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**FINAL**

**SWMU 360  
RCRA FACILITY INVESTIGATION REPORT**

**MCB CAMP LEJEUNE, NORTH CAROLINA**

**CONTRACT TASK ORDER 0143**

**OCTOBER 2005**

*Prepared for:*

**DEPARTMENT OF THE NAVY  
ATLANTIC DIVISION  
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Norfolk, Virginia**

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QC Review Page

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Final  
SWMU 360  
RCRA Facility Investigation Report  
MCB Camp Lejeune

Jacksonville, North Carolina

Contract Task Order Number - 041  
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*Prepared by*  
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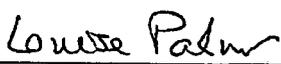
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## ACRONYMS AND ABBREVIATIONS

AOC	Area of Concern
ARAR	Applicable or Relevant and Appropriate Requirement
ATSDR	Agency for Toxic Substance and Disease Registry
Baker	Baker Environmental, Inc.
BCF	Bioconcentration Factor
bgs	below ground surface
Base	MCB Camp Lejeune, North Carolina
BERA	Baseline ERA
BHC	Hexachlorocyclohexane
C	Celsius
CaCO <sub>3</sub> /L	Calcium Carbonate per Liter
CDI	Chronic Daily Intake
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
cis-DCE	cis-1,2-Dichloroethene
CLEAN	Comprehensive Long-Term Environmental Action Navy
CLP	Contract Laboratory Program
CNO	Chief of Naval Operations
COC	Chain-of-Custody
COPC	Constituents of Potential Concern
CMS	Corrective Measures Study
CRAVE	Carcinogen Risk Assessment Verification Endeavor
CRDL	Contract Required Detection Limit
CRQL	Contract Required Quantitation Limit
CSF	Cancer Slope Factor
CSI	Confirmatory Sampling Investigation
CT	Central Tendency
CTO	Contract Task Order
DAD	Dermally-Absorbed Dose
1,1-DCE	1,1-Dichloroethene
4-4'-DDE	4,4'-Dichlorodiphenyldichloroethylene
4-4'-DDT	4,4'-Dichlorodiphenyltrichloroethane
DoN	Department of the Navy
DOT	United States Department of Transportation
EF	Exposure Frequency
ERA	Ecological Risk Assessment
ft/d	Feet per day
GC	Gas Chromatograph
GC/MS	Gas Chromatograph/Mass Spectrophotometer
gpm	Gallons Per Minute
gpd	Gallons Per Day
GPS	Global Positioning System

**ACRONYMS AND ABBREVIATIONS**  
**(Continued)**

HA	Health Advisories
HEAST	Health Effects Assessment Summary Table
HHRA	Human Health Risk Assessment
HI	Hazard Index
HQ	Hazard Quotient
HSWA	Hazardous and Solid Waste Amendments
ILCR	Incremental Lifetime Cancer Risk
IDW	Investigation Derived Waste
IMAC	Interim Maximum Allowable Concentrations
IR	Installation Restoration
IRIS	Integrated Risk Information System
$k_d$	distribution coefficient for solute with soil
KGS	Kansas Geological Society
$K_{oc}$	Organic Carbon Adsorption Coefficient
$K_{ow}$	Octanol/Water Partition Coefficient
MCAS	Marine Corps Air Station
MCB	Marine Corps Base
MCL	Maximum Contaminant Levels
MCLG	Maximum Contaminant Levels Goals
MDL	Maximum Detection Limit
$mg/m^3$	milligram per cubic meter
$mg/kg$	Milligram per Kilogram
MI	Mobility Index
mL	milliliters
MS	Matrix Spike
MSD	Matrix Spike Duplicate
msl	Mean Sea Level
NAPL	Non-aqueous Phase Liquid
NCAC	North Carolina Administrative Code
NC DENR	North Carolina Department of Environment and Natural Resources
NCEA	National Center for Environmental Assessment
NCWQS	North Carolina Water Quality Standards for Groundwater
NEESA	Naval Energy and Environmental Support Activity
OD	Outside Diameter
OEPA	Ohio Environmental Protection Agency
OSWER	Office of Solid Waste and Emergency Response
PAH	Poly-Aromatic Hydrocarbon
PCE	Tetrachloroethene
PE	Polyethylene
PEF	Particulate Emission Factor
PID	Photo Ionization Detector
PRGs	Preliminary Remediation Goals
PVC	Polyvinyl Chloride

