shipping papers (including hazardous waste manifests) will be prepared that describe the hazardous material offered for transportation and will include contents, shipper's name, proper shipping name, hazard class, identification number, total quantity, and certification that the material is presented according to DOT regulations. All wastes will be packaged according to DOT regulations with the proper markings on each container.

- RCRA Subtitle D - RCRA Subtitle D regulates the treatment, storage, and disposal of solid waste and materials designated by the State as special waste.

- State of North Carolina Department of Environment and Natural Resources Division of Environmental Management (15A NCA 2L.0106 - Classifications and Water Quality Standards Applicable to Groundwaters of North Carolina, Corrective Action - Regulates corrective actions taken to restore contaminated groundwater or terminate and control the discharge of a waste, hazardous substance, or oil to the groundwaters of the state. May be applicable to institutional controls alternative.

- North Carolina Sedimentation Pollution Control Act of 1973 (Chapter 113A) - This act regulates stormwater management and erosion/sedimentation control practices that must be followed during land disturbing activities.

4.5 Disposal Requirements

In order to identify appropriate technologies for the removal action alternatives, it is necessary to classify material encountered for this removal action into one of three waste categories:

1. Recyclable or recoverable materials;
2. Wastes restricted from land disposal under RCRA; and
3. All CERCLA/TSCA wastes not otherwise restricted, and all RCRA wastes not included in Categories 1 and 2.

Category 1 wastes will generally be recycled. Category 2 wastes will require treatment other than land disposal or some type of pre-treatment prior to land disposal. Category 3 wastes can be landfilled or disposed in an approved manner.

Old battery packs will be encountered during the removal action. These battery packs do not appear to be recyclable and even if the batteries could be recycled it would not be cost effective based on current landfill tipping fees. Therefore, all material excavated at Site 85 will be disposed of as a Category 3 waste.

Existing sampling results indicate that disposal of the excavated soil and batteries will be in a nonhazardous landfill. Field testing concurrent with the removal action excavation will verify the concentrations of the waste to be treated or disposed.

5.0 IDENTIFICATION OF REMOVAL ACTION ALTERNATIVES

The following section presents a discussion of potential removal action alternatives that address the battery piles and contaminated soils identified at Site 85. Current EE/CA guidance does not require initial screening of alternatives, but a brief evaluation of a focused list of potential technologies is presented to provide a cost-effective evaluation of the current and feasible removal action alternatives. Note that the No Action alternative that is typically evaluated as part of a Feasibility Study (FS) does not meet the objectives of the removal action for Site 85. Therefore, in accordance with current EE/CA guidance, the No Action alternative will not be evaluated. General response actions that are applicable to the battery piles and contaminated soil at Site 85 are discussed in the following paragraphs.

5.1 Institutional Controls

Institutional controls, which are non-engineering solutions to prevent public access to the site or contaminated media, may be considered when identifying removal action alternatives. These controls may include deed restrictions and access restrictions (i.e., fences and warning signs). Institutional controls may also include periodic monitoring and analysis of soils, sediment, surface water, and groundwater to determine, when or if, a remedial action may be required to protect public health or the environment.

5.2 Excavation, On-Base Disposal

This alternative provides for the disposal of battery piles and metals-contaminated soil at an on-Base landfill. Excavation will be performed with conventional earth moving equipment. Excavation will include the areal extent of the battery piles, and up to one foot below ground surface (bgs), or until the soil remedial action levels (Table 3-5) have been met. The excavated soils will be transported to an approved off-site facility. Based on initial testing, it appears that contaminated soil are not hazardous and therefore will be disposed at the on-Base Subtitle D landfill facility. The batteries will be transported to an approved off-site facility. The removal of the batteries and soil will prevent leaching of contaminants to groundwater, thereby removing the source of groundwater contamination. Over time, groundwater may return to its normal state. Groundwater at Site 85 will

not be addressed as part of this alternative, but will be monitored after the removal action to determine if the action has been effective in removing the source of contamination.

5.3 Treatment (Ex situ Soil Washing)

As in the previous alternative, this alternative provides for the disposal of battery piles at an on-site landfill and includes the excavation of contaminated soil, up to one foot bgs, or until the soil remedial action levels (Table 3-5) have been met. However, this alternative includes the treatment of the excavated soil using a technique referred to as soil washing. Soil washing is a water-based process of mechanically scrubbing soils to remove constituents of concern. This treatment technology extracts constituents from soil by: 1) dissolving or suspending them in the wash solution (which is later treated by conventional wastewater treatment methods) and/or 2) by concentrating constituents into a smaller volume of soil (i.e., fine fraction) through particle-size separation techniques. The "clean" soil will be used as backfill in the excavated areas while the fine particle cake containing concentrated constituents will be disposed of at an approved off-site landfill. As described in the previous alternative, the source of groundwater contamination will be removed and the groundwater may return to its normal state. Groundwater will be monitored after completion of the removal action.

5.4 Summary

A summary of the identification and screening of the remedial technologies evaluated for Site 85 is presented in Table 5-1. Based upon the evaluation conducted in this section, the following remedial technologies will be retained for further consideration:

- Institutional Controls
- Excavation, On-Site Disposal
- Treatment (Ex situ Soil Washing)

5.5 Remedial Alternative Selection

From the remedial technologies retained, only one remedial alternative will be implemented at Site 85. That alternative is Excavation, On-Site Disposal.

6.0 ANALYSIS OF REMOVAL ACTION ALTERNATIVES

This section provides a detailed analysis of the retained general response actions identified in Section 5.0. This analysis will provide information to compare the alternatives, select an appropriate removal action for the site, and demonstrate that the CERCLA removal selection requirements specified in the Action Memorandum have been met. Each alternative will be evaluated individually based on the following criteria listed in the USEPA guidance:

- Effectiveness
  - Protectiveness
  - Use of land disposal alternatives
- Implementability
  - Technical Feasibility
  - Administrative Feasibility
- Cost
  - Capital Cost
  - Operation and Maintenance Cost
  - Other Cost

Paralleling the USEPA guidance, the Navy/Marine Corps IR Manual recommends that criteria for evaluating removal alternatives include effectiveness to minimize the threat to public health, consistency with anticipated final remedial actions, consistency with ARARs, and cost effectiveness. These two guidance documents have been used to form the basis for this evaluation.

6.1 Alternative 1 - Institutional Controls

Alternative 1 includes institutional controls at Site 85 to protect human health from risks associated with the inorganics found at the site. These institutional controls will include access control (fencing and warning signs), deed restrictions, and a monitoring program to determine when or if further remediation will be required to protect public health or the environment.

6.1.1 Description of Alternative

Alternative 1 includes installation of a 6-foot-high chain link perimeter fence around battery piles identified at Site 85. The proposed fence location is shown on Figure 2-7. Deed restrictions will be implemented and recorded on the Base Master Plan to restrict future land use and prohibit future residential or commercial development.

Since the battery piles and contaminated soil would remain on site, an environmental monitoring program will be implemented in conjunction with this alternative. Three permanent groundwater monitoring wells will be installed at the approximate locations identified on Figure 2-7. Annual groundwater and soil sampling events will be conducted to determine if further remediation will be required.

6.1.2 Effectiveness

The effectiveness of Alternative 1 with respect to protectiveness and the use of an alternative other than land disposal is discussed below.

Protectiveness

Implementation of institutional controls at Site 85 will not present short-term exposure risks since there will be no excavation activities for installation of the controls. Restricted access to the site, or fencing, will provide protectiveness to human health from the risks associated with direct contact with the contaminants at the site. Deed restrictions at Site 85 will prevent future land use and thereby will eliminate potential human health risks associated with potential future development of the property.

This alternative will not reduce the volume or level of contamination at the site since the batteries (the source of soil contamination) and contaminated soil (the source of groundwater contamination) will remain on site.

Use of Alternative to Land Disposal

Institutional controls would comply with the policy that encourages the use of alternatives other than land disposal since there will be no excavation or removal of the contaminated material. However, the battery piles and contaminated soils will remain on site, preventing the future use or development of the land.

6.1.3 Implementability

The implementability of Alternative 1 with respect to technical and administrative feasibility is discussed below.

Technical Feasibility

The institutional controls proposed as Alternative 1 include: site fencing, deed restrictions, and installation of permanent groundwater monitoring wells. All of these controls have been previously demonstrated and are easily available for installation at this site.

Administrative Feasibility

Implementation of the institutional controls would include the use of standard construction equipment for the installation of the fence and monitoring wells. Administrative support would be required for the implementation of the deed restrictions.

6.1.4 Cost

The capital cost associated with this alternative is estimated to be $61,400. This cost includes the construction of the perimeter fence around the battery piles, installation of groundwater monitoring wells, and implementation of the deed restrictions. Operation and maintenance costs, or annual costs, include the costs associated with the annual sampling and analysis of the three monitoring wells and annual soil sampling. Also included in the annual costs is a report to summarize the results from the sampling of the groundwater and site soil. Table 6-1 shows the estimated costs for

Alternative 1. The annual cost for this alternative is estimated to be $2,100. Total present worth cost for Alternative 1 is estimated to be $70,400.

6.2 Alternative 2 - Excavation, On-Base Disposal

Alternative 2 includes the excavation of battery piles and inorganic contaminated soil beneath the piles, loading excavated materials directly into waste hauling trucks, and transportation to an on-base Subtitle D landfill facility.

6.2.1 Description of Alternative

This alternative includes the excavation of battery piles and all soils with contaminant concentrations higher than the established clean-up goals (Table 3-5). The location of the battery piles are shown on Figure 2-5. Through multiple site reconnaissance visits by Baker and the Navy, approximately 300 cubic yards of batteries and soil have been identified for removal and excavation.

The site will be cleared and grubbed prior to excavation. The waste from clearing and grubbing will be disposed of at the Base landfill. Appropriate erosion and sediment controls (silt fences and berms) will be used to prevent contaminants from leaving the site.

All of the excavated batteries and soil will be placed directly into waste hauling trucks continuously so no on-site stockpiling or storage is required. One composite confirmation sample will be collected from each excavated area. Each composite sample will be comprised of five discrete grab samples and analyzed for total inorganics. The excavated areas will not be restored until the confirmation sample results indicate the area meets the clean-up goals. A waste characterization sample will be collected to determine handling, transportation and disposal requirements. One composite sample will be collected that will be a composite of six discrete representative grab samples from the battery piles and surrounding soil. All Personnel Protective Equipment (PPE) will be disposed of with the soil.

All equipment used to excavate and transport excavated batteries and soil will be decontaminated prior to leaving Site 85 by brushing, scraping and pressure washing. All waste will be manifested

by a licensed hauler prior to leaving Camp Lejeune. The Base Environmental Management Division (EMD) will be responsible for signing all manifests. The excavated areas at Site 85 will be backfilled with material from the on-site borrow pit, graded to drain, and vegetated to prevent erosion.

6.2.2 Effectiveness

The effectiveness of Alternative 2 with respect to protectiveness and use of alternatives other than land disposal is discussed below.

Protectiveness

Alternative 2 is protective of human health and the environment at Site 85. Because the battery piles will be removed, they will no longer act as a source of contamination to the soil through leaching. Further, the soil that has been contaminated by the battery piles will be removed and no longer act as a secondary source of contamination to subsurface soils or groundwater. Groundwater contamination will not be addressed further under this alternative, but monitoring of the groundwater at Site 85 will be conducted after the removal action has been completed. An immediate reduction in the contaminant levels potentially migrating from the source area is anticipated. The volume of contaminated material will be reduced through this alternative by removal of the material from the site.

Potential risk to human receptors through direct exposure to surface soil, subsurface soil, and groundwater will be reduced to USEPA acceptable risk ranges for each contaminant of concern through the removal of the batteries and soil.

Short-term adverse impacts to the community and site workers during the implementation of this alternative will be minimized. Site workers will use the proper PPE to prevent dermal contact with batteries and soil, or inhalation of soils and dusts. Measures that will be taken to protect the community during implementation include dust suppression, enforcement of erosion and sedimentation controls, and enforcement of DOT regulations for the transportation of hazardous materials. These measures will minimize community exposure to contaminants. The actual removal action (excavation work) for this alternative will take a maximum of three months.

Use of Alternatives Other Than Landfill Disposal

Alternative 2 is a landfill disposal alternative. Therefore, it does not fulfill the policy of encouraging other means of remediating contaminated sites.

6.2.3 Implementability

The implementability of Alternative 2 with respect to technical and administrative feasibility is discussed below.

Technical Feasibility

The excavation of batteries and soil will be done with conventional equipment and techniques. Material handling may be difficult if groundwater is encountered. However, excavations are not anticipated below one foot from the ground surface. Precautions will be taken to limit direct contact with the contaminated material during removal. The appropriate PPE will be enforced during excavation activities. These are commonly practiced procedures and should not pose any problem. Erosion and sedimentation controls will be maintained during removal and backfilling operations.

Administrative Feasibility

A licensed waste hauler and permitted landfill that will accept the contaminated materials from Site 85 should be readily available. Manifesting will be required for the waste hauling and disposal. Conventional earthmoving permits and erosion and sediment control plans will be required.

6.2.4 Cost

The capital cost associated with this alternative is estimated to be $95,300 , which includes excavation, confirmation sampling and analysis, waste characterization testing, hauling and disposal, and site restoration costs. Table 6-2 shows the estimated costs for Alternative 2. Because the material will be removed from the site for disposal, there are no operation and maintenance costs associated with this alternative. Legal and administrative costs have not been estimated at this time, but are expected to be low in comparison with the cost to remove and treat the contaminated materials.

6.3 Alternative 3 - Treatment (Ex situ Soil Washing)

This treatment alternative would include implementation of a soil washing technology. Soil washing is an innovative technology for the effective treatment of wastes/soils containing heavy metals. Soil washing is performed ex situ, thereby requiring the soil to be excavated prior to treatment.

6.3.1 Description of Alternative

Alternative 3 includes the removal of battery piles and the excavation of all soils with contaminant concentrations higher than the established clean-up goals shown in Table 3-5. The area was previously defined as shown in Figure 2-6. Through multiple site reconnaissance visits by Baker and the Navy, the estimated quantity of batteries to be removed from the site is estimated at 200 CY, and the estimated quantity of soil to be excavated and treated is 100 CY.

Once excavated, the soil will be treated using a technique known as soil washing. Soil washing is a water-based process of mechanically scrubbing soils to remove constituents of concern. This treatment technology extracts constituents from soil by: 1) dissolving or suspending them in the wash solution (which is later treated by conventional wastewater treatment methods) and/or 2) by concentrating constituents into a smaller volume of soil (i.e., fine fraction) through particle-size separation techniques.

A soil washing area will be established at a central location at Site 85. Excavated contaminated soil will be transported to this soil washing area and loaded into a feed hopper at the front end of the soil washing treatment system. The feed material will pass through a vibrating screen to remove oversize debris. Screen undersize from the preliminary screening will be dropped onto a conveyor and transported to a mixing trommel where it will be mixed with water to form a slurry. Slurry will flow from the mixing trommel to a vibrating screen where feed material will be separated according to particle size with coarse oversize particles separated from the remaining sand and fine particle fractions. Screen undersize product will be fed to a froth flotation unit for removal of hydrophobic constituents. Froth from the flotation unit will be combined with the fine particle slurry from a multi-stage, counter-current, attrition/classification circuit, and fed to a thickening operation.

Primary treatment of feed material will evolve around a multi-stage counter-current attrition/classification circuit. It is at this stage of the process that the coarse fraction (i.e., medium and fine sand fractions) will be separated from the fine fraction (i.e., silt, clay, and organic matter) and a washed soil output stream produced.

Underflow from the froth flotation unit will enter a multi-stage, counter-current, intensive attrition scrubbing circuit. Soil agglomerates will be disintegrated by the scrubbing action of the attrition equipment, and the fine particle fraction released from the coarse fraction. Furthermore, surficial contamination will be removed from the coarse fraction by the abrasive scouring action of particles.

Fine soil particles suspended in process water from the scrubbing circuit will be fed to a mechanical thickening operation along with froth from the flotation unit. A polymeric flocculating agent will be added to the fine particle slurry to improve settling and separation from process water. Thickened solids underflow from the thickened operation will be fed to a dewatering operation. Horizontal centrifuges typically are used for the dewatering operation to form a fine particle cake. The fine particle cake will contain the majority of inorganic constituents (i.e., contaminants) from the feed material and will require further treatment and/or disposal.

Water from the thickening and dewatering operations will be combined for collection in a process water collection tank. Based on the constituents contained in the initial feed material, it is anticipated that the process water will contain metals (i.e., arsenic, manganese) and will require treatment.

After the treated solids are dewatered, the "clean" material fraction will be analyzed to verify that the appropriate level of treatment was achieved. Then the "clean" material will be placed on site, back in the excavated areas. The "fine" fraction containing concentrated constituents will be transported off-site to an approved landfill facility. Based on results of preliminary testing, this soil appears to be nonhazardous. However, the constituents from the raw soil material will be concentrated in the fine particle cake following thickening and dewatering operations. Therefore, it is possible that the concentrated fine fraction containing the constituents of concern may be characterized as a hazardous waste.

Confirmation sampling will be conducted and analyzed for total inorganics. One composite sample will be collected from each excavated area and will be comprised of five discrete grab samples. Following confirmation sampling, the excavated areas will be backfilled with the treated soil. Additional fill, as needed, will be obtained from the on-site Borrow Pit. Site 85 will be graded and vegetated to eliminate the potential for erosion.

The core of the soil washing technology is based on various unit operations common to the mineral processing industry. The effectiveness of soil washing technology is based on the premise that: 1) constituents tend to be concentrated in the fine size fraction of soil (i.e., silt, clay and soil organic matter, and 2) constituents associated with the coarse size fraction of soil (sand and gravel) are primarily surficial. Since Site 85 consists mainly of ~~sand, silt and~~ clay, ~~soil~~ washing may not be the most effective alternative for remediating the site.

6.3.2 Effectiveness

The effectiveness of Alternative 3 with respect to protectiveness and use of alternatives other than land disposal is discussed below.

Protectiveness

Alternative 3 is protective of human health and the environment at Site 85. Because the battery piles will be removed, they will no longer act as a source of contamination to the soil through leaching. Further, the soil that has been contaminated by the battery piles will be removed and treated and will no longer act as a secondary source of contamination to subsurface soils or groundwater. Groundwater contamination will not be further addressed under this alternative, but the groundwater at Site 85 will be monitored after completion of the removal action. An immediate reduction in the contaminant levels potentially migrating from the source area is anticipated. The volume of contaminated material will be reduced through this alternative by treatment of the soil. Soil washing reduces the volume of contaminated material to be transported from the site and landfilled.

Potential risk to human receptors through direct exposure to surface soil, subsurface soil, and groundwater will be reduced to USEPA acceptable risk ranges for each contaminant of concern through the removal of the batteries and excavation and treatment of the contaminated soil.

Short-term adverse impacts to the community and site workers during implementation of this alternative will be minimized. Site workers will use the proper PPE to prevent dermal contact with batteries, soil, and treatment residuals, or inhalation of soils and dusts. Measures that will be taken to protect the community during implementation include dust suppression, enforcement of erosion and sedimentation controls, and enforcement of DOT regulations for the transportation of hazardous materials. These measures will minimize community exposure to contaminants. The actual removal action (excavation and treatment) will take approximately six to twelve months.

Use of Alternatives Other Than Landfill Disposal

The soil washing portion of this alternative complies with the DoN policy encouraging the use of alternatives over land disposal, by reducing the quantity of material that will require landfilling. Landfilling the fine particle cake containing concentrated constituents does not comply with this preference.

6.3.3 Implementability

The implementability of Alternative 3 with respect to the technical feasibility and administrative feasibility is discussed below.

Technical Feasibility

The excavation of batteries and soil will be done with conventional equipment and techniques. Material handling may be difficult if groundwater is encountered. However, excavations are not anticipated below one foot from the ground surface. Precautions will be taken to limit direct contact with the contaminated material during removal. The appropriate PPE will be enforced during excavation activities. These are commonly practiced procedures and should not pose any problem. Erosion and sedimentation controls will be maintained during removal and backfilling operations.

Soil washing may not be technically feasible at this site due to the fine soil fractions expected (i.e., sand, silt, and clay). Therefore, a treatability study (including a soils analysis) will be required to determine the technical feasibility at Site 85.

Administrative Feasibility

A licensed hauler and permitted landfill that will accept the batteries from Site 85 should be readily available. Manifesting will be required for the waste hauling and disposal. Conventional earthmoving permits and erosion and sediment control plans will be required. Approval from the local POTW will be required to release potentially contaminated process water to their treatment system if chosen as a method for disposal of the wash water, or an NPDES permit may be required to discharge treated process water from the soil washing process.

6.3.4 Cost

The capital cost associated with this alternative is estimated to be $229,600 , which includes excavation, soil washing, disposal of wash water, confirmation sampling and analysis, waste characterization testing, hauling and disposal, and site restoration costs. Because the material will be removed from the site for treatment and disposal, there are no operation and maintenance costs associated with this alternative. Legal and administrative costs have not been estimated at this time, but are expected to be low in comparison with the cost to remove and treat the contaminated materials. Costs for treating the soil via soil washing is not cost effective for volumes of material less than 4000 tons based on discussions with a vendor and as presented in Table 6-3. The estimated volume of material to be treated is 100 CY or 162 tons, which is significantly less than the 4000 tons.

7.0 COMPARATIVE ANALYSIS

Three alternatives were qualitatively assessed and compared based on the criteria described in Section 6.0: effectiveness, implementability, and cost. A summary of the comparative analysis is shown on Table 7-1 and discussed below.

7.1 Effectiveness

7.1.1 Protectiveness

Alternative 1 is the only alternative that does not include excavation and removal of batteries and contaminated soils at Site 85. However, Alternative 1 does include access restrictions which will be protective of human health and since there is no excavation, there will be no short-term exposure to construction workers.

Alternatives 2 and 3 include excavation to remove one foot of contaminated soil. Therefore, in terms of initial protectiveness, both of these alternatives would include similar measures to protect construction workers and the environment (i.e., site specific health and safety plan, transportation via a licensed waste hauler, and proper erosion and sediment control measures). Use of the on-Base landfill for disposal will provide additional protectiveness, reducing risks associated with hauling contaminated materials a greater distance. However, Alternative 3 would require more time to implement, thereby, potentially exposing workers and the community to contaminants for a longer period of time.

7.1.2 Use of Alternatives to Land Disposal

Alternative 1 does not involve excavation and landfill disposal like Alternatives 2 and 3 do, since institutional controls will be used. However, the battery piles and contaminated soils will remain on site and therefore do not exclude this alternative as a land disposal alternative. Alternative 3 does involve treatment of the soil via ex situ soil washing, which reduces the volume of contaminated soil to be disposed. Therefore, to some extent, all of the alternatives will involve land disposal either

by leaving the soil in place (Alternative1) or disposing of some amount of the contaminated soil in the on-Base landfill (Alternatives 2 and 3).

7.2 Implementability

7.2.1 Technical Feasibility

All of the technologies proposed for Alternatives 1, 2 and 3 have been previously demonstrated and are all commercially available. Alternative 3, however, will require a treatability study to determine that soil washing will effectively treat the site soils comprised of silts, sands and clays. The availability of the on-Base landfill will provide a convenient location for disposal of batteries and contaminated soils.

7.2.2 Availability

All of the presented alternatives are readily available for the remediation of Site 85.

7.2.3 Administrative Feasibility

Alternative 1 requires administrative support for the implementation of the deed restrictions. Alternatives 2 and 3 require a licensed hauler and permitted landfill (on-Base landfill), all of which should be readily available. Permitting requirements for Alternatives 2 and 3 include conventional earthmoving permits and erosion and sediment control plans. However, Alternative 3 may require approval from the local POTW to release potentially contaminated process water to their treatment system if chosen as a method for disposal of the wash water, or an NPDES permit to discharge treated process water from the soil washing process.

7.3 Cost

The estimated capital costs for Alternatives 1, 2 and 3 are listed below. Alternative 1 is the only alternative with an operation and maintenance cost due to annual monitoring of the site.

- Alternative 1 Institutional Controls
  $70,400

- Alternative 2 Excavation, On-Base Disposal
  $95,300

- Alternative 3 Treatment (Ex Situ Soil Washing)
  $229,600

8.0 PROPOSED REMOVAL ACTION

The results of the comparative analysis presented in Section 7.0 indicate that all three alternatives would be effective in reducing or eliminating human health risks associated with contaminated soil at Site 85. However, only Alternatives 2 and 3 would include the removal of the source of contamination (i.e., battery piles and contaminated soils). Since the main goal at the site is to remove the source of contamination, Alternative 1 - Institutional Controls will be eliminated as a possible remedial action. In addition, fencing would disrupt the current use of the site and the Base does not elect to restrict land use (via deed restrictions) at this site.

Based on the overall comparison, all of the alternatives are technically feasible and implementable. However, a treatability study must be completed to verify that Alternative 3 is technically feasible due to the silts and clays at the site. As shown from the comparative cost estimates, and as determined during the development of the cost estimate, Alternative 3 would not be cost effective due to the small volume of material to be treated. Therefore, Alternative 3 will be eliminated as a possible remedial action for Site 85.

Based upon this evaluation, Alternative 2 - Excavation, On-Base Disposal is recommended for implementation at Site 85. This alternative provides the most direct and cost effective solution for the contaminated soil at Site 85 while maintaining the potential for future development of the site.

The main construction features of Alternative 2 include:

- Mobilization of construction equipment.
- Installation of temporary safety fencing.
- Clearing and removing vegetation.
- Installing erosion and sedimentation controls.

- Excavating contaminated soil and battery piles.
- Conducting confirmation sampling to ensure that all contaminated soil above the cleanup goals is removed.
- Conducting waste characterization sampling.
- Transporting the contaminated soil and batteries to the on-Base landfill for disposal.
- Backfilling the excavation with clean soil from the on-site borrow pit.
- Vegetating all disturbed areas.

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TABLES

TABLE 2-1

GEOLOGIC AND HYDROGEOLOGIC UNITS OF NORTH CAROLINA'S COASTAL PLAIN PRE-REMEDIAL INVESTIGATION SCREENING STUDY, CTO-0314 MCB, CAMP LEJEUNE, NORTH CAROLINA

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

Notes:

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

Source: Harned et al., 1989.

TABLE 2-2

SUMMARY OF SITE CONTAMINATION
SITE 85, CAMP JOHNSON BATTERY DUMP
MCB, CAMP LEJEUNE, NORTH CAROLINA

Media	Fraction	Detected Contaminants or Analytes	Comparison Criteria			Min.	Max.	Location of Maximum Detection	Detection Frequency	Detections Above		
			Screening Standard (4)	Base Background (3)	Baseline Concs.					Screening Standard	Base Background	Baseline Concs.
Surface Soil	Metals	Aluminum	78000 (2)	5,856	NA	1,140	3,190	85-SB04	5/5	0/5	0/5	NA
		Arsenic	15	1.3	NA	0.55	76.8	85-SB02	5/5	1/5	2/5	NA
		Barium	32	17.3	NA	6.9	134.0	85-SB02	5/5	1/5	2/5	NA
		Cadmium	6	0.70	NA	2.1	47.1	85-SB02	2/5	2/5	2/5	NA
		Chromium	19	6.60	NA	2.3	147.0	85-SB02	5/5	1/5	1/5	NA
		Cobalt	47000 (2)	2.05	NA	17.3	17.3	85-SB02	1/5	0/5	1/5	NA
		Copper	3,100 (2)	7.10	NA	0.88	1,870.0	85-SB02	5/5	0/5	3/5	NA
		Iron	23,000 (2)	3702.00	NA	1,480	339,000	85-SB02	5/5	1/5	2/5	NA
		Lead	NE	23.40	NA	4.9	3,030	85-SB02	5/5	NA	2/5	NA
		Manganese	1,800 (2)	18.51	NA	3.8	19,700	85-SB02	5/5	1/5	4/5	NA
		Mercury	3	0.09	NA	0.35	70.7	85-SB02	3/5	1/5	3/5	NA
		Nickel	21	3.46	NA	3.50	117.0	85-SB02	2/5	1/5	2/5	NA
		Vanadium	550 (2)	11.45	NA	4.10	13.9	85-SB02	5/5	0/5	1/5	NA
		Zinc	42,000	13.76	NA	5.20	63,900	85-SB02	5/5	1/5	4/5	NA
		Cyanide	1,600 (2)	2.90	NA	0.90	2	85-SB02	2/5	0/5	0/5	NA
Subsurface Soil	Metals	Aluminum	78000 (2)	7413.00	NA	348.00	10,200	85-SB02	10/10	0/10	1/10	NA
		Arsenic	15	1.97	NA	0.32	3	85-SB02	9/10	0/10	1/10	NA
		Barium	32	14.37	NA	0.78	13	85-SB02	10/10	0/10	0/10	NA
		Cadmium	6	0.72	NA	0.66	0.66	85-SB02	1/10	0/10	0/10	NA
		Chromium	19	12.54	NA	0.96	11.3	85-SB02	10/10	0/10	0/10	NA
		Copper	3,100 (2)	2.41	NA	0.35	8.8	85-SB02	9/10	0/10	1/10	NA
		Iron	23,000 (2)	7134.64	NA	385.00	9,480	85-SB02	10/10	0/10	1/10	NA
		Lead	NE	8.26	NA	1.20	41	85-SB02	10/10	NA	1/10	NA
		Manganese	1,800 (2)	7.99	NA	0.26	47.5	85-SB02	10/10	0/10	1/10	NA
		Mercury	3	0.13	NA	0.15	0.61	85-SB02	2/10	0/10	2/10	NA
		Nickel	21	3.73	NA	2.60	4	85-SB04	3/10	0/10	1/10	NA
		Vanadium	550 (2)	13.34	NA	1.20	20	85-SB02	10/10	0/10	1/10	NA
		Zinc	42,000	6.67	NA	1.10	187	85-SB02	10/10	0/10	3/10	NA

TABLE 2-2 (Continued)

SUMMARY OF SITE CONTAMINATION
SITE 85, CAMP JOHNSON BATTERY DUMP
MCB, CAMP LEJEUNE, NORTH CAROLINA

Media	Fraction	Detected Contaminants or Analytes	Comparison Criteria			Min.	Max.	Location of Maximum Detection	Detection Frequency	Detections Above		
			Screening Standard [4]	Base Background [3]	Baseline Concs.					Screening Standard	Base Background	Baseline Concs.
Subsurface Soil (continued)	TCLP Metals (Waste Mat. Composite)	Lead	500 [4]	NA	NA	1,110	3,640	85-WT02	2/2	2/2	NA	NA
		Barium	100,000 [4]	NA	NA	523	523	85-WT01	1/2	0/2	NA	NA
		Cadmium	1,000 [4]	NA	NA	151	230	85-WT01	2/2	0/2	NA	NA

TABLE 2-2 (Continued)

SUMMARY OF SITE CONTAMINATION
SITE 85, CAMP JOHNSON BATTERY DUMP
MCB, CAMP LEJEUNE, NORTH CAROLINA

Media	Fraction	Detected Contaminants or Analytes	Comparison Criteria			Min.	Max.	Location of Maximum Detection	Detection Frequency	Detections Above		
			Screening Standard (5)	Base Background	Baseline Concs.					Screening Standard	Base Background	Baseline Concs.
Groundwater	Metals (total)	Aluminum	NE/50	NA	NA	15,900	429,000	85TW-02	3/3	3/3	NA	NA
		Arsenic	50/50	NA	NA	10.9	20	85-TW03	3/3	0/3	NA	NA
		Barium	2,000/2,000	NA	NA	242	548	85TW-02	3/3	0/3	NA	NA
		Beryllium	NE/4	NA	NA	2.8	3	85TW-02	2/3	0/3	NA	NA
		Cadmium	5/5	NA	NA	4.9	25	85TW-02	3/3	2/3	NA	NA
		Chromium	50/100	NA	NA	383	821	85TW-02	3/3	3/3	NA	NA
		Cobalt	NE/NE	NA	NA	7.1	20	85TW-02	3/3	NA	NA	NA
		Copper	1,000/NE	NA	NA	55.4	173	85TW-02	3/3	0/3	NA	NA
		Iron	300/300	NA	NA	119,000	498,000	85TW-02	3/3	3/3	NA	NA
		Lead	15/NE	NA	NA	207	512	85TW-02	3/3	3/3	NA	NA
		Manganese	50/50	NA	NA	228	1,270	85TW-02	3/3	3/3	NA	NA
		Mercury	1.1/2.0	NA	NA	0.28	204	85TW-02	3/3	1/3	NA	NA
		Nickel	100/100	NA	NA	53.3	4,550	85-TW01	3/3	2/3	NA	NA
		Vanadium	NE/NE	NA	NA	332	908	85TW-02	3/3	NA	NA	NA
		Zinc	2,100/NE	NA	NA	93.1	3,970	85TW-02	3/3	1/3	NA	NA

Notes:
- Concentrations are presented in µg/L for liquid and µg/kg for solids (ppb), metal concentrations for soils are presented in mg/kg (ppm).
- Calcium, magnesium, potassium, and sodium are not included in the tables

(1) - USEPA Soil Screening Levels for Transfer from Soil to Groundwater (May, 1996)
(2) - USEPA Region III Risk-Based Concentrations (Residential Soil) were used because no Soil to Groundwater Screening Levels were available (May, 1996).
(3) - Twice the Average Base Background Concentration for Metals in Soil
(4) - Maximum Concentration of Contaminants for Toxicity Characteristic (40 CFR Part 261.24 July 1, 1994).
(5) - North Carolina Water Quality Standards for Groundwater/USEPA Maximum Contaminant Levels
NA - Not applicable
NE - Not Established

TABLE 3-1

SURFACE SOIL INORGANIC DATA AND COPC SELECTION SUMMARY
SITE 85, CAMP JOHNSON BATTERY DUMP
ENGINEERING EVALUATION/COST ANALYSIS, CTO-0314
MCB, CAMP LEJEUNE, NORTH CAROLINA

	Range/Frequency		Comparison to Criteria					
Analyte	Range of Positive Detections (mg/kg)	No. of Positive Detects/ No. of Samples	Twice the Average Base Specific Background[1] Concentration (mg/kg)	No. of Times Exceeded Twice the Average Background Concentration	USEPA Region III RBC Value[2] (mg/kg)	Positive Detects Above Residential RBC Value	Soil to Groundwater Soil Screening Level[3]	Positive Detects Above Soil to Groundwater Soil Screening Level
Aluminum	1,140 - 3,190	5/5	5,856.083	0	7,800	0	--	--
Arsenic	0.55 - 76.8	5/5	1.322	2	0.43	5	26.2	1
Barium	6.9 - 134	5/5	17.292	2	550	0	848	0
Cadmium	2.1 - 47.1	2/5	0.696	2	7.8	1	2.7	1
Calcium+	91 - 823	5/5	1,372.977	0	--	--	--	--
Chromium	2.3 - 147	5/5	6.607	1	39	1	27.2	1
Cobalt	17.3	1/5	2.046	1	470	0	--	0
Copper	0.88 - 1,870	5/5	7.104	3	310	1	704	1
Cyanide	0.9 - 2.1	2/5	2.905	0	160	0	31.1	0
Iron+	1,480 - 339,000	5/5	3,702.427	2	2,300	2	151	5
Lead	4.9 - 3,030	5/5	23.37	2	400[4]	1	270	1
Magnesium+	62.2 - 118	5/5	202.96	0	--	--	--	--
Manganese	3.8 - 19,700	5/5	18.51	4	160	3	65	3
Mercury	0.35 - 70.7	3/5	0.094	3	2.3[5]	1	0.0154	3
Nickel	3.5 - 117	2/5	3.455	2	160	0	56.4	1
Potassium+	158 - 456	5/5	200.06	3	--	--	--	--
Sodium+	9.7 - 69	5/5	59.013	1	--	--	--	--
Vanadium	4.1 - 13.9	5/5	11.447	1	55	0	520	0
Zinc	5.2 - 63,900	5/5	13.763	4	2,300	1	1,100	2

Notes: Shaded areas indicate analyte selected as COPC for human health risk assessment.
+ = Essential Nutrient
-- = No criteria published
(1) Soil background concentrations are based on reference background soil samples collected from MCB Camp Lejeune investigations.
(2) USEPA Region III Risk Based Concentration (RBC) Table (April 15, 1998)
(3) USEPA Soil Screening Levels for Transfer from Soil to Groundwater (May 1996)
(4) Action Level for residential soils (USEPA, 1994)
(5) Mercuric chloride used as a surrogate

TABLE 3-2

SUBSURFACE SOIL INORGANIC DATA AND COPC SELECTION SUMMARY
SITE 85, CAMP JOHNSON BATTERY DUMP
ENGINEERING EVALUATION/COST ANALYSIS, CTO-0314
MCB, CAMP LEJEUNE, NORTH CAROLINA

	Range/Frequency		Comparison to Criteria					
Analyte	Range of Positive Detections (mg/kg)	No. of Positive Detects/ No. of Samples	Twice the Average Base Specific Background[1] Concentration (mg/kg)	No. of Times Exceeded Twice the Average Background Concentration	USEPA Region III RBC Value[2] (mg/kg)	Positive Detects Above Residential COC Value	Soil to Groundwater Soil Screening Level[3]	Positive Detects Above Soil to Groundwater Soil Screening Level
Aluminum	348 - 10,200	10/10	7,413.23	1	7,800	1	--	--
Arsenic	0.32 - 3	9/10	1.971	1	0.43	6	26.2	0
Barium	0.78 - 13.3	10/10	14.37	0	550	0	848	0
Cadmium	0.66	1/10	0.718	0	3.9	0	2.7	0
Calcium+	7.8 - 127	10/10	387.824	0	--	--	--	--
Chromium	0.96 - 11.3	10/10	12.537	0	39	0	27.2	0
Copper	0.35 - 8.8	9/10	2.41	1	310	0	704	0
Iron+	385 - 9,840	10/10	7,134.639	1	2,300	5	151	10
Lead	1.2 - 40.6	10/10	8.264	1	400[4]	0	270	0
Magnesium+	10.6 - 232	10/10	263.398	0	--	--	--	--
Manganese	0.26 - 47.5	10/10	7.99	1	160	0	55	0
Mercury	0.15 - 0.61	2/10	0.129	2	2.3[5]	0	0.0154	2
Nickel	2.6 - 4.4	3/10	3.725	1	160	0	56.4	0
Potassium+	105 - 242	7/10	344.252	0	--	--	--	--
Sodium+	4.7 - 17	10/10	54.57	0	--	--	--	--
Vanadium	1.2 - 20	10/10	13.34	1	55	0	520	0
Zinc	1.1 - 187	10/10	6.668	3	2,300	0	1,100	0