**ACRONYMS AND ABBREVIATIONS**  
**(Continued)**

QA	Quality Assurance
QAPP	Quality Assurance Project Plans
QC	Quality Control
RAC	Remedial Action Contractor
RAGS	Risk Assessment Guidance for Superfund
RBC	Risk-Based Concentration
RCRA	Resource Conservation and Recovery Act
RfC	Reference Concentration
RfD	Reference Dose
RFA	RCRA Facility Assessment
RFI	RCRA Facility Investigation
RME	Reasonable Maximum Exposure
RPD	Relative Percent Difference
S	Water Solubility
SAF	Skin Adherence Factor
SLERA	Screening Level Ecological Risk Assessment
SOP	Standard Operating Procedure
SQL	Sample Quantitation Level
STGC	Soil-to-Groundwater Concentrations
SVOC	Semi-Volatile Organic Compound
SWL	Static Water Level
SWMU	Solid Waste Management Unit
TAL	Target Analyte List
TCE	Trichloroethene
TCL	Target Compound List
TSD	Treatment, Storage, and Disposal (Facility)
TIC	Tentatively Identified Compound
trans-DCE	Trans-1,2-dichloroethene
UCL	Upper Confidence Limit
USGS	United States Geological Survey
USEPA	United States Environmental Protection Agency
UST	Underground Storage Tank
VKT	Vehicle Kilometers Traveled
VOC	Volatile Organic Compound
µg/L	Micrograms per Liter
µg/kg	Micrograms per Kilogram

## EXECUTIVE SUMMARY

This document presents the Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI) Report for Solid Waste Management Unit (SWMU) 360 at Marine Corps Base (MCB) Camp Lejeune, North Carolina (the Base). The primary goal of this RFI is to determine the potential for future corrective action at SWMU 360 (if any) based on risk to human health and the environment. Specifically, the objectives of this RFI are as follows:

- Collect information to supplement and/or verify the environmental setting at the SWMU.
- Characterize the sources via the collection of analytical data, and evaluate the migration and dispersal characteristics of the waste.
- Characterize the hazardous constituents (if any) via the collection of groundwater and soil samples in the vicinity of the SWMU.
- Assess the risk of site contaminants to potential receptors in the vicinity of the SWMU.
- Evaluate potential receptors by collecting data describing human populations and environmental systems susceptible to contaminant exposure.
- Collect information to provide recommendations for site management.

The field program was conducted in conjunction with two other SWMUs (SWMU 311 and SWMU 43) and initiated June 2003 and completed in July 2003. The RFI objectives were met through a field program that consisted of soil borings, collection of surface and subsurface soil samples, groundwater sample collection via Geoprobe<sup>®</sup> Screen Point Sampler, and installation of permanent monitoring wells. Samples were analyzed by an onsite mobile laboratory for Volatile Organic Compounds (VOCs) and also submitted to a fixed-base laboratory for analysis of the other constituents of concern, including Semi-volatile Organic Compounds (SVOCs), pesticides and metals along with confirmatory samples for VOCs. Other physical parameters of soils, including grain size distribution and vertical permeability, were collected to support characterization of fate and transport properties.

Constituent concentrations in surface and subsurface soil are compared to four main criteria; USEPA Region IX preliminary remediation goals (PRGs), North Carolina Soil-to-Groundwater values (STGCs), AOC 7 background, and Base background concentrations. Constituent concentrations in groundwater are compared to three main criteria; North Carolina Groundwater Quality Standards (2L Standards), USEPA Region III Tap Water Risk-Based Concentrations (RBCs), and base-wide background concentrations.

Previous investigations gave an indication of organic and inorganic contamination in subsurface soil and groundwater. Constituents of potential concern (COPCs) in subsurface soils included dieldrin, arsenic, Bromoform, methylene chloride, and Tetrachloroethylene (PCE). COPCs in groundwater included Aldrin, alpha-hexachlorocyclohexane (alpha-BHC), beta-BHC, alpha-chlordane, gamma-chlordane, 4,4'-dichlorodiphenyldichloroethylene (4,4'-DDE), 4,4'-dichlorodiphenyltrichloroethane (4,4'-DDT), heptachlor, heptachlor epoxide, 4-methylphenol, acetophenone, cis-1,2-dichloroethylene, PCE and trichloroethylene (TCE). In light of the new RFI data, only some of these COPCs were confirmed during this investigation.