Notes: Shaded areas indicate analyte selected as COPC for human health risk assessment.
+ = Essential Nutrient
-- = No criteria published
(1) Soil background concentrations are based on reference background soil samples collected from MCB Camp Lejeune investigations.
(2) USEPA Region III Risk Based Concentration (RBC) Table (April 15, 1998)
(3) USEPA Soil Screening Levels for Transfer from Soil to Groundwater (May 1996)
(4) Action Level for residential soils (USEPA, 1994)
(5) Mercuric chloride used as a surrogate

TABLE 3-3

GROUNDWATER DATA AND COPC SELECTION SUMMARY
INORGANICS
SITE 85, CAMP JOHNSON BATTERY DUMP
ENGINEERING EVALUATION/COST ANALYSIS, CTO-0314
MCB, CAMP LEJEUNE, NORTH CAROLINA

Parameter	Groundwater Criteria					Frequency/Range		Comparison to Criteria				
	NCWQS[1] (µg/L)	MCL[2] (µg/L)	Region III Tapwater RBC Value[3] (µg/L)	Federal Health Advisories[4] (µg/L)		No. of Positive Detects/ No. of Samples	Concentration Range (µg/L)	No. of Detects Above NCWQS	No. of Detects Above MCL	No. of Detects Above RBC	No. of Detects Above Health Advisories	
				10 kg Child	70 kg Adult						10 kg Child	70 kg Adult
Inorganics												
Aluminum	NE	50/200[5]	3,700	NE	NE	3/3	159,000-429,000	NA	3/3	3	NA	NA
Arsenic	50	50	0.045	NE	NE	3/3	10.9 - 20.2	0	0	3	NA	NA
Barium	2,000	2,000	260	NE	NE	3/3	242 -548	0	0	2	NA	NA
Beryllium	NE	4	7.3	4,000	20,000	2/3	2.8 - 3.3	NA	0	0	0	0
Cadmium	5	5	1.8	5	20	3/3	4.9 - 24.6	2	2	3	2	1
Calcium+	NE	NE	NE	NE	NE	3/3	2,070 - 6,180	NA	NA	NA	NA	NA
Chromium	50	100	18	200	800	3/3	383 - 821	3	3	3	3	1
Cobalt	NE	NE	220	NE	NE	3/3	7.1 - 20.3	NA	NA	0	NA	NA
Copper	1,000	1,300[6]	150	NE	NE	3/3	55.4 - 173	0	0	1	NA	NA
Iron	300	300[5]	1,100	NE	NE	3/3	119,00-498,000	3	3	3	NA	NA
Lead	15	15[6]	NE	NE	NE	3/3	207 - 512	3	3	NA	NA	NA
Magnesium+	NE	NE	NE	NE	NE	3/3	5,530 - 13,700	NA	NA	NA	NA	NA
Manganese	50	50[5]	73	NE	NE	3/3	228 - 1,270	3	3	3	NA	NA
Mercury	1.1	2	1.1[7]	NE	2	3/3	0.28 - 2.4	1	1	1	NA	1
Nickel	100	100	73	500	1,700	3/3	53.3 - 4,550	2	2	2	1	1
Potassium+	NE	NE	NE	NE	NE	3/3	5,480 - 16,000	NA	NA	NA	NA	NA
Sodium+	NE	NE	NE	NE	NE	3/3	1,850 - 5,580	NA	NA	NA	NA	NA

TABLE 3-3 (Continued)

GROUNDWATER DATA AND COPC SELECTION SUMMARY
INORGANICS
SITE 85, CAMP JOHNSON BATTERY DUMP
ENGINEERING EVALUATION/COST ANALYSIS, CTO-0314
MCB, CAMP LEJEUNE, NORTH CAROLINA

Parameter	Groundwater Criteria					Frequency/Range		Comparison to Criteria				
	NCWQS[1] (µg/L)	MCL[2] (µg/L)	Region III Tapwater RBCValue[3] (µg/L)	Federal Health Advisories[4] (µg/L)		No. of Positive Detects/ No. of Samples	Concentration Range (µg/L)	No. of Detects Above NCWQS	No. of Detects Above MCL	No. of Detects Above RBC	No. of Detects Above Health Advisories	
				10 kg Child	70 kg Adult						10 kg Child	70 kg Adult
Vanadium	NE	NE	26	NE	NE	3/3	322 - 908	NE	NE	3	NE	NE
Zinc	2,100	5,000[5]	1,100	3,000	10,000	3/3	93.1 - 3,970	1	1	1	1	0

Notes:

Shaded areas indicate parameter selected as COPC for human health risk assessment.
(1) NCWQS = North Carolina Water Quality Standards for Groundwater
(2) MCL = Safe Drinking Water Act Maximum Contaminant Level
(3) USEPA Region III Risk Based Concentration (RBC) Table (April 15, 1998).
(4) Longer Term Health Advisories for a 10 kg Child and 70 kg Adult
(5) SMCL = Secondary Maximum Contaminant Level
(6) Action Level for drinking water.
(7) Value for mercuric chloride used as a surrogate.
+ - Essential Nutrient
NE - No Criteria Established
NA - Not Applicable

TABLE 3-4

INCREMENTAL LIFETIME CANCER RISK (ICR) AND HAZARD INDEX (HI)
FUTURE ADULT AND CHILD ON-SITE RESIDENTS, CURRENT MILITARY PERSONNEL
SITE 85, CAMP JOHNSON BATTERY DUMP
ENGINEERING EVALUATION/COST ANALYSIS, CTO-0314
MCB, CAMP LEJEUNE, NORTH CAROLINA

Pathway	Receptors					
	Adults		Children (1-6 yrs.)		Military Personnel	
	ICR	HI	ICR	HI	ICR	HI
Surface Soil						
Ingestion	6.8×10^{-5} (76)	14 (66)	1.3×10^{-4} (100)	134 (88)	6.4×10^{-6} (81)	10 (72)
Dermal Contact	2.0×10^{-5} (23)	4.2 (20)	7.3×10^{-6}	8 (5)	1.4×10^{-6} (19)	2 (14)
Inhalation	6.5×10^{-7} (1)	2.9 (14)	4.6×10^{-7}	10 (7)	6.2×10^{-8}	2 (14)
Subtotal	8.8×10^{-5}	21	1.3×10^{-4}	152	7.9×10^{-6}	14
Subsurface Soil						
Ingestion	NA	NA	NA	NA	2.0×10^{-7} (82)	0.05 (83)
Dermal Contact	NA	NA	NA	NA	4.3×10^{-8} (18)	0.01 (17)
Inhalation	NA	NA	NA	NA	3.1×10^{-10}	<0.01
Subtotal	NA	NA	NA	NA	2.4×10^{-7}	0.06
Groundwater						
Ingestion	3.5×10^{-4} (99)	77 (99)	1.6×10^{-4} (99)	180 (99)	NA	NA
Dermal Contact	5.1×10^{-6} (1)	1 (1)	2.1×10^{-6} (1)	2 (1)	NA	NA
Subtotal	3.6×10^{-4}	78	1.6×10^{-4}	182	NA	NA

TABLE 3-4 (Continued)

INCREMENTAL LIFETIME CANCER RISK (ICR) AND HAZARD INDEX (HI)
FUTURE ADULT AND CHILD ON-SITE RESIDENTS, CURRENT MILITARY PERSONNEL
SITE 85, CAMP JOHNSON BATTERY DUMP
ENVIRONMENTAL EVALUATION/COST ANALYSIS, CTO-0314
MCB, CAMP LEJEUNE, NORTH CAROLINA

Pathway	Receptors					
	Adults		Children (1-6 yrs.)		Military Personnel	
	ICR	HI	ICR	HI	ICR	HI
TOTAL	4.5×10^{-4}	99	2.9×10^{-4}	334	8.1×10^{-6}	14

Notes:
Shaded values in table represent exceedences of USEPA acceptable risk criteria (i.e., target ICR range of 1×10^{-06} to 1×10^{-04} and target HI value of 1.0).
() = Percent contribution of exposure pathway to media subtotal risk.
NA = Exposure pathway not applicable for receptor.

TABLE 3-5

CLEAN UP GOALS BASED ON RBCs AND EPA RECOMMENDED CRITERIA
SITE 85, CAMP JOHNSON BATTERY DUMP
ENGINEERING EVALUATION/COST ANALYSIS, CTO-0314
MCB, CAMP LEJEUNE, NORTH CAROLINA

Analyte	Potential Clean Up Goals			Clean Up Goal (mg/kg)
	Residential Screening Level[1] (mg/kg)	Soil to Groundwater Soil Screening Level[2] (mg/kg)	Twice the Average Base Background Concentration - Subsurface Soil (mg/kg)	
Aluminum	15,600	14.8	7,413	7,413
Arsenic	6.2	26.2	2.0	6.2
Barium	1,100	848	14	1,100
Cadmium	7.8	2.7	0.72	2.7
Chromium	78	27.2	12.5	27.2
Cobalt	940	--	1.6	940
Copper	62	704	2.4	62
Iron	4,600	151	7,135	7,135
Lead	400	270	8.3	270
Manganese	320	65	8.0	65
Mercury	4.6	0.0154	0.13	0.13
Nickel	320	56.4	3.7	56.4
Vanadium	110	520	13.3	110
Zinc	4,600	1,100	6.7	1,100

(1) USEPA Region III Residential Soil Risk Based Concentration (RBC) value (USEPA, 1998) multiplied by 0.2. The multiplier accounts for potential synergistic effects of multiple contaminants.

(2) USEPA Soil Screening Levels for Transfer from Soil to Groundwater (May, 1996)

-- Criteria not established.

TABLE 5-1

SUMMARY OF REMEDIAL TECHNOLOGIES
SITE 85, CAMP JOHNSON BATTERY DUMP
MCB, CAMP LEJEUNE, NORTH CAROLINA

Response Action	Technology Options	Screening Comment
Institutional Controls	Fencing Monitoring Deed Restrictions	Retained
Excavation, On-Base Disposal	Excavation and Disposal at Permitted On-Base Landfill	Retained
Treatment (Ex Situ Soil Washing)	Soil Washing	Retained

TABLE 6-1

COST ESTIMATE: ALTERNATIVE 1 - INSTITUTIONAL CONTROLS
SITE 85, MCB, CAMP LEJEUNE, NORTH CAROLINA

Cost Component	Unit	Quantity	Unit Cost	Subtotal Cost	Total Cost	Source	Basis/Comments
DIRECT CAPITAL COSTS							
General							
Pre-construction	LS	1	$5,000	$5,000		Engr. Est.	Work, E&S, H&S, & QC Plans; Permits; Shop Drawings
Mobilization/Demobilization	LS	1	$5,500	$5,500		Engr. Est.	Includes mobilization for all subcontractors, temporary facilities
Deed Restrictions	LS	1	$10,000	$10,000		Engr. Est.	Legal Fees; Recording of Deeds;etc.
General - Subtotal					$20,500		
Site Work							
Site Fencing	LF	1,800	$11.15	$20,070		Engr. Est.; Means Site Work, 1998, 015-304-0100	Assume 6-foot-high chain-link fence around battery piles.
Double Swing Gates	EA	2	$970	$1,940		Engr. Est.; Means Site Work, 1998, 028-308-5070	
Permanent Well Installation	EA	3	$2,750	$8,250		Engr. Est.; Means Site Work, 1998, 026-704-1200	Assume well installation to an average depth of 25 feet
Site Work - Subtotal					$30,260		
DIRECT CAPITAL COSTS - TOTAL					$50,760		
INDIRECT CAPITAL COSTS							
Engineering and Design	LS	1	$3,046	$3,046		Engr. Est.	Assumes 6% of Total Direct Capital Costs
Contingency Allowance	LS	1	$7,614	$7,614		Engr. Est.	Assumes 15% of Total Direct Capital Costs
INDIRECT CAPITAL COSTS - TOTAL					$10,660		
ANNUAL (O&M) COSTS							
Environmental Monitoring							
Annual Groundwater Monitoring	LS	1	$1,000	$1,000		Engr. Est..	Assumes 2 technicians, 8 hours to gather samples
Analysis of Groundwater (TCLP Metals)	EA	3	$128	$384		Quanterra Estimate	
Report	LS	1	$700	$700		Engr. Est.	Assume Senior Engineer 8 hours to write report
Environmental Monitoring - Subtotal					$2,084		
ANNUAL (O&M) COSTS - TOTAL					$2,084	Revisions: Draft - October 8, 1998	
CAPITAL COSTS (DIRECT AND INDIRECT)					**$61,400**		
ANNUAL (O&M) COSTS - PW					**$9,000**		Assume 5% discount over 5 year review period.
TOTAL COST (PW) - RAA NO. 1					**$70,400**	By: BWP Chk: KMC	Date Completed: October 6, 1998

TABLE 6-2

COST ESTIMATE: ALTERNATIVE 2 - EXCAVATION, ON-BASE DISPOSAL
SITE 85, MCB, CAMP LEJEUNE, NORTH CAROLINA

Cost Component	Unit	Quantity	Unit Cost	Subtotal Cost	Total Cost	Source	Basis/Comments
DIRECT CAPITAL COSTS							
General							
Pre-construction	LS	1	$7,000	$7,000		Engr. Est.	Work, E&S, H&S, & QC Plans; Permits; Shop Drawings
Mobilization/Demobilization	LS	1	$5,500	$5,500		Engr. Est.	Includes mobilization for all subcontractors, temporary facilities
Decontamination Pad	LS	1	$7,500	$7,500		Engr. Est.	Includes decon/laydown area
Contract Administration (Distributive Costs)	LS	1	$35,000	$35,000		Engr. Est.	Invoicing, project management, field supervision, engineering, equipment maintenance, H&S, etc.
Post-Construction Submittals	LS	1	$7,000	$7,000		Engr. Est.	Record drawings, etc.
General - Subtotal					$62,000		
Site Work							
Temporary Safety Fencing	LF	100	$2.60	$260		Engr. Est.; Means Site Work, 1998, 028-320-5000	Assume safety fencing around all excavation areas
Clearing and Grubbing	ACRE	0.35	$4,550	$1,593		Engr. Est.; Means Site Work, 1998, 021-104-0260	Major brush and tree removal
Seed/Mulch/Fertilizer	MSF	17	$30.66	$506		Engr. Est.; Means Site Work, 1998, 029-308-5300	Revegetation over all excavation areas;100% increase due to small, multiple areas
Site Work - Subtotal					$2,358		
Soil Excavation/Backfill							
Excavation of Soil/Battery Piles	CY	300	$2.27	$681		Engr. Est.: Means Site Work, 1998, 022-238-0260	add 50% for battery separation; add 15% for loading
Backfilling of Excavation Areas	CY	120	$0.59	$71		Engr. Est., Means Site Work, 1998, 022-208-3020	Assume clean fill obtained from an on-site borrow pit
Backfill Hauling	CY	120	$7.78	$934		Engr. Est.: Means Site Work, 1998, 022-266-5040	
Spreading	CY	120	$0.62	$74		Engr. Est.: Means Site Work, 1998, 022-208-2020	
Compaction	CY	120	$0.15	$18		Engr. Est.: Means Site Work, 1998, 022-226-5040	
Top Soil Over Excavation Areas	CY	50	$15.18	$759		Engr. Est.: Means Site Work, 1998, 022-216-7010	Assume 6" of top soil over 2,670 sf
Top Soil Hauling	CY	50	$7.78	$389		Engr. Est.: Means Site Work, 1998, 022-266-0540	Assume 5 mile round trip
Soil Excavation/Backfill - Subtotal					$2,926		
Sampling and Analysis							
Sampling Liquid Waste	EA	1	$120	$120		Engr. Est.	Includes shipping and sampling
Sampling Soil	EA	17	$22	$374		Engr. Est.	Confirmation and characterization sampling]
Liquid Characterization Sample Analysis	EA	3	$1,091	$3,273		OHM contract	TCL organics, TAL inorganics
Confirmation Samples Analysis	EA	16	$212	$3,392		Baker BOAs	TAL inorganics
Characterization Sample Analysis	EA	1	$2,500	$2,500		OHM Contract	TCL organics, TAL inorganics
Sampling and Analysis - Subtotal					$9,659		
Disposal							
Disposal and Hauling Soil and Batteries	CY	300	$4.52	$1,356		Engr. Est.; Means Site Work, 1998, A12.1-614-2600	includes loading/unloading; no cost for disposal at on-Base landfill
Decontamination Fluid Disposal	LS	1	$500	$500		Engr. Est.	Includes pumping, transportation to treatment facility
Disposal - Subtotal					$1,856		
DIRECT CAPITAL COSTS - TOTAL					$78,799		
INDIRECT CAPITAL COSTS							
Engineering and Design	LS	1	$4,728	$4,728		Engr. Est.	Assumes 6% of Total Direct Capital Costs
Contingency Allowance	LS	1	$11,820	$11,820		Engr. Est.	Assumes 15% of Total Direct Capital Costs
INDIRECT CAPITAL COSTS - TOTAL					$16,548		
CAPITAL COSTS (DIRECT AND INDIRECT)					$95,300		
TOTAL COST (PW) - RAA NO. 1					$95,300	By: ELB Chk: KHC	Date Completed: October 9, 1998

TABLE 6-3

COST ESTIMATE: ALTERNATIVE 3 - TREATMENT (EX SITU SOIL WASHING)
SITE 85, MCB, CAMP LEJEUNE, NORTH CAROLINA

Cost Component	Unit	Quantity	Unit Cost	Subtotal Cost	Total Cost	Source	Basis/Comments
DIRECT CAPITAL COSTS							
General							
Pre-construction	LS	1	$10,000	$10,000		Engr. Est.	Work, E&S, H&S, & QC Plans; Permits; Shop Drawings
Treatability Study	LS	1	$20,000	$20,000		Engr. Est.	Ex-situ soil washing bench-scale test
Mobilization/Demobilization	LS	1	$85,000	$85,000		Engr. Est.; Vendor Quote	Includes mobilization for all subcontractors
Decontamination Pad	LS	1	$7,500	$7,500		Engr. Est.	Includes decon/laydown area
Contract Administration (Distributive Costs)	LS	1	$35,000	$35,000		Engr. Est.	Invoicing, project management, field supervision, engineering, equipment maintenance, H&S, etc.
Post-Construction Submittals	LS	1	$7,000	$7,000		Engr. Est.	Record drawings, etc.
General - Subtotal					$164,500		
Site Work							
Temporary Safety Fencing	LF	100	$2.60	$260		Engr. Est.; Means Site Work, 1998, 028-320-5000	Assume safety fencing around all excavation areas
Clearing and Grubbing	ACRE	0.35	$4,550	$1,593		Engr. Est.; Means Site Work, 1998, 021-104-0260	Major brush and tree removal
Seed/Mulch/Fertilizer	MSF	17	$30.66	$506		Engr. Est.; Means Site Work, 1998, 029-308-5300	Revegetation over all excavation areas;100% increase due to small, multiple areas
Site Work - Subtotal					$2,358		
Soil Excavation/Backfill							
Excavation of Soil/Battery Piles	CY	300	$2.27	$681		Engr. Est.; Means Site Work, 1998, 022-238-0260	add 50% for battery separation; add 15% for loading
Backfilling of Excavation Areas	CY	120	$0.59	$71		Engr. Est.; Means Site Work, 1998, 022-208-3020	Assume clean fill obtained from an on-site borrow pit
Backfill Hauling	CY	120	$7.78	$934		Engr. Est.; Means Site Work, 1998, 022-266-5040	
Spreading	CY	120	$0.62	$74		Engr. Est.; Means Site Work, 1998, 022-208-2020	
Compaction	CY	120	$0.15	$18		Engr. Est.; Means Site Work, 1998, 022-226-5040	
Top Soil Over Excavation Areas	CY	50	$15.18	$759		Engr. Est.; Means Site Work, 1998, 022-216-7010	Assume 6" of top soil over 2,670 sf
Top Soil Hauling	CY	50	$7.78	$389		Engr. Est.; Means Site Work, 1998, 022-266-0540	Assume 5 mile round trip
Soil Excavation/Backfill - Subtotal					$2,926		
Sampling and Analysis							
Sampling Liquid Waste	EA	2	$120	$240		Engr. Est.	Includes shipping and sampling of decon fluid and soil washing wastewater
Sampling Soil	EA	17	$22	$374		Engr. Est.	Confirmation and characterization sampling
Liquid Characterization Sample Analysis	EA	6	$1,091	$6,546		OHM contract	TCL organics, TAL inorganics; decon fluid and soil washing wastewater
Confirmation Samples Analysis	EA	16	$212	$3,392		Baker BOAs	TAL inorganics
Characterization Sample Analysis	EA	1	$2,500	$2,500		OHM Contract	TCL organics, TAL inorganics
Filter Cake Analysis	EA	1	$1,091	$128		Baker BOAs	TCLP inorganics; filter cake from soil washing wastewater treatment
Sampling and Analysis - Subtotal					$13,052		
Treatment - Soil Washing							
Loading	CY	100	$6.39	$639		Engr. Est.; Means Site Work, 1998, 022-216-4000	Load soil into soil washing unit
Soil Washing Operation	TON	162	$450	$72,900		Engr. Est.; Vendor Quote	Assume 120 pcf
Wastewater Treatment System	EA	1	$6,490	$6,490		Engr. Est.; Means Site Work, 1998, 027-354-0100	Assume 1,500 gallon fiberglass tank
Treatment - Soil Washing - Subtotal					$80,029		
Disposal							
Batteries	CY	200	$0	$0		Engr. Est.; Means Site Work, 1998, A12.1-614-2600	Includes loading/unloading; no cost for disposal at on-Base landfill
Filter Cake	LS	1	$6,400	$6,400		Engr. Est.; Means Site Work, 1998, 020-717-1120 Means Site Work, 1998, 020-717-6000	Resulting from soil washing wastewater treatment; assume 25 cy of filter cake at 120 pcf = 40 tons; two truckloads @ $4/mile; assume 300 miles to Subtitle C landfill = 600 miles total ($2400); $100/ton = $4000
Decontamination Fluid Disposal	LS	1	$500	$500		Engr. Est.	Includes pumping, transportation to treatment facility
Disposal - Subtotal					$6,900		
DIRECT CAPITAL COSTS - TOTAL					$189,736		
INDIRECT CAPITAL COSTS							
Engineering and Design	LS	1	$11,384	$11,384		Engr. Est.	Assumes 6% of Total Direct Capital Costs
Contingency Allowance	LS	1	$28,460	$28,460		Engr. Est.	Assumes 15% of Total Direct Capital Costs
INDIRECT CAPITAL COSTS - TOTAL					$39,845		
CAPITAL COSTS (DIRECT AND INDIRECT)					$229,600		
TOTAL COST (PW) - RAA NO. 1					$229,600	By: ELB Chk: KJC	Date Completed: October 9, 1998

FIGURES

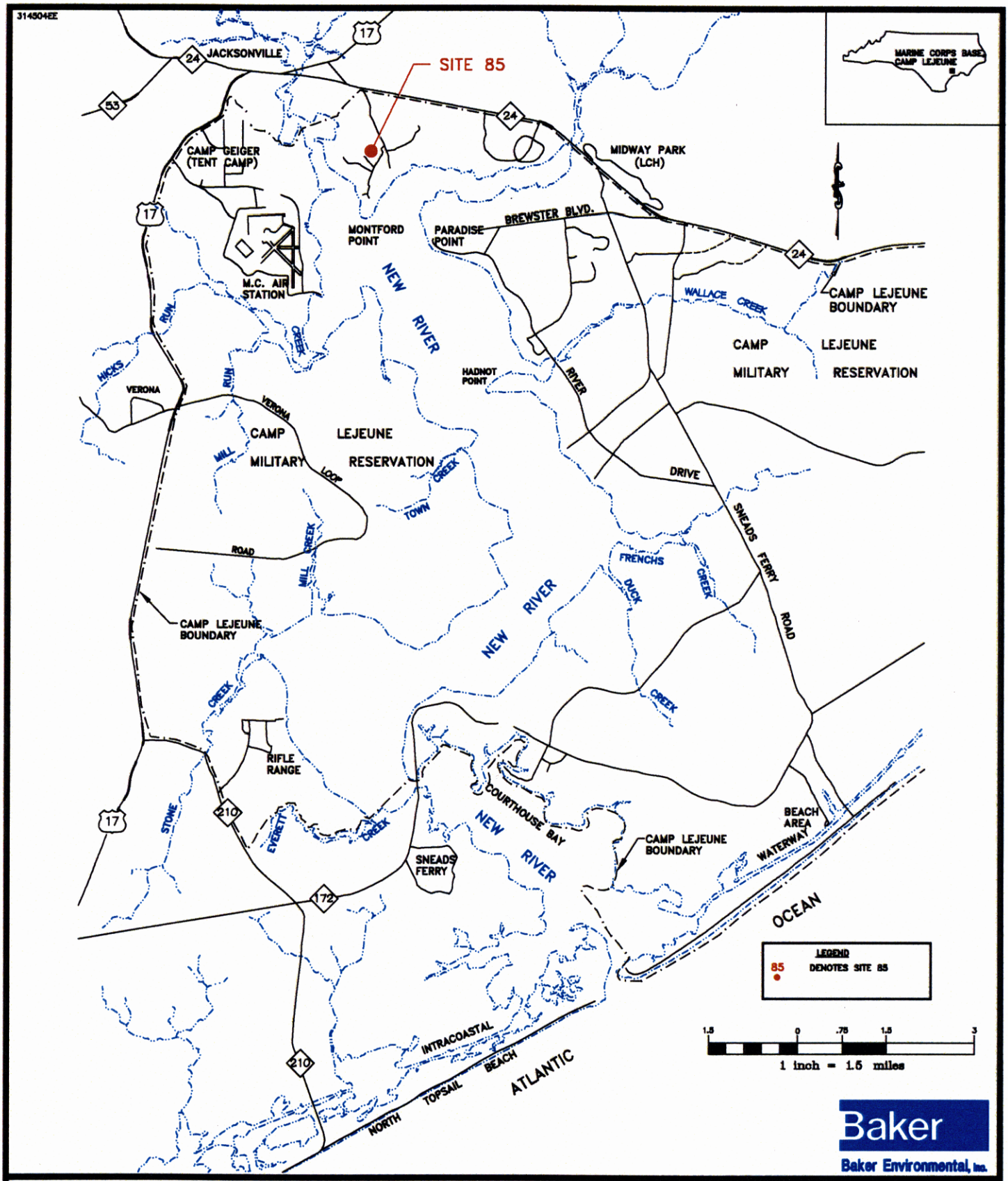
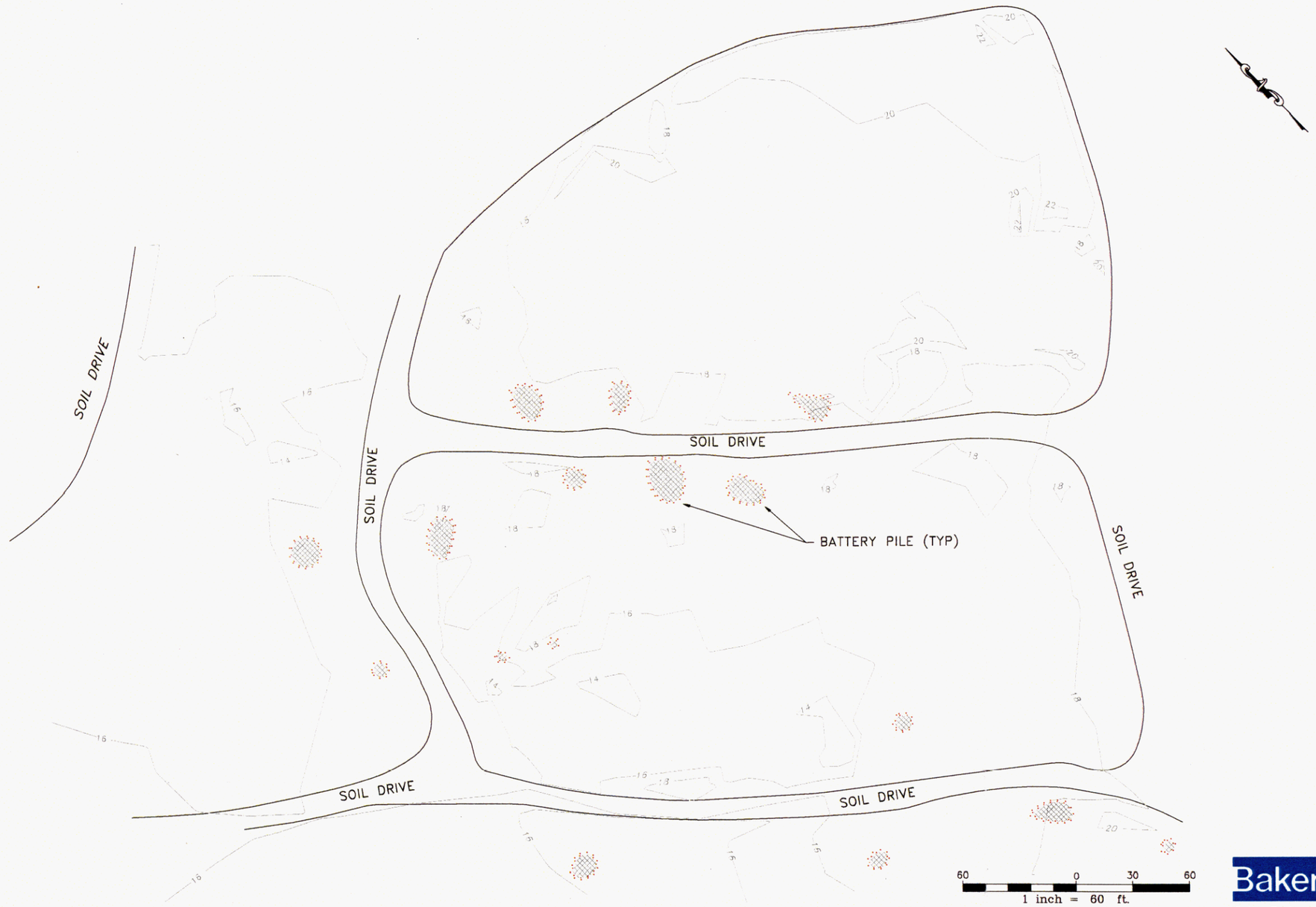


FIGURE 2-1
SITE LOCATION MAP
SITE 85
THE CAMP JOHNSON BATTERY DUMP
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

02371D01Y

314500EE



Baker
Baker Environmental, Inc.

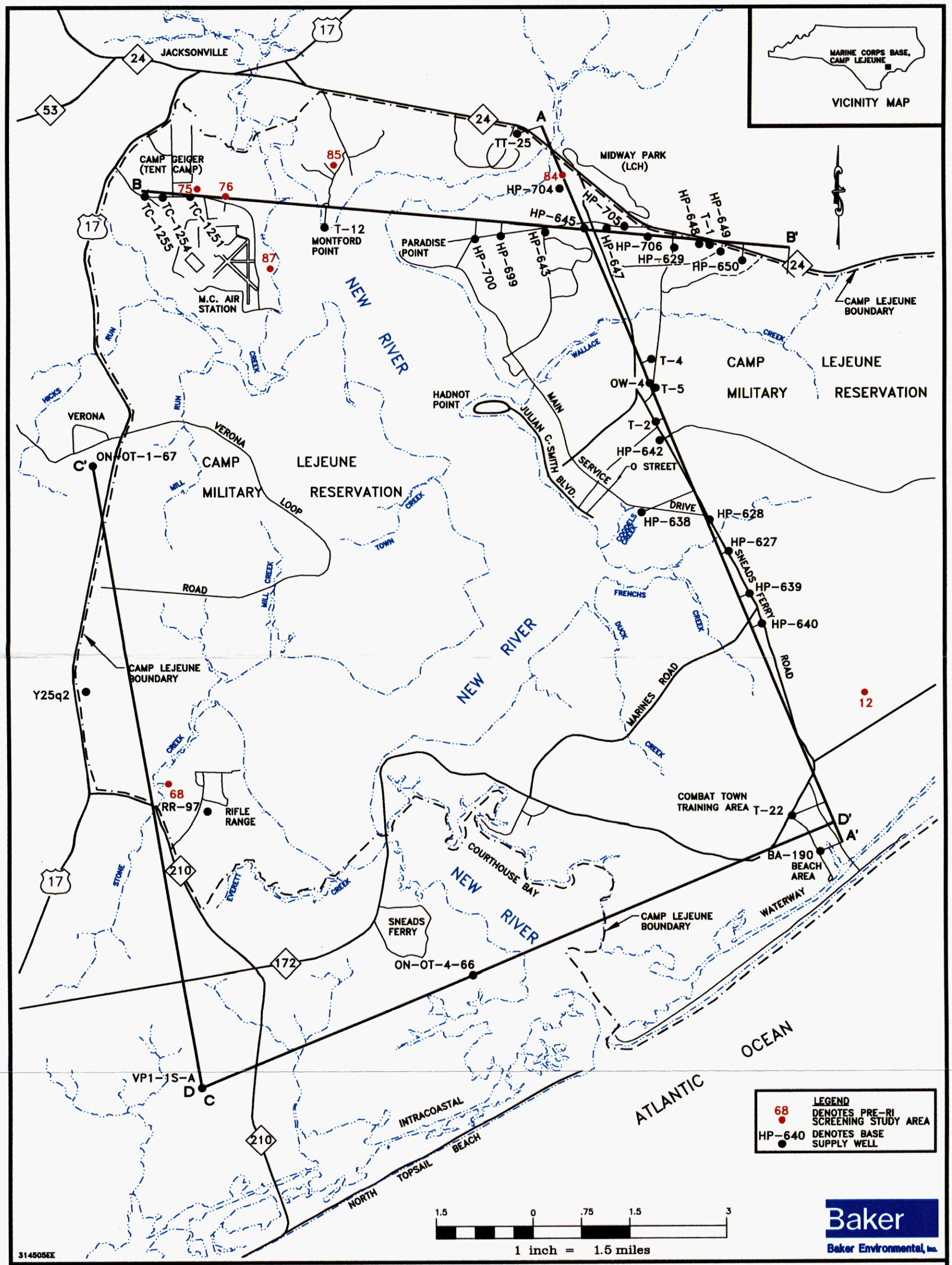
LEGEND

- BATTERY PILE

SOURCE OF BASE MAP: WK. DICKSON AND CO., INC., MARCH 28, 1998.