Based on the RFI, subsurface soil contamination of PCE is evident at the SWMU. The soil contamination is limited to the area in the northeast corner of the compound associated to Building 1817. This contamination may be another potential source area for the groundwater contamination at SWMU 360. The extent of the soil contamination is defined and should be considered conservative, based on the sample distribution.

Pesticides and SVOC contamination found in the Phase II Confirmatory Sampling Investigation (CSI) in groundwater was not confirmed in this RFI. Evidence suggests that this contamination is isolated or anomalous based on the findings of this RFI. The detections during the Phase II CSI may have been a result of turbidity during the sampling of the temporary wells.

PCE and TCE were detected in groundwater samples collected around SWMU 360. Groundwater sampling during this RFI has defined the horizontal side gradient directions of this plume (southwest and northeast). However, the down gradient, up gradient, and the vertical extent of groundwater contamination has not been defined. Analytical data provides evidence of a separate groundwater plume and up gradient source of TCE contamination in groundwater and another small area of groundwater contamination (PCE) in the communications compound located to the south of SWMU 360.

The Human Health Risk Assessment (HHRA) indicates that detections of PCE, TCE and heptachlor epoxide in groundwater exhibit a risk to human health for future adult and child residents. This risk is based on the accidental contact with groundwater and the fact that the Base may become a future residential area. The ecological risk assessment determined that risk is not likely at the SWMU based on a negligible terrestrial habitat that does not warrant ecological evaluation and the fact that no aquatic habitat is present on or near the study area.

Because the extent of groundwater contamination has not been adequately defined, it is recommended that additional groundwater grab samples be collected and additional monitoring wells be installed to more adequately define the horizontal and vertical extent of contamination. Also, a Corrective Measures Study (CMS) is recommended at SWMU 360 to mitigate the human health risk associated with contamination at the SWMU. In conjunction with the CMS, it is recommended that the human health risks be further defined in subsequent steps of the HHRA process.

## 1.0 INTRODUCTION

This document presents the Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI) Report for Solid Waste Management Unit (SWMU) 360 at Marine Corps Base (MCB) Camp Lejeune, North Carolina (the Base)(Figure 1-1). This document has been prepared by Baker Environmental, Inc. (Baker) under Contract Task Order (CTO) 0143 of the Department of the Navy's (DoN's) Comprehensive Long-Term Environmental Action Navy (CLEAN) Program. Baker is subcontracted to CH2M Hill for implementation of this project.

The Base was issued a RCRA Part B Permit to operate a hazardous waste container storage facility in September 1984. This permit was issued before the enactment of the Hazardous and Solid Waste Amendments of 1984 (HSWA), which under Section 3004(u) empowers the United States Environmental Protection Agency (USEPA) to order corrective action at treatment, storage, and disposal (TSD) facilities. This section of the HSWA requires corrective action to be taken for all releases of hazardous waste or hazardous constituents from any SWMU. As a result, a revised Hazardous Waste Management Permit was issued on January 10, 1997 and included corrective actions for SWMUs.

The USEPA Region IV and the North Carolina Department of Environment and Natural Resources (NC DENR) conducted an initial RCRA Facility Assessment (RFA) at the Base in January 1989. The RFA included 76 SWMUs. Seven of the SWMUs required confirmatory sampling; 23 of the SWMUs required an RFI; 46 of the SWMUs required no further action. The initial RFA was later expanded to include units such as landfills, surface impoundments, waste piles, tanks, container storage areas, septic tanks, drain fields, waste treatment units, and storm water conveyances. More than 3,500 SWMUs were identified during a preliminary review of Base records. Visual site inspections were conducted on nearly 500 of these SWMUs. The findings from the RFA are presented in the RCRA Facility Assessment Report for Marine Corps Base, Camp Lejeune, North Carolina (EnSafe, 1996).

The 1996 RFA Report identified 41 Installation Restoration (IR) sites, 112 underground storage tank (UST) sites, and 56 SWMUs that required confirmatory sampling or corrective measures. Based on further negotiations between NC DENR and the Base, 62 SWMUs required confirmatory sampling. The Confirmatory Sampling Investigation (CSI) was completed in two phases. Phase I was conducted by Baker in 1997 and included a soil investigation in the vicinity of these 62 SWMUs. Phase II was conducted by Baker in 2002 and included additional soil

sampling and a groundwater investigation at 41 of the SWMUs that warranted additional investigation at the conclusion of Phase I. In addition, six new SWMUs were included in the Phase II CSI thus increasing the number of SWMUs to 47. Of the 47 SWMUs, it was recommended that 29 SWMUs required no further action, five required additional confirmatory sampling, three required Interim Measures, two required additional confirmatory sampling/Interim Measures, and eight required RFIs. The findings from the Phase I and II CSIs are presented in the reports titled Revised Final Phase I Confirmatory Sampling Report (Baker, 2001) and Draft Phase II Confirmatory Sampling Report (Baker, 2002).