FIGURE 2-2
SITE MAP
SITE 85 – THE CAMP JOHNSON
BATTERY DUMP
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

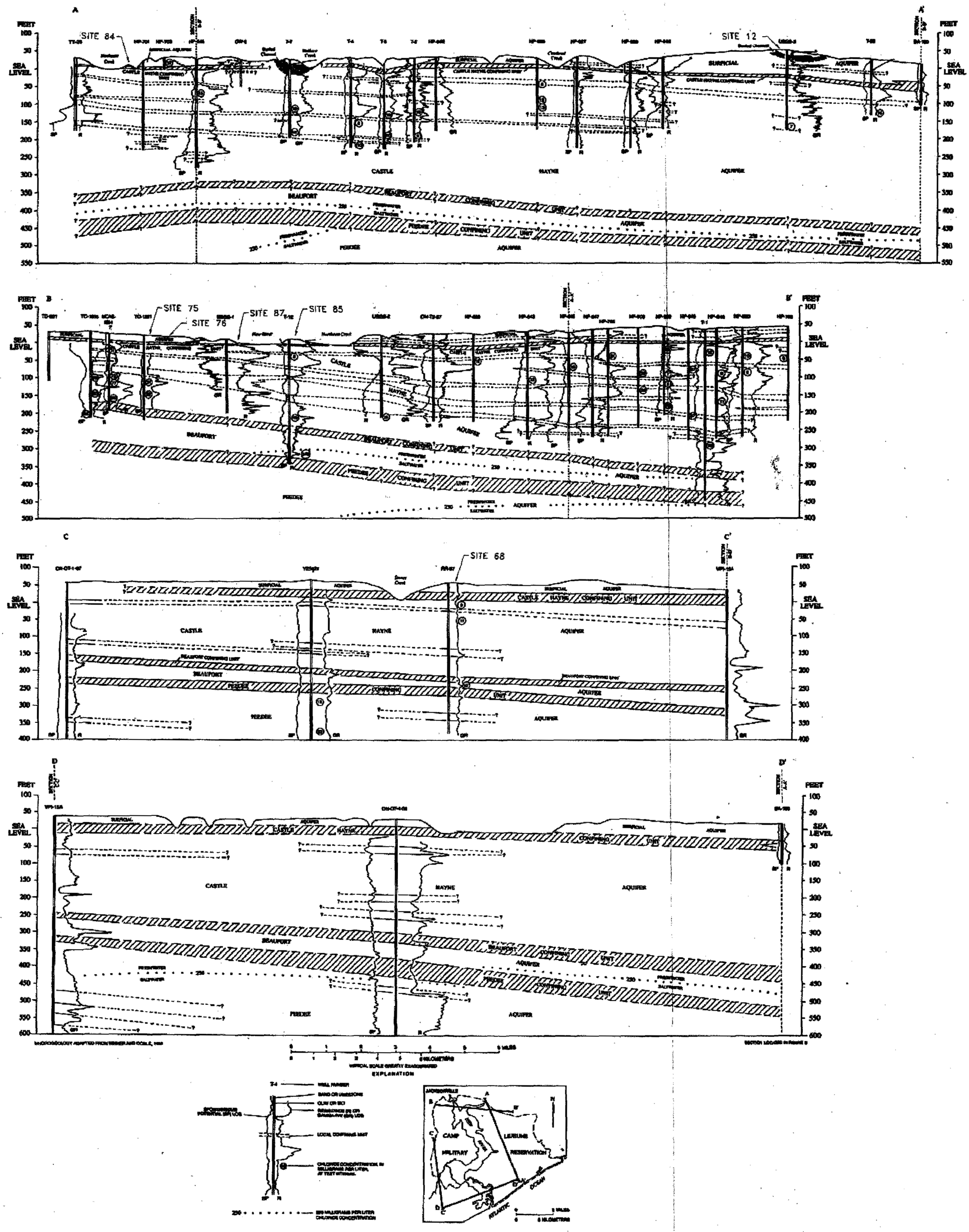
0237/DB02Y



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

FIGURE 2-3
LOCATIONS OF HYDROGEOLOGIC CROSS-SECTIONS
SITE 85
THE CAMP JOHNSON BATTERY DUMP

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

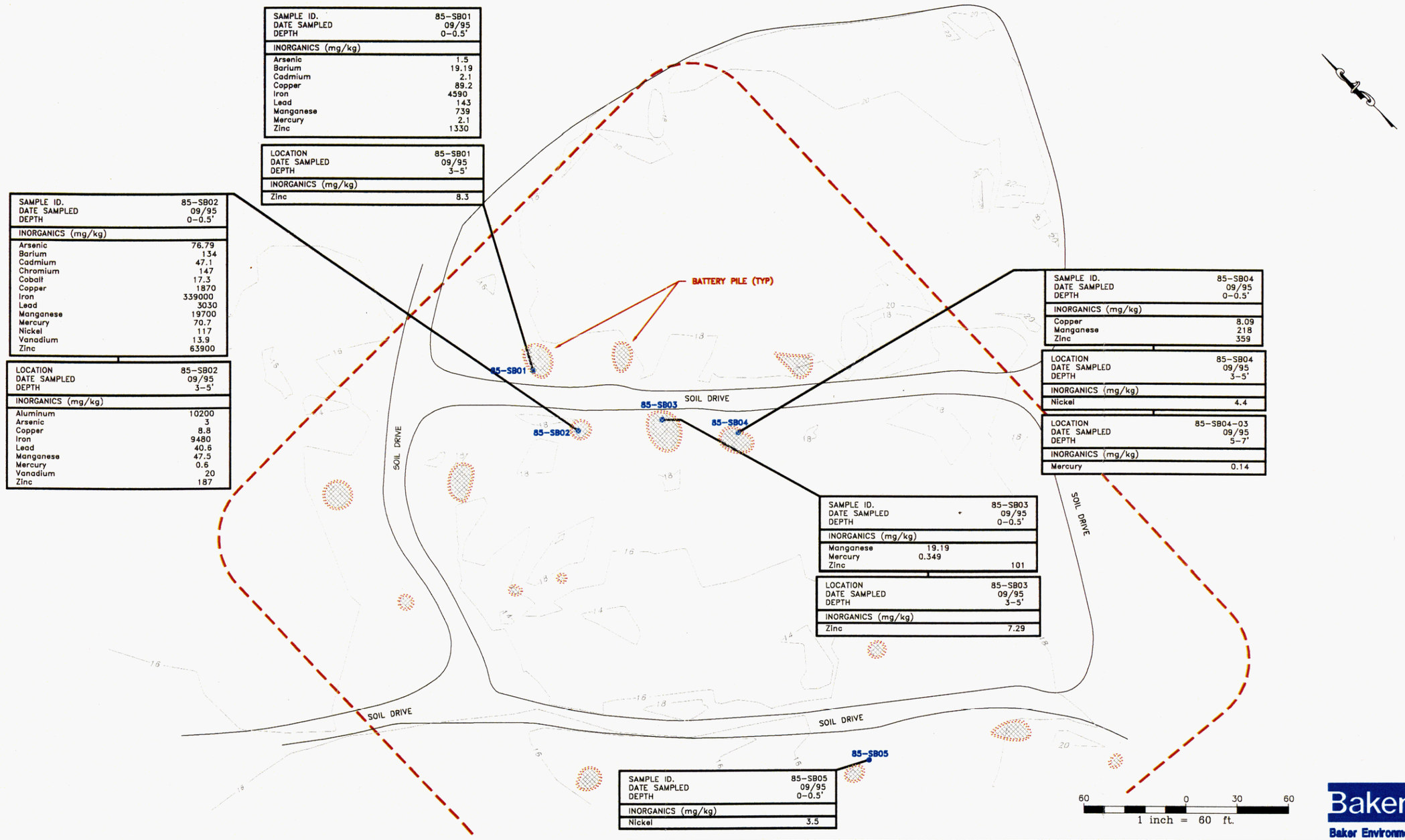


HYDROGEOLOGIC SECTIONS A-A', B-B', C-C', AND D-D' AT CAMP LEJEUNE, NORTH CAROLINA

By
Alex P. Cardinell, Steven A. Berg, and Orville B. Lloyd, Jr.
1993

REVISIONS	DRAWN WJH REVIEWED CMC S.O.# 62470-314-0000-07000 CADD# 314506EE	CTO - 0314 MARINE CORPS BASE, CAMP LEJEUNE NORTH CAROLINA BAKER ENVIRONMENTAL, Inc. Coraopolis, Pennsylvania	Baker Baker Environmental, Inc.	HYDROGEOLOGIC CROSS-SECTION SCALE AS SHOWN DATE OCTOBER 1998	FIGURE NO. 2-4

314503EE



SAMPLE ID.	85-SB01
DATE SAMPLED	09/95
DEPTH	0-0.5'
INORGANICS (mg/kg)	
Arsenic	1.5
Barium	19.19
Cadmium	2.1
Copper	89.2
Iron	4590
Lead	143
Manganese	739
Mercury	2.1
Zinc	1330

LOCATION	85-SB01
DATE SAMPLED	09/95
DEPTH	3-5'
INORGANICS (mg/kg)	
Zinc	8.3

SAMPLE ID.	85-SB02
DATE SAMPLED	09/95
DEPTH	0-0.5'
INORGANICS (mg/kg)	
Arsenic	76.79
Barium	134
Cadmium	47.1
Chromium	147
Cobalt	17.3
Copper	1870
Iron	339000
Lead	3030
Manganese	19700
Mercury	70.7
Nickel	117
Vanadium	13.9
Zinc	63900

LOCATION	85-SB02
DATE SAMPLED	09/95
DEPTH	3-5'
INORGANICS (mg/kg)	
Aluminum	10200
Arsenic	3
Copper	8.8
Iron	9480
Lead	40.6
Manganese	47.5
Mercury	0.6
Vanadium	20
Zinc	187

SAMPLE ID.	85-SB04
DATE SAMPLED	09/95
DEPTH	0-0.5'
INORGANICS (mg/kg)	
Copper	8.09
Manganese	218
Zinc	359

LOCATION	85-SB04
DATE SAMPLED	09/95
DEPTH	3-5'
INORGANICS (mg/kg)	
Nickel	4.4

LOCATION	85-SB04-03
DATE SAMPLED	09/95
DEPTH	5-7'
INORGANICS (mg/kg)	
Mercury	0.14

SAMPLE ID.	85-SB03
DATE SAMPLED	09/95
DEPTH	0-0.5'
INORGANICS (mg/kg)	
Manganese	19.19
Mercury	0.349
Zinc	101

LOCATION	85-SB03
DATE SAMPLED	09/95
DEPTH	3-5'
INORGANICS (mg/kg)	
Zinc	7.29

SAMPLE ID.	85-SB05
DATE SAMPLED	09/95
DEPTH	0-0.5'
INORGANICS (mg/kg)	
Nickel	3.5

Baker
Baker Environmental, Inc.

LEGEND

- BATTERY PILE
- CONTOUR
- 20 – CONTOUR INDEX
- APPROXIMATE STUDY AREA
- SOIL BORING

SOURCE OF BASE MAP: WK. DICKSON AND CO., INC., MARCH 28, 1998.

FIGURE 2-5
ANALYTICAL RESULTS
SITE 85 – THE CAMP JOHNSON
BATTERY DUMP
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

02371DB04Y

314501EE

Baker
Baker Environmental, Inc.

LEGEND

⁂ – BATTERY PILE

SOURCE OF BASE MAP: WK. DICKSON AND CO., INC., MARCH 28, 1998.

FIGURE 2–6
SOURCE AREA LOCATION
SITE 85 – THE CAMP JOHNSON
BATTERY DUMP
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

314502EE

VEHICULAR ACCESS GATES

SOIL DRIVE

SOIL DRIVE

SOIL DRIVE

6-FOOT-HIGH CHAIN-LINK SITE FENCE

BATTERY PILE (TYP)

SOIL DRIVE

SOURCE AREA

SOIL DRIVE

SOIL DRIVE

VEHICULAR ACCESS GATES

MW-03

PERMANENT MONITORING WELL

MW-02

MW-01

60 0 30 60

1 inch = 60 ft.

Baker

Baker Environmental, Inc.

LEGEND

- BATTERY PILE
- SITE FENCING
- MW-01 – PROPOSED MONITORING WELL

SOURCE OF BASE MAP: WK. DICKSON AND CO., INC., MARCH 28, 1998.

FIGURE 2-7
ALTERNATIVE 1 – INSTITUTIONAL CONTROLS
SITE 85 – THE CAMP JOHNSON BATTERY DUMP
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

APPENDIX A
ANALYTICAL DATA SUMMARIES

TABLE 4 - 10
POSITIVE DETECTION SUMMARY - SURFACE SOIL
METALS AND CYANIDE
SITE 85, THE CAMP JOHNSON BATTERY DUMP
PRE-REMEDIAL INVESTIGATION SCREENING STUDY
CTO-0314
MCB, CAMP LEJEUNE, NORTH CAROLINA

LOCATION	85-SB01-00	85-SB02-00	85-SB03-00	85-SB04-00	85-SB05-00
DATE SAMPLED	09/27/95	09/27/95	09/27/95	09/27/95	09/27/95
DEPTH	0-0.5'	0-0.5'	0-0.5'	0-0.5'	0-0.5'
TOTAL ANALYTES (mg/kg)					
ALUMINUM, TOTAL	3080	1140	2910	3190	1870
ARSENIC, TOTAL	1.5	76.8	0.63	0.55	0.55
BARIUM, TOTAL	19.2	134	9.5	9.4	6.9
CADMIUM, TOTAL	2.1	47.1	0.49 U	0.61 U	0.63 U
CALCIUM, TOTAL	580	823	91	196	91.9
CHROMIUM, TOTAL	2.3	147	2.8	3.2	3.3
COBALT, TOTAL	0.45 U	17.3	0.38 U	0.48 U	0.5 U
COPPER, TOTAL	89.2	1870	2	8.1	0.88
IRON, TOTAL	4590	339000	1570	1990	1480
LEAD, TOTAL	143	3030	20.5	4.9	10.8
MAGNESIUM, TOTAL	118	108	89.6	104	62.2
MANGANESE, TOTAL	739	19700	19.2	218	3.8
MERCURY, TOTAL	2.1	70.7	0.35	0.12 U	0.12 U
NICKEL, TOTAL	2.4 U	117	2 U	2.5 U	3.5
POTASSIUM, TOTAL	214	456	159	158	238
SODIUM, TOTAL	12.9	69	9.7	12.5	10.5
VANADIUM, TOTAL	4.8	13.9	4.1	5.1	5.9
ZINC, TOTAL	1330	63900	101	359	5.2
CYANIDE	0.9	2.1	0.51 U	0.56 U	0.57 U

QUALIFIER DEFINITIONS

U = Not detected. The associated number indicates approximate sample concentration necessary to be detected.

NOTES
mg/kg = milligrams per kilogram.

TABLE 4-10
POSITIVE DETECTION SUMMARY - SUBSURFACE SOIL
METALS AND CYANIDE
SITE 85, THE CAMP JOHNSON BATTERY DUMP
CTO-0314
MCB CAMP LEJEUNE, NORTH CAROLINA

SAMPLE ID.	85-SB01-02	85-SB01-04	85-SB02-02	85-SB02-04	85-SB03-02	85-SB03-03
DATE SAMPLED	09/27/95	09/27/95	09/27/95	09/27/95	09/27/95	09/27/95
DEPTH	3-5'	7-9'	3-5'	7-9'	3-5'	5-7'
TOTAL ANALYTES (mg/kg)						
ALUMINUM, TOTAL	4800	702	10200	348	3840	592
ARSENIC, TOTAL	0.96	0.37	3	0.37 U	1.1	0.32
BARIUM, TOTAL	3.8	0.81	13.3	0.87	5.2	0.81
CADMIUM, TOTAL	0.58 U	0.45 U	0.66	0.45 U	0.52 U	0.45 U
CALCIUM, TOTAL	29.9	127	82.1	10.5	93.2	9.5
CHROMIUM, TOTAL	5.5	1.2	11.3	0.96	4.4	0.96
COPPER, TOTAL	1.7	0.5	8.8	0.39	0.65	0.35
IRON, TOTAL	2750	398	9480	385	2520	980
LEAD, TOTAL	3.9	2.7	40.6	1.2	4.5	1.2
MAGNESIUM, TOTAL	110	33	232	10.6	82.5	14.3
MANGANESE, TOTAL	2.1	0.95	47.5	0.92	1.7	0.65
MERCURY, TOTAL	0.092 U	0.11 U	0.61	0.1 U	0.096 U	0.11 U
NICKEL, TOTAL	2.6	1.9 U	3	1.9 U	2.1 U	1.9 U
POTASSIUM, TOTAL	214	105	238	214	113	116
SODIUM, TOTAL	12.1	11.6	17	8.6	10.4	4.7
VANADIUM, TOTAL	8	1.9	20	1.2	6.4	2
ZINC, TOTAL	8.3	6.3	187	4.4	7.3	1.1

QUALIFIER DEFINITIONS

U = Not detected. The associated number indicates approximate sample concentration necessary to be detected.

NOTES
mg/kg = milligrams per kilogram.

TABLE 4-10
POSITIVE DETECTION SUMMARY - SUBSURFACE SOIL
METALS AND CYANIDE
SITE 85, THE CAMP JOHNSON BATTERY DUMP
CTO-0314
MCB CAMP LEJEUNE, NORTH CAROLINA

SAMPLE ID.	85-SB04-02	85-SB04-03	85-SB05-02	85-SB05-03
DATE SAMPLED	09/27/95	09/27/95	09/27/95	09/27/95
DEPTH	3-5'	5-7'	3-5'	5-7'
TOTAL ANALYTES (mg/kg)				
ALUMINUM, TOTAL	3460	475	5220	1540
ARSENIC, TOTAL	1.1	0.98	1.6	0.38
BARIUM, TOTAL	4.8	0.78	7.5	2.2
CADMIUM, TOTAL	0.52 U	0.48 U	0.6 U	0.56 U
CALCIUM, TOTAL	19.7	7.8	18.8	13.3
CHROMIUM, TOTAL	5.3	2.2	6.1	2.3
COPPER, TOTAL	0.43	0.35	1	0.38 U
IRON, TOTAL	2590	1420	3790	935
LEAD, TOTAL	2.7	2.2	4.8	1.7
MAGNESIUM, TOTAL	87.6	11.1	148	52.9
MANGANESE, TOTAL	5.2	0.26	1.9	1.5
MERCURY, TOTAL	0.11 U	0.15	0.1 U	0.088 U
NICKEL, TOTAL	4.4	2 U	2.5 U	2.3 U
POTASSIUM, TOTAL	98.7 U	92.4 U	242	107 U
SODIUM, TOTAL	10.2	8	11.2	8.4
VANADIUM, TOTAL	7.3	2.8	10.4	3.5
ZINC, TOTAL	6.1	1.8	1.5	1.5

QUALIFIER DEFINITIONS

U = Not detected. The associated number indicates approximate sample concentration necessary to be detected.

NOTES
mg/kg = milligrams per kilogram.

TABLE 4 - 10
POSITIVE DETECTION SUMMARY - GROUNDWATER
TOTAL METALS
SITE 85, THE CAMP JOHNSON BATTERY DUMP
PRE-REMEDIAL INVESTIGATION SCREENING STUDY, CTO-0314
CTO-0314
MCB, CAMP LEJEUNE, NORTH CAROLINA

LOCATION	85-TW01	85-TW02	85-TW03
DATE SAMPLED	09/27/95	09/27/95	09/27/95
ANALYTES (ug/L)			
ALUMINUM	159000	429000	223000
ARSENIC	10.9	16.7	20.2
BARIUM	242	548	377
BERYLLIUM	1.5 U	3.3	2.8
CADMIUM	6.7	24.6	4.9
CALCIUM	2420	6180	2070
CHROMIUM	436	821	383
COBALT	8.6	20.3	7.1
COPPER	138	173	55.4
IRON	119000	498000	180000
LEAD	207	512	380
MAGNESIUM	5530	13700	11500
MANGANESE	395	1270	228
MERCURY	0.28	2.4	0.29
NICKEL	4550	206	53.3
POTASSIUM	5480	16000	8300
SODIUM	1850	2660	5580
VANADIUM	322	908	436
ZINC	485	3970	93.1

QUALIFIER DEFINITIONS

U = Not detected. The associated number indicates approximate sample concentration necessary to be detected

NOTES
ug/L = micrograms per liter.

TABLE 4 - 10
POSITIVE DETECTION SUMMARY - GROUNDWATER
DISSOLVED METALS
SITE 85, THE CAMP JOHNSON BATTERY DUMP
PRE-REMEDIAL INVESTIGATION SCREENING STUDY, CTO-0314
CTO-0314
MCB, CAMP LEJEUNE, NORTH CAROLINA

SAMPLE ID.	85-TW01D	85-TW02D	85-TW03D
DATE SAMPLED	09/27/95	09/27/95	09/27/95
ANALYTES (ug/L)			
ALUMINUM	79.9	175	105
BARIUM	13.8	8.3	15.4
CADMIUM	2.8 U	3.4	2.8 U
CALCIUM	766	1940	633
COPPER	2.2	1.9 U	1.9 U
IRON	4770	10500	2600
LEAD	1.4 U	1.4 U	2.2
MAGNESIUM	866	477	1790
MANGANESE	55.1	224	32.6
NICKEL	206	11.6 U	11.6 U
POTASSIUM	686	1400	775
SODIUM	1640	1970	4520
ZINC	58.8	473	4.6

QUALIFIER DEFINITIONS

U = Not detected. The associated number indicates approximate sample concentration necessary to be detected.

NOTES
ug/L = micrograms per liter.