### **1.1 Purpose/Objectives**

The primary goal of this RFI was to determine the need for future corrective action at SWMU 360 (if any) based on risk to human health and the environment. Specifically, the objectives of this RFI were as follows:

- Collect information to supplement and/or verify the environmental setting at the SWMU including hydrogeology, geology, hydrology, topography, aquifer characteristics, and any other man-made influences that may affect the hydrology or contaminant pathways at the site.
- Characterize the sources via the collection of analytical data, and evaluate the migration and dispersal characteristics of the waste.
- Characterize the hazardous constituents (if any) via the collection of groundwater, soil, surface water and sediment in the vicinity of the SWMU. Characterization will include definition of the extent, origin, direction and rate of movement of any contamination.
- Assess the risk of site contaminants to potential receptors in the vicinity of the SWMU.
- Evaluate potential receptors by collecting data describing human populations and environmental systems susceptible to contaminant exposure.
- Collect information to provide recommendations for site management.

## **1.2 Site Descriptions and History**

SWMU 360 was a former 300-gallon waste oil UST near Building 1817. The UST was removed in July of 1997 and confirmatory samples were collected (Clean East Associates, Inc, 1997). Additional sampling was completed in December 1997 (Catlin/Law Engineers and Scientists, 1997). Confirmatory samples confirmed that a petroleum release had occurred at the SWMU.

Building 1817 is located in the Hadnot Point Industrial Area between Duncan Street and "O" Street and one block northeast of McHugh Boulevard or the former Main Service Road (Figure 1-2). Two Marine Units are utilizing building 1817. The actual SWMU is located in the eastern portion of the compound, which is occupied by a Hazardous Materials Unit and is being used as a temporary staging area for batteries, refrigeration units and other used equipment prior to disposal and or reutilization. The entire compound is fenced in and has limited access. A new wash pad has been built near the area of the UST excavation and is utilized by the Marine Units occupying the facility.

## **1.3 Previous Investigations**

Results of the confirmatory sampling performed by Clean East Associates, Inc during the UST removal confirmed that a petroleum release had occurred (Clean East Associates, Inc, 1997). As a result, Catlin/Law Engineers and Scientists were contracted to perform a limited site assessment to verify the possible release of petroleum constituents. The limited site assessment was conducted in December 1997 and included installing a single well within the former UST excavation. Results of the sampling showed elevated concentrations of chlorinated compounds in the soil and groundwater (Catlin/Law Engineers and Scientists, 1997). Therefore, due to the nature of the contaminants identified, the site was removed from the UST program and included in the Phase II CSI under the RCRA program.

A Phase II CSI was conducted in March/April 2002 with the intention of further evaluation of potential impacts to soil and groundwater in the vicinity of the SWMU. The field investigation included surface and subsurface soil sampling at four temporary well borings, installation of four temporary wells, and groundwater sampling at the four temporary wells (Figures 1-3 and 1-4). The soil and groundwater samples were submitted to the laboratory and analyzed for VOCs, SVOCs, pesticides and metals. Based on evaluation of the results, VOCs, SVOCs, pesticides and metals were detected in soil and/or groundwater at concentrations exceeding the regulatory driven

screening criteria and established background/secondary criteria (Figures 1-3 and 1-4). Based on the results of the limited site assessment conducted by Catlin/Law Engineers and Scientists, and the Phase II CSI conducted by Baker, an RFI was recommended at SWMU 360.