POSITIVE DETECTION SUMMARY - SURFACE SOIL
METALS AND CYANIDE (TCLP)
SITE 85, THE CAMP JOHNSON BATTERY DUMP
CTO-0314
MCB CAMP LEJEUNE, NORTH CAROLINA

LOCATION	85-WT01-00	85-WT02-00
DATE SAMPLED	01/23/96	01/23/96
DEPTH	0-0.5'	0-0.5'
METALS (ug/L)		
LEAD, TCLP	1110	3640
BARIUM, TCLP	523	500 U
CADMIUM, TCLP	230	151

QUALIFIER DEFINITIONS

U = Not detected. The associated number indicates approximate sample concentration necessary to be de

NOTES
ug/L = micrograms per liter.

APPENDIX B
RISK EVALUATION CALCULATIONS

SURFACE SOIL INGESTION EXPOSURE ASSESSMENT
SITE 85-CAMP JOHNSON BATTERY DUMP
PRE-RI INVESTIGATION SCREENING STUDY CTO-0314
MCB CAMP LEJEUNE, NORTH CAROLINA
FUTURE RESIDENTIAL ADULT

Intake from ingestion of soil is calculated as follows:

Intake (mg/kg-day) = C * CF * EF * ED * IR/BW * ATc or ATnc * DY

Risk = Intake * CSF or /RfD

Where:		INPUTS
C = contaminant concentration in soil (mg/kg)		
CF = conversion for kg to mg		1E-06
EF = adult exposure frequency (days/yr)		350
ED = adult exposure duration (yr)		30
IR = adult soil ingestion rate (mg/day)		100
BW = adult body weight (kg)		70
ATc = averaging time for carcinogen (yr)		70
ATnc = averaging time for noncarcinogen (yr)		30
DY = days per year (days/year)		365
CSF = cancer slope factor (mg/kg-day)-1	specific	
RfD = reference dose (mg/kg-day)	specific	

COPC	Concentration (mg/kg)	Exposure Frequency (days/yr) Adult	Exposure Duration (yr) Adult	Conversion Factor (kg/mg)	Ingestion Rate (mg/day) Adult	Body Weight (kg) Adult	Average Carc Time (days)	Carc Dose (mg/kg/day) Adult	Slope Factor (mg/kg/day)-1	Carcinogenic Risk Adult	Percent Carcinogenic Risk Adult	Average Noncarc Time (days)	Noncarc Dose (mg/kg/day) Adult	Reference Dose (mg/kg/day)	Noncarcinogenic Risk Adult	Percent Noncarcinogenic Risk Adult
Arsenic	76.80	350	30	1E-06	100	70	25550	4.5E-05	1.5E+00	6.76E-05	100%	10950	1.1E-04	3.0E-04	3.5E-01	2%
Cadmium (soil)	47.10	350	30	1E-06	100	70	25550	2.8E-05	0.0E+00	0.00E+00	0%	10950	6.5E-05	1.0E-03	6.5E-02	0%
Chromium	147.00	350	30	1E-06	100	70	25550	8.6E-05	0.0E+00	0.00E+00	0%	10950	2.0E-04	5.0E-03	4.0E-02	0%
Copper	1870.00	350	30	1E-06	100	70	25550	1.1E-03	0.0E+00	0.00E+00	0%	10950	2.6E-03	4.0E-02	6.4E-02	0%
Iron	339000.00	350	30	1E-06	100	70	25550	2.0E-01	0.0E+00	0.00E+00	0%	10950	4.6E-01	3.0E-01	1.5E+00	11%
Lead	3030.00	350	30	1E-06	100	70	25550	1.8E-03	0.0E+00	0.00E+00	0%	10950	4.2E-03	0.0E+00	0.0E+00	0%
Manganese	197000.00	350	30	1E-06	100	70	25550	1.2E-01	0.0E+00	0.00E+00	0%	10950	2.7E-01	2.3E-02	1.2E+01	81%
Mercury	70.70	350	30	1E-06	100	70	25550	4.2E-05	0.0E+00	0.00E+00	0%	10950	9.7E-05	3.0E-04	3.2E-01	2%
Zinc	63900.00	350	30	1E-06	100	70	25550	3.8E-02	0.0E+00	0.00E+00	0%	10950	8.8E-02	3.0E-01	2.9E-01	2%
TOTAL										6.8E-05					1.4E+01	

SURFACE SOIL DERMAL CONTACT EXPOSURE ASSESSMENT
SITE 85-CAMP JOHNSON BATTERY DUMP
PRE-RI INVESTIGATION SCREENING STUDY CTO-0314
MCB CAMP LEJEUNE, NORTH CAROLINA
FUTURE RESIDENTIAL ADULT

Dermal contact with soil is calculated as follows:

Intake (mg/kg-day) = C * CF * SA * AF * Abs * EF * ED/BW * ATc or ATnc * DY

Risk = Intake * CSF or /RfD

Where:	INPUTS
C = contaminant concentration in soil (mg/kg)	
CF = conversion factor (kg/mg)	1E-06
SA = adult exposed skin surface area (cm2)	5800
AF = soil to skin adherence factor (mg/cm2)	1
Abs = fraction absorbed (unitless)	Specific
EF = adult exposure frequency (events/yr)	350
ED = adult exposure duration (years)	30
BW = adult body weight (kg)	70
ATc = averaging time for carcinogen (yr)	70
ATnc = averaging time for noncarcinogen (yr)	30
DY = day per year (day/yr)	365
CSF = cancer slope factor (mg/kg-day)-1	specific
RfD = reference dose (mg/kg-day)	specific

COPC	Concentration (mg/kg)	Conversion Factor (kg/mg)	Surface Area (cm2) Adult	Adherence Factor (mg/cm2)	Fraction Absorbed (%)	Exposure Frequency (events/yr) Adult	Exposure Duration (yrs) Adult	Body Weight (kg) Adult	Average Carc Time (days)	Carc Dose (mg/kg/day) Adult	Dermal Adjust. Slope Factor (mg/kg-day)-1	Carcinogenic Risk Adult	Percent Carcinogenic Risk Adult	Average Noncarc Tim (days)	Noncarc Dose (mg/kg/day) Adult	Dermal Adjust. Reference Dose (mg/kg-day)	Noncarcinogenic Risk Adult	Percent Noncarcinogenic Risk Adult
Arsenic	76.80	1E-06	5800	1	0.001	350	30	70	25550	2.6E-06	7.5E+00	1.96E-05	100%	10950	6.1E-06	6.0E-05	1.0E-01	2%
Cadmium (soil)	47.10	1E-06	5800	1	0.001	350	30	70	25550	1.6E-06	0.0E+00	0.00E+00	0%	10950	3.7E-06	2.0E-04	1.9E-02	0%
Chromium	147.00	1E-06	5800	1	0.001	350	30	70	25550	5.0E-06	0.0E+00	0.00E+00	0%	10950	1.2E-05	1.0E-03	1.2E-02	0%
Copper	1870.00	1E-06	5800	1	0.001	350	30	70	25550	6.4E-05	0.0E+00	0.00E+00	0%	10950	1.5E-04	8.0E-03	1.9E-02	0%
Iron	339000.00	1E-06	5800	1	0.001	350	30	70	25550	1.2E-02	0.0E+00	0.00E+00	0%	10950	2.7E-02	6.0E-02	4.5E-01	11%
Lead	3030.00	1E-06	5800	1	0.001	350	30	70	25550	1.0E-04	0.0E+00	0.00E+00	0%	10950	2.4E-04	0.0E+00	0.0E+00	0%
Manganese	197000.00	1E-06	5800	1	0.001	350	30	70	25550	6.7E-03	0.0E+00	0.00E+00	0%	10950	1.6E-02	4.6E-03	3.4E+00	81%
Mercury	70.70	1E-06	5800	1	0.001	350	30	70	25550	2.4E-06	0.0E+00	0.00E+00	0%	10950	5.6E-06	6.0E-05	9.4E-02	2%
Zinc	63900.00	1E-06	5800	1	0.001	350	30	70	25550	2.2E-03	0.0E+00	0.00E+00	0%	10950	5.1E-03	6.0E-02	8.5E-02	2%
TOTAL												2.0E-05					4.2E+00	

SURFACE SOIL PARTICULATE INHALATION EXPOSURE ASSESSMENT
SITE 85-CAMP JOHNSON BATTERY DUMP
PRE-RI INVESTIGATION SCREENING STUDY CTO-0314
MCB CAMP LEJEUNE, NORTH CAROLINA
FUTURE RESIDENTIAL ADULT

Intake from the Inhalation of particulates is calculated as follows:

Intake (mg/kg-day) = (C * EF * ED * IR * 1/PEF)/(BW * ATc or ATnc * DY)

Risk = Intake * CSF or /RfD

Where:	INPUTS
C = contaminant concentration in soil (mg/kg)	Calculated
CSF = carcinogenic slope factor	Specific
RfD = reference dose for noncarcinogen	Specific
IR = inhalation rate (m3)	20
EF = adult exposure frequency (days)	350
ED = adult exposure duration (years)	30
BW = adult body weight (kg)	70
ATc = averaging time for carcinogen (yr)	70
ATnc = averaging time for noncarcinogen (yr)	30
DY = day per year (day/yr)	365
PEF = particulate emission factor (m3/kg)	1.32E+09

COPC	Concentration (mg/kg)	Particulate Emission Factor (m3/kg)	Exposure Frequency (events/yr)	Inhalation Rate (m3/day)	Exposure Duration (yrs)	Body Weight (kg)	Average Carc Time (days)	Carc Dose (mg/kg/day)	Slope Factor (mg/kg-day)-1	Carcinogenic Risk	Percent Contribution to Risk	Average Noncarc Time (days)	Noncarc Dose (mg/kg/day)	Reference Dose (mg/kg-day)	Noncarcinogenic Risk	Percent Noncarcinogenic Risk
Arsenic	76.80	1.3E+09	350	20	30	70	25550	6.8E-09	1.5E+01	1.0E-07	16%	10950	1.6E-08	0.0E+00	0.0E+00	0%
Cadmium (soil)	47.10	1.3E+09	350	20	30	70	25550	4.2E-09	0.0E+00	0.0E+00	0%	10950	9.8E-09	0.0E+00	0.0E+00	0%
Chromium	147.00	1.3E+09	350	20	30	70	25550	1.3E-08	4.2E+01	5.5E-07	84%	10950	3.1E-08	0.0E+00	0.0E+00	0%
Copper	1870.00	1.3E+09	350	20	30	70	25550	1.7E-07	0.0E+00	0.0E+00	0%	10950	3.9E-07	0.0E+00	0.0E+00	0%
Iron	339000.00	1.3E+09	350	20	30	70	25550	3.0E-05	0.0E+00	0.0E+00	0%	10950	7.0E-05	0.0E+00	0.0E+00	0%
Lead	3030.00	1.3E+09	350	20	30	70	25550	2.7E-07	0.0E+00	0.0E+00	0%	10950	6.3E-07	0.0E+00	0.0E+00	0%
Manganese	197000.00	1.3E+09	350	20	30	70	25550	1.8E-05	0.0E+00	0.0E+00	0%	10950	4.1E-05	1.4E-05	2.9E+00	0%
Mercury	70.70	1.3E+09	350	20	30	70	25550	6.3E-09	0.0E+00	0.0E+00	0%	10950	1.6E-08	8.6E-05	1.7E-04	0%
Zinc	83900.00	1.3E+09	350	20	30	70	25550	5.7E-06	0.0E+00	0.0E+00	0%	10950	1.3E-05	0.0E+00	0.0E+00	0%
TOTAL										6.5E-07					2.9E+00	

GROUNDWATER INGESTION EXPOSURE ASSESSMENT
SITE 85-CAMP JOHNSON BATTERY DUMP
PRE-RI INVESTIGATION SCREENING STUDY CTO-0314
MCB CAMP LEJEUNE, NORTH CAROLINA
FUTURE RESIDENTIAL ADULT

Intake from drinking water is calculated as follows:

Intake (mg/kg-day) = C * IRw * EF * ED/BW * AT or ATnc * DY

Risk = Intake * CSF or /RfD

Where:		INPUTS
C = contaminant concentration in water (mg/l)		
IRw = adult daily water ingestion rate (L/Day)		2
EF = adult exposure frequency (days/yr)		350
ED = adult exposure duration (yr)		30
BW = adult body weight (kg)		70
ATc = averaging time for carcinogen (yr)		70
ATnc = averaging time for noncarcinogen (yr)		30
DY = days per year (day/year)		365
CSF = cancer slope factor (mg/kg-day)-1	specific	
RfD = reference dose (mg/kg-day)	specific	

COPC	Concentration (mg/l)	Ingestion Rate (L/day) Adult	Exposure Frequency (day/year) Adult	Exposure Duration (year) Adult	Body Weight (kg) Adult	Average Carc Time (days)	Carc Dose (mg/kg-day) Adult	Slope Factor (mg/kg-day)-1	Carcinogenic Risk Adult	Percent Carcinogeni Risk Adult	Average Noncarc Time (days)	Noncarc Dose (mg/kg-day) Adult	Reference Dose (mg/kg-day)	Noncarcinogenic Risk Adult	Percent Noncarcionogenic Risk Adult
Aluminum	429.000	2	350	30	70	25550	5.0E+00	0.0E+00	0.0E+00	0%	10950	1.2E+01	1.0E+00	1.2E+01	15%
Arsenic	0.020	2	350	30	70	25550	2.3E-04	1.5E+00	3.5E-04	100%	10950	5.5E-04	3.0E-04	1.8E+00	2%
Barium	0.548	2	350	30	70	25550	6.4E-03	0.0E+00	0.0E+00	0%	10950	1.5E-02	7.0E-02	2.1E-01	0%
Cadmium (water)	0.025	2	350	30	70	25550	2.9E-04	0.0E+00	0.0E+00	0%	10950	6.7E-04	5.0E-04	1.3E+00	2%
Chromium	0.821	2	350	30	70	25550	9.6E-03	0.0E+00	0.0E+00	0%	10950	2.2E-02	5.0E-03	4.5E+00	6%
Copper	0.173	2	350	30	70	25550	2.0E-03	0.0E+00	0.0E+00	0%	10950	4.7E-03	4.0E-02	1.2E-01	0%
Iron	498.000	2	350	30	70	25550	5.8E+00	0.0E+00	0.0E+00	0%	10950	1.4E+01	3.0E-01	4.5E+01	59%
Lead	0.512	2	350	30	70	25550	6.0E-03	0.0E+00	0.0E+00	0%	10950	1.4E-02	0.0E+00	0.0E+00	0%
Manganese	1.270	2	350	30	70	25550	1.5E-02	0.0E+00	0.0E+00	0%	10950	3.5E-02	2.3E-02	1.5E+00	2%
Mercury	0.002	2	350	30	70	25550	2.8E-05	0.0E+00	0.0E+00	0%	10950	6.6E-05	3.0E-04	2.2E-01	0%
Nickel	4.550	2	350	30	70	25550	5.3E-02	0.0E+00	0.0E+00	0%	10950	1.2E-01	2.0E-02	6.2E+00	8%
Vanadium	0.908	2	350	30	70	25550	1.1E-02	0.0E+00	0.0E+00	0%	10950	2.5E-02	7.0E-03	3.6E+00	5%
Zinc	3.970	2	350	30	70	25550	4.7E-02	0.0E+00	0.0E+00	0%	10950	1.1E-01	3.0E-01	3.6E-01	0%
TOTAL									3.52E-04					77.12	

GROUNDWATER DERMAL CONTACT EXPOSURE ASSESSMENT
SITE 85-CAMP JOHNSON BATTERY DUMP
PRE-RI INVESTIGATION SCREENING STUDY CTO-0314
MCB CAMP LEJEUNE, NORTH CAROLINA
FUTURE RESIDENTIAL ADULT

Dermal Contact from groundwater is calcuated as follows:

Intake (mg/kg-day) = CW * SA * PC * ET * EF * ED * CF/BW * ATc or ATnc * DY

Risk = Intake * CSF or /RfD

Where:	INPUTS
CW = contaminant concentration in water (mg/l)	
SA = adult skin surface available for contact (cm2)	23000
PC = contaminant specific dermal permability (cm/hr)	Specific
ET = adult exposure time (hours/day)	0.25
EF = adult exposure frequency (days/yr)	350
ED = adult exposure duration (years)	30
CF = volumetric conversion factor for water (1liter/1000 cm3)	0.001
BW = adult body weight (kg)	70
ATc = averaging time for carcinogen (yr)	70
ATnc = averaging time for noncarcinogen (yr)	30
DY = days per year (days)	365

Note: Inputs are site and scenario specific

COPC	Concentration Carcinogen (mg/l)	Surface Area (cm2) Adult	Dermal Permeability (cm/hr)	Exposure Time (hours/day) Adult	Exposure Frequency (days/yr) Adult	Exposure Duration (years) Adult	Volumetric Conversion (L/m3)	Body Weight (kg) Adult	Averaging Carc Time (years)	Carc Dose (mg/kg-day) Adult	Derm. Adj. Slope Factor (mg/kg-day)-1	Carcinogenic Risk Adult	Percent Carcinogeni Risk Adult	Average Noncarc Time (years)	Noncarc Dose (mg/kg-day) Adult	Dermal Adjust. Reference Dose (mg/kg-day)	Noncarc Risk Adult	Percent Noncarcinogenic Risk Adult
Aluminum	429.000	23000	1.00E-03	0.25	350	30	0.001	70	25550	1.4E-02	0.0E+00	0.0E+00	0%	10950	3.4E-02	2.0E-01	1.7E-01	16%
Arsenic	0.020	23000	1.00E-03	0.25	350	30	0.001	70	25550	6.8E-07	7.5E+00	5.1E-06	100%	10950	1.6E-06	6.0E-05	2.6E-02	3%
Barium	0.548	23000	1.00E-03	0.25	350	30	0.001	70	25550	1.8E-05	0.0E+00	0.0E+00	0%	10950	4.3E-05	1.4E-02	3.1E-03	0%
Cadmium (water)	0.025	23000	1.00E-03	0.25	350	30	0.001	70	25550	8.3E-07	0.0E+00	0.0E+00	0%	10950	1.9E-06	1.0E-04	1.9E-02	2%
Chromium	0.821	23000	1.00E-03	0.25	350	30	0.001	70	25550	2.8E-05	0.0E+00	0.0E+00	0%	10950	6.5E-05	1.0E-03	6.5E-02	6%
Copper	0.173	23000	1.00E-03	0.25	350	30	0.001	70	25550	5.8E-06	0.0E+00	0.0E+00	0%	10950	1.4E-05	8.0E-03	1.7E-03	0%
Iron	498.000	23000	1.00E-03	0.25	350	30	0.001	70	25550	1.7E-02	0.0E+00	0.0E+00	0%	10950	3.9E-02	6.0E-02	6.5E-01	64%
Lead	0.512	23000	4.00E-06	0.25	350	30	0.001	70	25550	6.9E-08	0.0E+00	0.0E+00	0%	10950	1.6E-07	0.0E+00	0.0E+00	0%
Manganese	1.270	23000	1.00E-03	0.25	350	30	0.001	70	25550	4.3E-05	0.0E+00	0.0E+00	0%	10950	1.0E-04	4.6E-03	2.2E-02	2%
Mercury	0.002	23000	1.00E-03	0.25	350	30	0.001	70	25550	8.1E-08	0.0E+00	0.0E+00	0%	10950	1.9E-07	6.0E-05	3.2E-03	0%
Nickel	4.550	23000	1.00E-04	0.25	350	30	0.001	70	25550	1.5E-05	0.0E+00	0.0E+00	0%	10950	3.6E-05	4.0E-03	9.0E-03	1%
Vanadium	0.908	23000	1.00E-03	0.25	350	30	0.001	70	25550	3.1E-05	0.0E+00	0.0E+00	0%	10950	7.2E-05	1.4E-03	5.1E-02	5%
Zinc	3.970	23000	6.00E-04	0.25	350	30	0.001	70	25550	8.0E-05	0.0E+00	0.0E+00	0%	10950	1.9E-04	6.0E-02	3.1E-03	0%
TOTAL												5.1E-06					1.0E+00	