The conclusion of Phase II CSI identified the following COPCs in soil:

- VOCs- bromoform, methylene chloride and tetrachloroethene
- Pesticides - dieldrin
- Metals- arsenic

The conclusion of Phase II CSI identified the following COPCs in groundwater:

- Volatile Organic Compounds (VOCs) - cis-1,2-dichloroethene, tetrachloroethene, and trichloroethene
- Semivolatile Organic Compounds (SVOCs) - 4-Methylphenol and acetophenone
- Pesticides - 4,4'-Dichlorodiphenyldichloroethylene (4,4'-DDE), 4,4'-Dichlorodiphenyltrichloroethane (4,4'-DDT), aldrin, alpha-chlordane, gamma-chlordane, heptachlor, heptachlor epoxide, alpha- Hexachlorocyclohexane (alpha-BHC) and beta-BHC



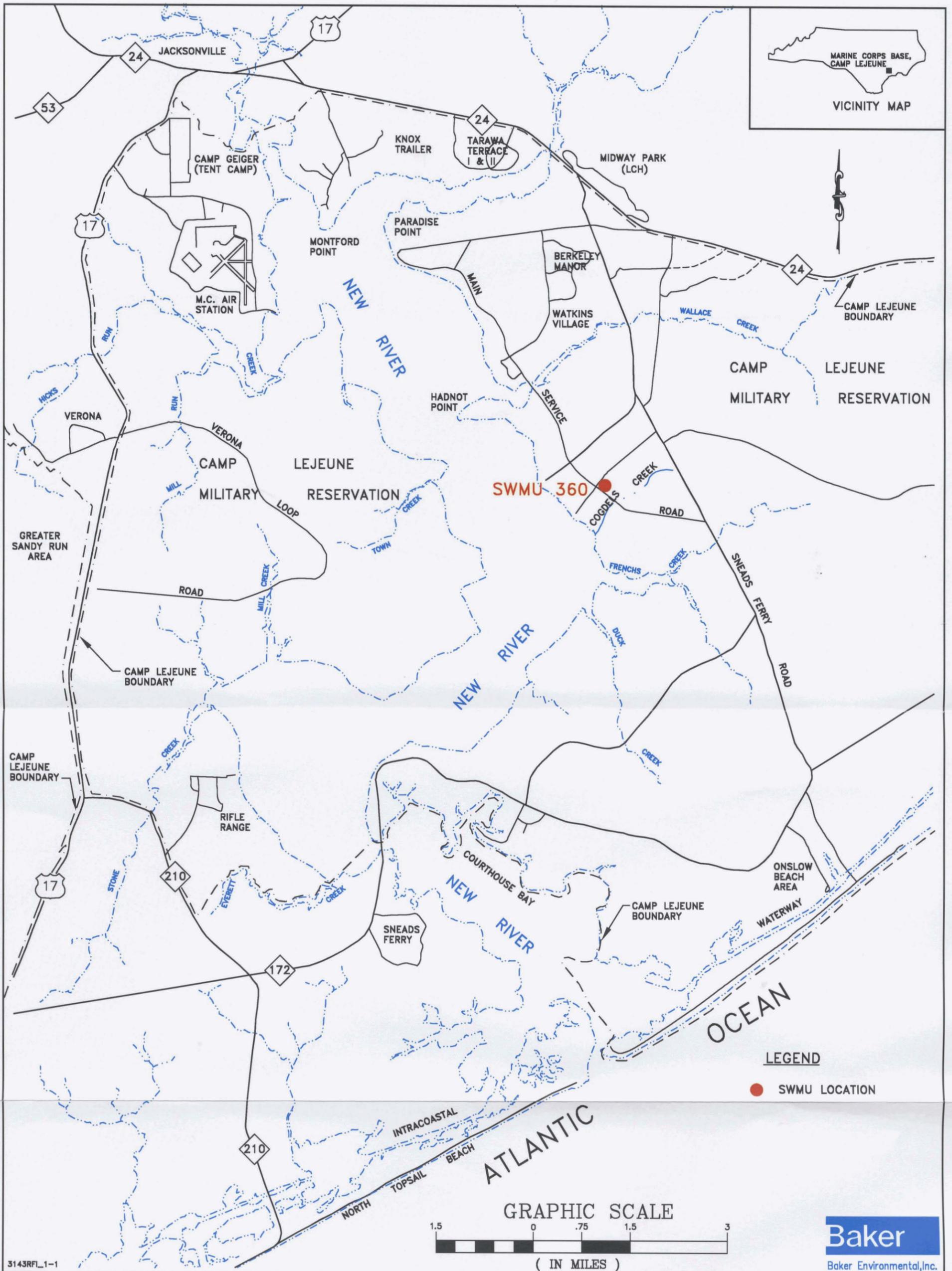
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**SECTION 1.0**

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***FIGURES***

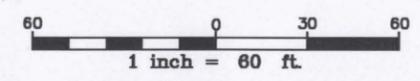
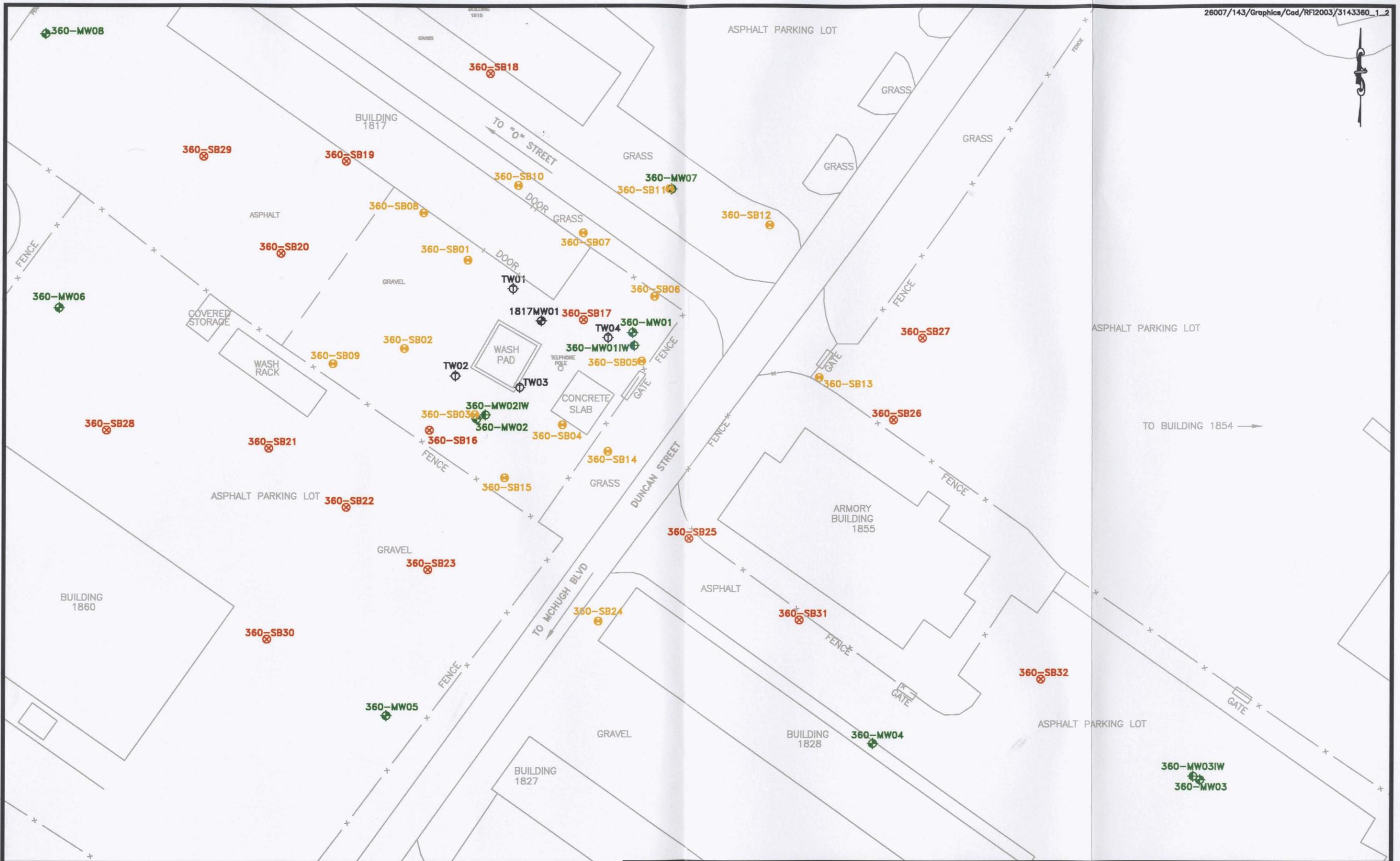