SURFACE SOIL INGESTION EXPOSURE ASSESSMENT
SITE 85-CAMP JOHNSON BATTERY DUMP
PRE-RI INVESTIGATION SCREENING STUDY CTO-0314
MCB CAMP LEJEUNE, NORTH CAROLINA
FUTURE RESIDENTIAL CHILD

Intake from ingestion of soil is calculated as follows:

Intake (mg/kg-day) = C * CF * EF * ED * IR/BW * ATc or ATnc * DY

Risk = Intake * CSF or /RfD

Where:	INPUTS
C = contaminant concentration in soil (mg/kg)	
CF = conversion for kg to mg	1E-06
EF = child exposure frequency (days/yr)	350
ED = child exposure duration (yr)	6
IR = child soil ingestion rate (mg/day)	200
BW = child body weight (kg)	15
ATc = averaging time for carcinogen (yr)	70
ATnc = averaging time for noncarcinogen (yr)	6
DY = days per year (days/year)	365
CSF = cancer slope factor (mg/kg-day)-1	specific
RfD = reference dose (mg/kg-day)	specific

COPC	Concentration (mg/kg)	Exposure Frequency (days/yr) Child	Exposure Duration (yr) Child	Conversion Factor (kg/mg)	Ingestion Rate (mg/day) Child	Body Weight (kg) Child	Average Carc Time (days)	Carc Dose (mg/kg/day) Child	Slope Factor (mg/kg/day)-1	Carcinogenic Risk Child	Percent Carcinogenic Risk Child	Average Noncarc Time (days)	Noncarc Dose (mg/kg/day) Child	Reference Dose (mg/kg/day)	Noncarcinogenic Risk Child	Percent Noncarcinogenic Risk Child
Arsenic	76.80	350	6	1E-06	200	15	25550	8.4E-05	1.50E+00	1.26E-04	100%	2190	9.8E-04	3.00E-04	3.3E+00	2%
Cadmium (soil)	47.10	350	6	1E-06	200	15	25550	5.2E-05	0.00E+00	0.00E+00	0%	2190	6.0E-04	1.00E-03	6.0E-01	0%
Chromium	147.00	350	6	1E-06	200	15	25550	1.6E-04	0.00E+00	0.00E+00	0%	2190	1.9E-03	5.00E-03	3.8E-01	0%
Copper	1870.00	350	6	1E-06	200	15	25550	2.0E-03	0.00E+00	0.00E+00	0%	2190	2.4E-02	4.00E-02	6.0E-01	0%
Iron	339000.00	350	6	1E-06	200	15	25550	3.7E-01	0.00E+00	0.00E+00	0%	2190	4.3E+00	3.00E-01	1.4E+01	11%
Lead	3030.00	350	6	1E-06	200	15	25550	3.3E-03	0.00E+00	0.00E+00	0%	2190	3.9E-02	0.00E+00	0.0E+00	0%
Manganese	197000.00	350	6	1E-06	200	15	25550	2.2E-01	0.00E+00	0.00E+00	0%	2190	2.5E+00	2.30E-02	1.1E+02	81%
Mercury	70.70	350	6	1E-06	200	15	25550	7.7E-05	0.00E+00	0.00E+00	0%	2190	9.0E-04	3.00E-04	3.0E+00	2%
Zinc	63900.00	350	6	1E-06	200	15	25550	7.0E-02	0.00E+00	0.00E+00	0%	2190	8.2E-01	3.00E-01	2.7E+00	2%
TOTAL										1.3E-04					1.3E+02	

SURFACE SOIL DERMAL CONTACT EXPOSURE ASSESSMENT
SITE 85-CAMP JOHNSON BATTERY DUMP
PRE-RI INVESTIGATION SCREENING STUDY CTO-0314
MCB CAMP LEJEUNE, NORTH CAROLINA
FUTURE RESIDENTIAL CHILD

Dermal contact with soil is calculated as follows:

Intake (mg/kg-day) = C * CF * SA * AF * Abs * EF * ED/BW * ATc or ATnc * DY

Risk = Intake * CSF or /RfD

Where:	INPUTS
C = contaminant concentration in soil (mg/kg)	
CF = conversion factor (kg/mg)	1E-06
SA = child exposed skin surface area (cm2)	2300
AF = soil to skin adherence factor (mg/cm2)	1
Abs = fraction absorbed (unitless)	Specific
EF = child exposure frequency (events/yr)	350
ED = child exposure duration (years)	6
BW = child body weight (kg)	15
ATc = averaging time for carcinogen (yr)	70
ATnc = averaging time for noncarcinogen (yr)	6
DY = day per year (day/yr)	365
CSF = cancer slope factor (mg/kg-day)-1	specific
RfD = reference dose (mg/kg-day)	specific

COPC	Concentration (mg/kg)	Conversion Factor (kg/mg)	Surface Area (cm2) Child	Adherence Factor (mg/cm2)	Fraction Absorbed (%)	Exposure Frequency (events/yr) Child	Exposure Duration (yrs) Child	Body Weight (kg) Child	Average Carc Time (days)	Carc Dose (mg/kg/day) Child	Dermal Adjust. Slope Factor (mg/kg-day)-1	Carcinogenic Risk Child	Percent Carcinogenic Risk Child	Average Noncarc Time (days)	Noncarc Dose (mg/kg/day) Child	Dermal Adjust. Reference Dose (mg/kg-day)	Noncarcinogenic Risk Child	Percent Noncarcinogenic Risk Child
Arsenic	76.80	1E-06	2300	1	0.001	350	6	15	25550	9.7E-07	7.5E+00	7.26E-06	100%	2190	1.1E-05	6.0E-05	1.9E-01	2%
Cadmium (soil)	47.10	1E-06	2300	1	0.001	350	6	15	25550	5.9E-07	0.0E+00	0.00E+00	0%	2190	6.9E-06	2.0E-04	3.5E-02	0%
Chromium	147.00	1E-06	2300	1	0.001	350	6	15	25550	1.9E-06	0.0E+00	0.00E+00	0%	2190	2.2E-05	1.0E-03	2.2E-02	0%
Copper	1870.00	1E-06	2300	1	0.001	350	6	15	25550	2.4E-05	0.0E+00	0.00E+00	0%	2190	2.7E-04	8.0E-03	3.4E-02	0%
Iron	339000.00	1E-06	2300	1	0.001	350	6	15	25550	4.3E-03	0.0E+00	0.00E+00	0%	2190	5.0E-02	6.0E-02	8.3E-01	11%
Lead	3030.00	1E-06	2300	1	0.001	350	6	15	25550	3.8E-05	0.0E+00	0.00E+00	0%	2190	4.5E-04	0.0E+00	0.0E+00	0%
Manganese	197000.00	1E-06	2300	1	0.001	350	6	15	25550	2.5E-03	0.0E+00	0.00E+00	0%	2190	2.9E-02	4.6E-03	6.3E+00	81%
Mercury	70.70	1E-06	2300	1	0.001	350	6	15	25550	8.9E-07	0.0E+00	0.00E+00	0%	2190	1.0E-05	6.0E-05	1.7E-01	2%
Zinc	63900.00	1E-06	2300	1	0.001	350	6	15	25550	8.1E-04	0.0E+00	0.00E+00	0%	2190	9.4E-03	6.0E-02	1.6E-01	2%
TOTAL												7.3E-06					7.7E+00	

SURFACE SOIL PARTICULATE INHALATION EXPOSURE ASSESSMENT
SITE 85-CAMP JOHNSON BATTERY DUMP
PRE-RI INVESTIGATION SCREENING STUDY CTO-0314
MCB CAMP LEJEUNE, NORTH CAROLINA
FUTURE RESIDENTIAL CHILD

Intake from the inhalation of particulates is calculated as follows:

Intake (mg/kg-day) = (C * EF * ED * IR * 1/PEF)/(BW * ATc or ATnc * DY)

Risk = Intake * CSF or /RfD

Where:	INPUTS
C = contaminant concentration in soil (mg/kg)	Calculated
CSF = carcinogenic slope factor	Specific
RfD = reference dose for noncarcinogen	Specific
IR = inhalation rate (m3)	15
EF = child exposure frequency (days)	350
ED = child exposure duration (years)	6
BW = child body weight (kg)	15
ATc = averaging time for carcinogen (yr)	70
ATnc = averaging time for noncarcinogen (yr)	6
DY = day per year (day/yr)	365
PEF = particulate emission factor (m3/kg)	1.32E+09

COPC	Concentration (mg/kg)	Particulate Emission Factor (m3/kg)	Exposure Frequency (events/yr)	Inhalation Rate (m3/day)	Exposure Duration (yrs)	Body Weight (kg)	Average Carc Time (days)	Carc Dose (mg/kg/day)	Slope Factor (mg/kg-day)-1	Carcinogenic Risk	Percent Contribution to Risk	Average Noncarc Time (days)	Noncarc Dose (mg/kg/day)	Reference Dose (mg/kg-day)	Noncarcinogenic Risk	Percent Noncarcinogenic Risk
Arsenic	76.80	1.3E+09	350	15	6	15	25550	4.8E-09	1.5E+01	7.2E-08	16%	2190	5.6E-08	0.0E+00	0.0E+00	0%
Cadmium (soil)	47.10	1.3E+09	350	15	6	15	25550	2.9E-09	0.0E+00	0.0E+00	0%	2190	3.4E-08	0.0E+00	0.0E+00	0%
Chromium	147.00	1.3E+09	350	15	6	15	25550	9.2E-09	4.2E+01	3.8E-07	84%	2190	1.1E-07	0.0E+00	0.0E+00	0%
Copper	1870.00	1.3E+09	350	15	6	15	25550	1.2E-07	0.0E+00	0.0E+00	0%	2190	1.4E-06	0.0E+00	0.0E+00	0%
Iron	339000.00	1.3E+09	350	15	6	15	25550	2.1E-05	0.0E+00	0.0E+00	0%	2190	2.5E-04	0.0E+00	0.0E+00	0%
Lead	3030.00	1.3E+09	350	15	6	15	25550	1.9E-07	0.0E+00	0.0E+00	0%	2190	2.2E-06	0.0E+00	0.0E+00	0%
Manganese	197000.00	1.3E+09	350	15	6	15	25550	1.2E-05	0.0E+00	0.0E+00	0%	2190	1.4E-04	1.4E-05	1.0E+01	100%
Mercury	70.70	1.3E+09	350	15	6	15	25550	4.4E-09	0.0E+00	0.0E+00	0%	2190	5.1E-08	8.6E-05	6.0E-04	0%
Zinc	63900.00	1.3E+09	350	15	6	15	25550	4.0E-06	0.0E+00	0.0E+00	0%	2190	4.6E-05	0.0E+00	0.0E+00	0%
TOTAL										4.6E-07					1.0E+01	

GROUNDWATER INGESTION EXPOSURE ASSESSMENT
SITE 85-CAMP JOHNSON BATTERY DUMP
PRE-RI INVESTIGATION SCREENING STUDY CTO-0314
MCB CAMP LEJEUNE, NORTH CAROLINA
FUTURE RESIDENTIAL CHILD

Intake from drinking water is calculated as follows:

Intake (mg/kg-day) = C * IRw * EF * ED/BW * AT or ATnc * DY

Risk = Intake * CSF or /RfD

Where:	INPUTS
C = contaminant concentration in water (mg/l)	
IRw = child daily water ingestion rate (L/Day)	1
EF = child exposure frequency (days/yr)	350
ED = child exposure duration (yr)	6
BW = child body weight (kg)	15
ATc = averaging time for carcinogen (yr)	70
ATnc = averaging time for noncarcinogen (yr)	6
DY = days per year (day/year)	365
CSF = cancer slope factor (mg/kg-day)-1	specific
RfD = reference dose (mg/kg-day)	specific

COPC	Concentration Carcinogen (mg/l)	Ingestion Rate (L/day) Child	Exposure Frequency (day/year) Child	Exposure Duration (year) Child	Body Weight (kg) Child	Average Carc Time (days)	Carc Dose (mg/kg-day) Child	Slope Factor (mg/kg-day)-1	Carcinogenic Risk Child	Percent Carcinogenic Risk Child	Average Noncarc Time (days)	Noncarc Dose (mg/kg-day) Child	Reference Dose (mg/kg-day)	Noncarcinogenic Risk Child	Percent Noncarcinogenic Risk Child
Aluminum	429.000	1	350	6	15	25550	2.4E+00	0.0E+00	0.0E+00	0%	2190	2.7E+01	1.0E+00	2.7E+01	15%
Arsenic	0.020	1	350	6	15	25550	1.1E-04	1.5E+00	1.6E-04	100%	2190	1.3E-03	3.0E-04	4.3E+00	2%
Barium	0.548	1	350	6	15	25550	3.0E-03	0.0E+00	0.0E+00	0%	2190	3.5E-02	7.0E-02	5.0E-01	0%
Cadmium (water)	0.025	1	350	6	15	25550	1.3E-04	0.0E+00	0.0E+00	0%	2190	1.6E-03	5.0E-04	3.1E+00	2%
Chromium	0.821	1	350	6	15	25550	4.5E-03	0.0E+00	0.0E+00	0%	2190	5.2E-02	5.0E-03	1.0E+01	6%
Copper	0.173	1	350	6	15	25550	9.5E-04	0.0E+00	0.0E+00	0%	2190	1.1E-02	4.0E-02	2.8E-01	0%
Iron	498.000	1	350	6	15	25550	2.7E+00	0.0E+00	0.0E+00	0%	2190	3.2E+01	3.0E-01	1.1E+02	59%
Lead	0.512	1	350	6	15	25550	2.8E-03	0.0E+00	0.0E+00	0%	2190	3.3E-02	0.0E+00	0.0E+00	0%
Manganese	1.270	1	350	6	15	25550	7.0E-03	0.0E+00	0.0E+00	0%	2190	8.1E-02	2.3E-02	3.5E+00	2%
Mercury	0.002	1	350	6	15	25550	1.3E-05	0.0E+00	0.0E+00	0%	2190	1.5E-04	3.0E-04	5.1E-01	0%
Nickel	4.550	1	350	6	15	25550	2.5E-02	0.0E+00	0.0E+00	0%	2190	2.9E-01	2.0E-02	1.5E+01	8%
Vanadium	0.908	1	350	6	15	25550	5.0E-03	0.0E+00	0.0E+00	0%	2190	5.8E-02	7.0E-03	8.3E+00	5%
Zinc	3.970	1	350	6	15	25550	2.2E-02	0.0E+00	0.0E+00	0%	2190	2.5E-01	3.0E-01	8.5E-01	0%
TOTAL									1.6E-04					179.9	

GROUNDWATER DERMAL CONTACT EXPOSURE ASSESSMENT
SITE 85-CAMP JOHNSON BATTERY DUMP
PRE-RI INVESTIGATION SCREENING STUDY CTO-0314
MCB CAMP LEJEUNE, NORTH CAROLINA
FUTURE RESIDENTIAL CHILD

Dermal Contact from groundwater is calcuated as follows:

*Intake (mg/kg-day) = CW * SA * PC * ET * EF * ED * CF/BW * ATc or ATnc * DY*

Risk = Intake * CSF or /RfD

Where:	INPUTS
CW = contaminant concentration in water (mg/l)	
SA = child skin surface available for contact (cm2)	10000
PC = contaminant specific dermal permability (cm/hr)	Specific
ET = child exposure time (hours/day)	0.25
EF = child exposure frequency (days/yr)	350
ED = child exposure duration (years)	6
CF = volumetric conversion factor for water (1liter/1000 cm3)	0.001
BW = child body weight (kg)	15
ATc = averaging time for carcinogen (yr)	70
ATnc = averaging time for noncarcinogen (yr)	6
DY = days per year (days)	365

COPC	Concentration Carcinogen (mg/l)	Surface Area (cm2) Child	Dermal Permeability (cm/hr)	Exposure Time (hours/day) Child	Exposure Frequency (days/yr) Child	Exposure Duration (years) Child	Volumetric Conversion (L/m3)	Body Weight (kg) Child	Averaging Carc Time (days)	Carc Dose (mg/kg-day) Child	Dermal Adjust. Slope Factor (mg/kg-day)-1	Carcinogenic Risk Child	Percent Carcinogenic Risk Child	Average Noncarc Time (days)	Noncarc Dose (mg/kg-day) Child	Dermal. Adjust. Reference Dose (mg/kg-day)	Noncarc Risk Child	Percent Noncarcinogeni Risk Child
Aluminum	429.000	10000	1.00E-03	0.25	350	6	0.001	15	25550	5.9E-03	0.0E+00	0.0E+00	0%	2190	6.9E-02	2.0E-01	3.4E-01	16%
Arsenic	0.020	10000	1.00E-03	0.25	350	6	0.001	15	25550	2.7E-07	7.5E+00	2.1E-06	100%	2190	3.2E-06	6.0E-05	5.3E-02	3%
Barium	0.548	10000	1.00E-03	0.25	350	6	0.001	15	25550	7.5E-06	0.0E+00	0.0E+00	0%	2190	8.8E-05	1.4E-02	6.3E-03	0%
Cadmium (water)	0.025	10000	1.00E-03	0.25	350	6	0.001	15	25550	3.4E-07	0.0E+00	0.0E+00	0%	2190	3.9E-06	1.0E-04	3.9E-02	2%
Chromium	0.821	10000	1.00E-03	0.25	350	6	0.001	15	25550	1.1E-05	0.0E+00	0.0E+00	0%	2190	1.3E-04	1.0E-03	1.3E-01	6%
Copper	0.173	10000	1.00E-03	0.25	350	6	0.001	15	25550	2.4E-06	0.0E+00	0.0E+00	0%	2190	2.8E-05	8.0E-03	3.5E-03	0%
Iron	498.000	10000	1.00E-03	0.25	350	6	0.001	15	25550	6.8E-03	0.0E+00	0.0E+00	0%	2190	8.0E-02	6.0E-02	1.3E+00	64%
Lead	0.512	10000	4.00E-06	0.25	350	6	0.001	15	25550	2.8E-08	0.0E+00	0.0E+00	0%	2190	3.3E-07	0.0E+00	0.0E+00	0%
Manganese	1.270	10000	1.00E-03	0.25	350	6	0.001	15	25550	1.7E-05	0.0E+00	0.0E+00	0%	2190	2.0E-04	4.6E-03	4.4E-02	2%
Mercury	0.002	10000	1.00E-03	0.25	350	6	0.001	15	25550	3.3E-08	0.0E+00	0.0E+00	0%	2190	3.8E-07	6.0E-05	6.4E-03	0%
Nickel	4.550	10000	1.00E-04	0.25	350	6	0.001	15	25550	6.2E-06	0.0E+00	0.0E+00	0%	2190	7.3E-05	4.0E-03	1.8E-02	1%
Vanadium	0.908	10000	1.00E-03	0.25	350	6	0.001	15	25550	1.2E-05	0.0E+00	0.0E+00	0%	2190	1.5E-04	1.4E-03	1.0E-01	5%
Zinc	3.970	10000	6.00E-04	0.25	350	6	0.001	15	25550	3.3E-05	0.0E+00	0.0E+00	0%	2190	3.8E-04	6.0E-02	6.3E-03	0%
TOTAL												2.1E-06					2.1E+00	

SURFACE SOIL INGESTION EXPOSURE ASSESSMENT
SITE 85-CAMP JOHNSON BATTERY DUMP
PRE-RI INVESTIGATION SCREENING STUDY CTO-0314
MCB CAMP LEJEUNE, NORTH CAROLINA
CURRENT MILITARY PERSONNEL

Intake from ingestion of soil is calculated as follows:

Intake (mg/kg-day) = C * CF * EF * ED * IR/BW * ATc or ATnc * DY

Risk = Intake * CSF or /RfD

Where:	INPUTS
C = contaminant concentration in soil (mg/kg)	
CF = conversion for kg to mg	1E-06
EF = adult exposure frequency (days/yr)	250
ED = adult exposure duration (yr)	4
IR = adult soil ingestion rate (mg/day)	100
BW = adult body weight (kg)	70
ATc = averaging time for carcinogen (yr)	70
ATnc = averaging time for noncarcinogen (yr)	4
DY = days per year (days/year)	365
CSF = cancer slope factor (mg/kg-day)-1	specific
RfD = reference dose (mg/kg-day)	specific

COPC	Concentration Carcinogen (mg/kg)	Exposure Frequency (days/yr) Adult	Exposure Duration (yr) Adult	Conversio Factor (kg/mg)	Ingestion Rate (mg/day) Adult	Body Weight (kg) Adult	Average Carc Tim (days)	Carc Dose (mg/kg/day) Adult	Slope Factor (mg/kg/day)-1	Carcinogenic Risk Adult	Percent Carcinogenic Risk Adult	Average Noncarc Time (days)	Noncarc Dose (mg/kg/day) Adult	Reference Dose (mg/kg/day)	Noncarcinogenic Risk Adult	Percent Noncarcinogenic Risk Adult
Arsenic	76.80	250	4	1E-06	100	70	25550	4.3E-06	1.5E+00	6.44E-06	100%	1460	7.5E-05	3.0E-04	2.50E-01	2%
Cadmium (soil)	47.10	250	4	1E-06	100	70	25550	2.6E-06	0.0E+00	0.00E+00	0%	1460	4.6E-05	1.0E-03	4.61E-02	0%
Chromium	147.00	250	4	1E-06	100	70	25550	8.2E-06	0.0E+00	0.00E+00	0%	1460	1.4E-04	5.0E-03	2.88E-02	0%
Copper	1870.00	250	4	1E-06	100	70	25550	1.0E-04	0.0E+00	0.00E+00	0%	1460	1.8E-03	4.0E-02	4.57E-02	0%
Iron	339000.00	250	4	1E-06	100	70	25550	1.9E-02	0.0E+00	0.00E+00	0%	1460	3.3E-01	3.0E-01	1.11E+00	11%
Lead	3030.00	250	4	1E-06	100	70	25550	1.7E-04	0.0E+00	0.00E+00	0%	1460	3.0E-03	0.0E+00	0.00E+00	0%
Manganese	197000.00	250	4	1E-06	100	70	25550	1.1E-02	0.0E+00	0.00E+00	0%	1460	1.9E-01	2.3E-02	8.38E+00	83%
Mercury	70.70	250	4	1E-06	100	70	25550	4.0E-06	0.0E+00	0.00E+00	0%	1460	6.9E-05	3.0E-04	2.31E-01	2%
Chromium	147.00	250	4	1E-06	100	70	25550	8.2E-06	0.0E+00	0.00E+00	0%	1460	1.4E-04	5.0E-03	2.88E-02	0%
TOTAL										6.4E-06					1.0E+01	

SURFACE SOIL DERMAL CONTACT EXPOSURE ASSESSMENT
SITE 85-CAMP JOHNSON BATTERY DUMP
PRE-RI INVESTIGATION SCREENING STUDY CTO-0314
MCB CAMP LEJEUNE, NORTH CAROLINA
CURRENT MILITARY PERSONNEL

Dermal contact with soil is calculated as follows:

Intake (mg/kg-day) = C * CF * SA * AF * Abs * EF * ED/BW * ATc or ATnc * DY

Risk = Intake * CSF or /RfD

Where:	INPUTS
C = contaminant concentration in soil (mg/kg)	
CF = conversion factor (kg/mg)	1E-06
SA = adult exposed skin surface area (cm2)	4300
AF = soil to skin adherence factor (mg/cm2)	1
Abs = fraction absorbed (unitless)	Specific
EF = adult exposure frequency (events/yr)	250
ED = adult exposure duration (years)	4
BW = adult body weight (kg)	70
ATc = averaging time for carcinogen (yr)	70
ATnc = averaging time for noncarcinogen (yr)	4
DY = day per year (day/yr)	365
CSF = cancer slope factor (mg/kg-day)-1	specific
RfD = reference dose (mg/kg-day)	specific

Note: Inputs are scenario and site specific

COPC	Concentration Carcinogen (mg/kg)	Conversion Factor (kg/mg)	Surface Area (cm2) Adult	Adherence Factor (mg/cm2)	Fraction Absorbed (%)	Exposure Frequency (events/yr) Adult	Exposure Duration (yrs) Adult	Body Weight (kg) Adult	Average Carc Time (days)	Carc Dose (mg/kg/day) Adult	Dermal Adjust Slope Factor (mg/kg-day)-1	Carcinogenic Risk Adult	Percent Carcinogenic Risk Adult	Average Noncarc Time (days)	Noncarc Dose (mg/kg/day) Adult	Dermal Adjust. Reference Dose (mg/kg-day)	Noncarcinogenic Risk Adult
Arsenic	76.80	1E-06	4300	1	0.001	250	4	70	25550	1.8E-07	7.50E+00	1.38E-06	100%	1460	3.2E-06	6.00E-05	5.39E-02
Cadmium (soil)	47.10	1E-06	4300	1	0.001	250	4	70	25550	1.1E-07	0.00E+00	0.00E+00	0%	1460	2.0E-06	2.00E-04	9.91E-03
Chromium	147.00	1E-06	4300	1	0.001	250	4	70	25550	3.5E-07	0.00E+00	0.00E+00	0%	1460	6.2E-06	1.00E-03	6.18E-03
Copper	1870.00	1E-06	4300	1	0.001	250	4	70	25550	4.5E-06	0.00E+00	0.00E+00	0%	1460	7.9E-05	8.00E-03	9.83E-03
Iron	339000.00	1E-06	4300	1	0.001	250	4	70	25550	8.2E-04	0.00E+00	0.00E+00	0%	1460	1.4E-02	6.00E-02	2.38E-01
Lead	3030.00	1E-06	4300	1	0.001	250	4	70	25550	7.3E-06	0.00E+00	0.00E+00	0%	1460	1.3E-04	0.00E+00	0.00E+00
Manganese	197000.00	1E-06	4300	1	0.001	250	4	70	25550	4.7E-04	0.00E+00	0.00E+00	0%	1460	8.3E-03	4.60E-03	1.80E+00
Mercury	70.70	1E-06	4300	1	0.001	250	4	70	25550	1.7E-07	0.00E+00	0.00E+00	0%	1460	3.0E-06	6.00E-05	4.96E-02
Zinc	63900.00	1E-06	4300	1	0.001	250	4	70	25550	1.5E-04	0.00E+00	0.00E+00	0%	1460	2.7E-03	6.00E-02	4.48E-02
TOTAL												1.4E-06					2.2E+00

SURFACE SOIL PARTICULATE INHALATION EXPOSURE ASSESSMENT
SITE 85-CAMP JOHNSON BATTERY DUMP
PRE-RI INVESTIGATION SCREENING STUDY CTO-0314
MCB CAMP LEJEUNE, NORTH CAROLINA
CURRENT MILITARY PERSONNEL

Intake from the inhalation of particulates is calculated as follows:

Intake (mg/kg-day) = (C * EF * ED * IR * 1/PEF)/(BW * ATc or ATnc * DY)

Risk = Intake * CSF or /RfD

Where:	INPUTS
C = contaminant concentration in soil (mg/kg)	Calculated
CSF = carcinogenic slope factor	Specific
RfD = reference dose for noncarcinogen	Specific
IR = inhalation rate (m3)	20
EF = adult exposure frequency (days)	250
ED = adult exposure duration (years)	4
BW = adult body weight (kg)	70
ATc = averaging time for carcinogen (yr)	70
ATnc = averaging time for noncarcinogen (yr)	4
DY = day per year (day/yr)	365
PEF = particulate emission factor (m3/kg)	1.32E+09

COPC	Concentration Carcinogen (mg/kg)	Particulate Emission Factor (m3/kg)	Exposure Frequency (events/yr)	Inhalation Rate (m3/day)	Exposure Duration (yrs)	Body Weight (kg)	Average Carc Tim (days)	Carc Dose (mg/kg/day)	Slope Factor (mg/kg-day)-1	Carcinogenic Risk	Percent Contribution to Risk	Average Noncarc Time (days)	Noncarc Dose (mg/kg/day)	Reference Dose (mg/kg-day)	Noncarcinogenic Risk	Percent Noncarcinogenic Risk
Arsenic	76.80	1.3E+09	250	20	4	70	25550	6.5E-10	1.5E+01	9.8E-09	16%	1460	1.1E-08	0.0E+00	0.0E+00	0%
Cadmium (soil)	47.10	1.3E+09	250	20	4	70	25550	4.0E-10	0.0E+00	0.0E+00	0%	1460	7.0E-09	0.0E+00	0.0E+00	0%
Chromium	147.00	1.3E+09	250	20	4	70	25550	1.2E-09	4.2E+01	5.2E-08	84%	1460	2.2E-08	0.0E+00	0.0E+00	0%
Copper	1870.00	1.3E+09	250	20	4	70	25550	1.6E-08	0.0E+00	0.0E+00	0%	1460	2.8E-07	0.0E+00	0.0E+00	0%
Iron	339000.00	1.3E+09	250	20	4	70	25550	2.9E-06	0.0E+00	0.0E+00	0%	1460	5.0E-05	0.0E+00	0.0E+00	0%
Lead	3030.00	1.3E+09	250	20	4	70	25550	2.6E-08	0.0E+00	0.0E+00	0%	1460	4.5E-07	0.0E+00	0.0E+00	0%
Manganese	197000.00	1.3E+09	250	20	4	70	25550	1.7E-06	0.0E+00	0.0E+00	0%	1460	2.9E-05	1.4E-05	2.0E+00	100%
Mercury	70.70	1.3E+09	250	20	4	70	25550	6.0E-10	0.0E+00	0.0E+00	0%	1460	1.0E-08	8.6E-05	1.2E-04	0%
Zinc	63900.00	1.3E+09	250	20	4	70	25550	5.4E-07	0.0E+00	0.0E+00	0%	1460	9.5E-06	0.0E+00	0.0E+00	0%
TOTAL										6.2E-08					2.0E+00	

SUBSURFACE SOIL INGESTION EXPOSURE ASSESSMENT
SITE 85-CAMP JOHNSON BATTERY DUMP
PRE-RI INVESTIGATION SCREENING STUDY CTO-0314
MCB CAMP LEJEUNE, NORTH CAROLINA
CURRENT MILITARY PERSONNEL

Intake from ingestion of soil is calculated as follows:

Intake (mg/kg-day) = C * CF * EF * ED * IR/BW * ATc or ATnc * DY

Risk = Intake * CSF or /RfD

Where:	INPUTS
C = contaminant concentration in soil (mg/kg)	
CF = conversion for kg to mg	1E-06
EF = adult exposure frequency (days/yr)	250
ED = adult exposure duration (yr)	4
IR = adult soil ingestion rate (mg/day)	100
BW = adult body weight (kg)	70
ATc = averaging time for carcinogen (yr)	70
ATnc = averaging time for noncarcinogen (yr)	4
DY = days per year (days/year)	365
CSF = cancer slope factor (mg/kg-day)-1	specific
RfD = reference dose (mg/kg-day)	specific

COPC	Concentration (mg/kg)	Exposure Frequency (days/yr) Adult	Exposure Duration (yr) Adult	Conversion Factor (kg/mg)	Ingestion Rate (mg/day) Adult	Body Weight (kg) Adult	Average Carc Time (days)	Carc Dose (mg/kg/day) Adult	Slope Factor (mg/kg/day)-1	Carcinogenic Risk Adult	Percent Carcinogenic Risk Adult	Average Noncarc Time (days)	Noncarc Dose (mg/kg/day) Adult	Reference Dose (mg/kg/day)	Noncarcinogenic Risk Adult	Percent Noncarcinogenic Risk Adult
Aluminum	10200.00	250	4	1E-06	100	70	25550	5.7E-04	0.0E+00	0.0E+00	0%	1460	1.0E-02	1.0E+00	1.0E-02	21%
Arsenic	2.41	250	4	1E-06	100	70	25550	1.3E-07	1.5E+00	2.0E-07	100%	1460	2.4E-06	3.0E-04	7.9E-03	16%
Iron	9176.27	250	4	1E-06	100	70	25550	5.1E-04	0.0E+00	0.0E+00	0%	1460	9.0E-03	3.0E-01	3.0E-02	63%
TOTAL										2.0E-07					4.8E-02	

SUBSURFACE SOIL DERMAL CONTACT EXPOSURE ASSESSMENT
SITE 85-CAMP JOHNSON BATTERY DUMP
PRE-RI INVESTIGATION SCREENING STUDY CTO-0314
MCB CAMP LEJEUNE, NORTH CAROLINA
CURRENT MILITARY PERSONNEL

Dermal contact with soil is calculated as follows:

Intake (mg/kg-day) = C * CF * SA * AF * Abs * EF * ED/BW * ATc or ATnc * DY

Risk = Intake * CSF or /RfD

Where:	INPUTS
C = contaminant concentration in soil (mg/kg)	
CF = conversion factor (kg/mg)	1E-06
SA = adult exposed skin surface area (cm2)	4300
AF = soil to skin adherence factor (mg/cm2)	1
Abs = fraction absorbed (unitless)	Specific
EF = adult exposure frequency (events/yr)	250
ED = adult exposure duration (years)	4
BW = adult body weight (kg)	70
ATc = averaging time for carcinogen (yr)	70
ATnc = averaging time for noncarcinogen (yr)	4
DY = day per year (day/yr)	365
CSF = cancer slope factor (mg/kg-day)-1	specific
RfD = reference dose (mg/kg-day)	specific

COPC	Concentration (mg/kg)	Conversion Factor (kg/mg)	Surface Area (cm2) Adult	Adherence Factor (mg/cm2)	Fraction Absorbed (%)	Exposure Frequency (events/yr) Adult	Exposure Duration (yrs) Adult	Body Weight (kg) Adult	Average Carc Time (days)	Carc Dose (mg/kg/day) Adult	Dermal Adjust. Slope Factor (mg/kg-day)-1	Carcinogenic Risk Adult	Percent Carcinogenic Risk Adult	Average Noncarc Time (days)	Noncarc Dose (mg/kg/day) Adult	Dermal Adjust. Reference Dose (mg/kg-day)	Noncarcinogenic Risk Adult	Percent Noncarcinogenic Risk Adult
Aluminum	10200.00	1E-06	4300	1	0.001	250	4	70	25550	2.5E-05	0.0E+00	0.0E+00	0%	1460	4.3E-04	2.0E-01	2.1E-03	21%
Arsenic	2.41	1E-06	4300	1	0.001	250	4	70	25550	5.8E-09	7.5E+00	4.3E-08	100%	1460	1.0E-07	6.0E-05	1.7E-03	16%
Iron	9176.27	1E-06	4300	1	0.001	250	4	70	25550	2.2E-05	0.0E+00	0.0E+00	0%	1460	3.9E-04	6.0E-02	6.4E-03	63%
TOTAL												4.3E-08					1.0E-02	

SUBSURFACE SOIL PARTICULATE INHALATION EXPOSURE ASSESSMENT
SITE 85-CAMP JOHNSON BATTERY DUMP
PRE-RI INVESTIGATION SCREENING STUDY CTO-0314
MCB CAMP LEJEUNE, NORTH CAROLINA
CURRENT MILITARY PERSONNEL

Intake from the inhalation of particulates is calculated as follows:

Intake (mg/kg-day) = (C * EF * ED * IR * 1/PEF)/(BW * ATc or ATnc * DY)

Risk = Intake * CSF or /RfD

Where:	INPUTS
C = contaminant concentration in soil (mg/kg)	Calculated
CSF = carcinogenic slope factor	Specific
RfD = reference dose for noncarcinogen	Specific
IR = inhalation rate (m3)	20
EF = adult exposure frequency (days)	250
ED = adult exposure duration (years)	4
BW = adult body weight (kg)	70
ATc = averaging time for carcinogen (yr)	70
ATnc = averaging time for noncarcinogen (yr)	4
DY = day per year (day/yr)	365
PEF = particulate emission factor (m3/kg)	1.32E+09

COPC	Concentration (mg/kg)	Particulate Emission Factor (m3/kg)	Exposure Frequency (events/yr)	Inhalation Rate (m3/day)	Exposure Duration (yrs)	Body Weight (kg)	Average Carc Time (days)	Carc Dose (mg/kg/day)	Slope Factor (mg/kg-day)-1	Carcinogenic Risk	Percent Contribution to Risk	Average Noncarc Time (days)	Noncarc Dose (mg/kg/day)	Reference Dose (mg/kg-day)	Noncarcinogenic Risk	Percent Noncarcinogenic Risk
Aluminum	10200.000	1.3E+09	250	20	4	70	25550	8.6E-08	0.0E+00	0.0E+00	0%	1460	1.5E-06	0.0E+00	0.0E+00	0%
Arsenic	2.410	1.3E+09	250	20	4	70	25550	2.0E-11	1.5E+01	3.1E-10	100%	1460	3.6E-10	0.0E+00	0.0E+00	0%
Iron	9176.270	1.3E+09	250	20	4	70	25550	7.8E-08	0.0E+00	0.0E+00	0%	1460	1.4E-06	0.0E+00	0.0E+00	0%
TOTAL										3.1E-10					0.0E+00	