3143RFL\_1-1

FIGURE 1-1  
 SWMU LOCATION MAP - MCB CAMP LEJEUNE  
 RCRA FACILITY INVESTIGATION (RFI)  
 SWMU 360, CTO-0143

MARINE CORPS BASE, CAMP LEJEUNE  
 NORTH CAROLINA

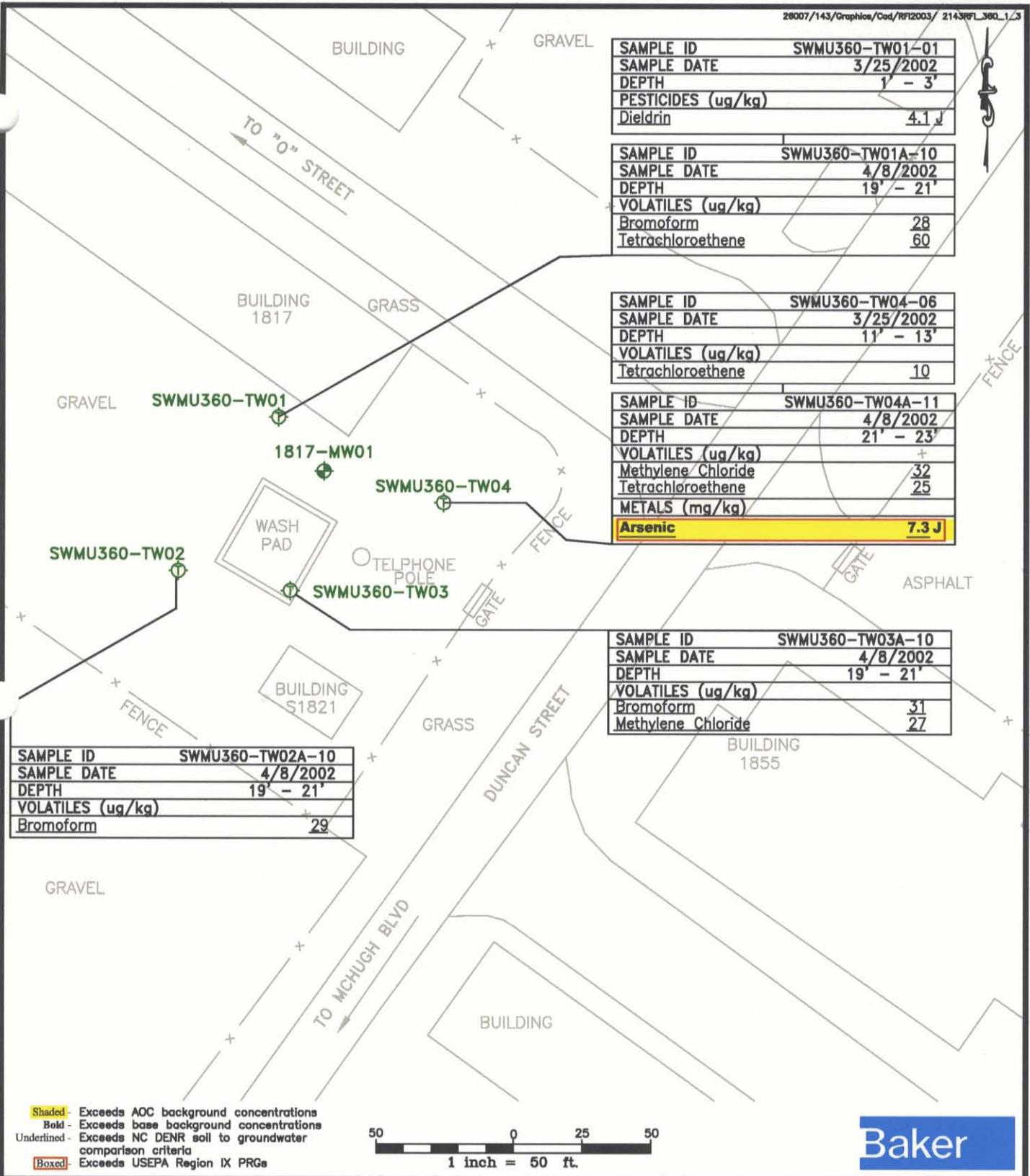
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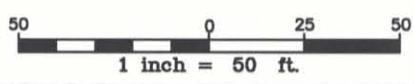
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- LEGEND**
- ⊕ - PHASE II TEMPORARY WELL
  - ⊙ - EXISTING MONITORING WELL
  - ⊕ - MONITORING WELL LOCATION
  - ⊕ - INTERMEDIATE MONITORING WELL LOCATION
  - ⊕ - SOIL BORING AND GROUND WATER GRAB LOCATION
  - ⊗ - GROUND WATER GRAB LOCATION
- SOURCE: MCB CAMP LEJEUNE MARCH 2000

**FIGURE 1-2**  
**CURRENT CONDITIONS MAP**  
**RCRA FACILITY INVESTIGATION**  
**SWMU 360, CTO-143**  
**MARINE CORPS BASE, CAMP LEJEUNE**  
**NORTH CAROLINA**



**Shaded** - Exceeds AOC background concentrations  
**Bold** - Exceeds base background concentrations  
Underlined - Exceeds NC DENR soil to groundwater comparison criteria  
**Boxed** - Exceeds USEPA Region IX PRGs

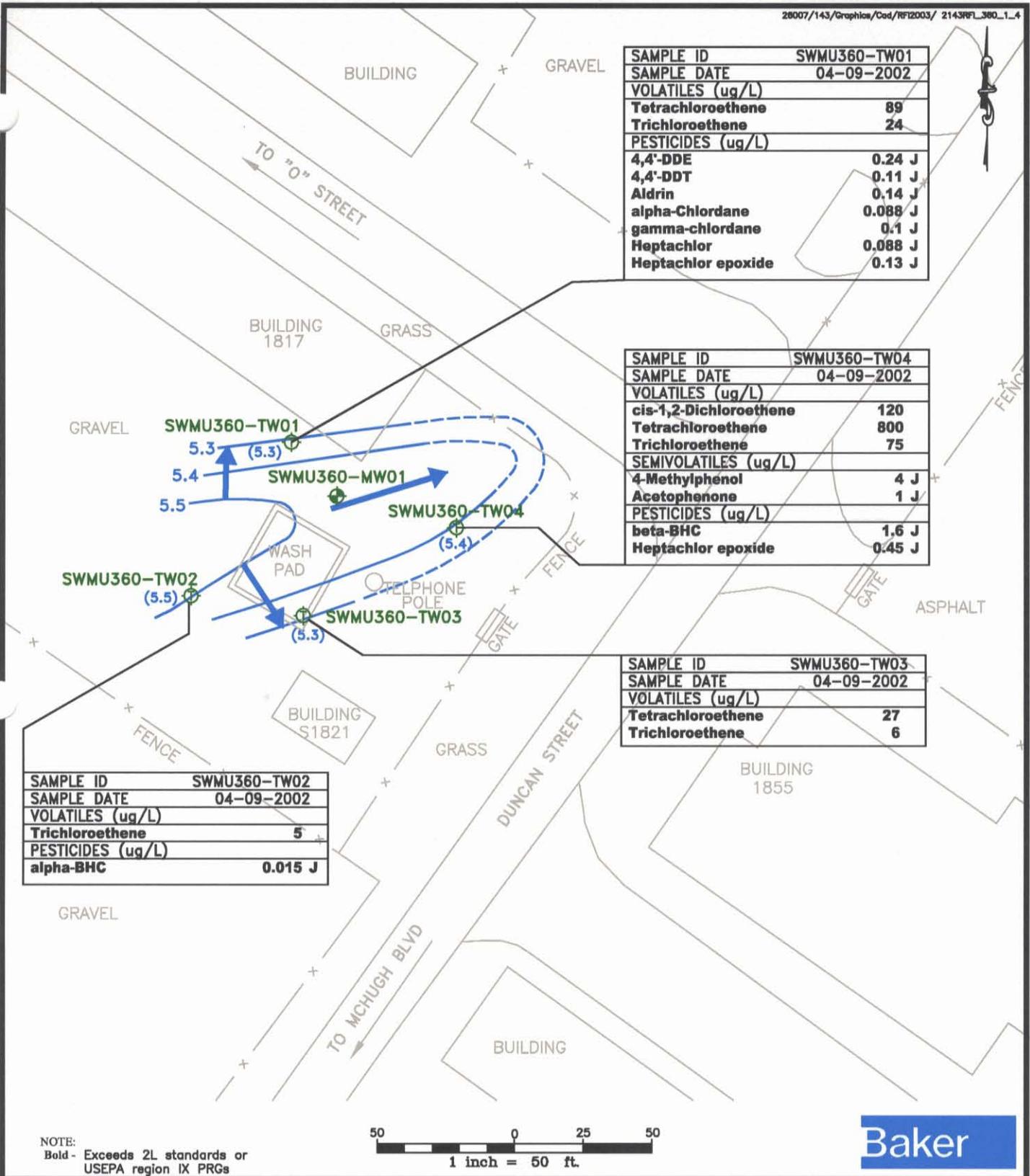


**LEGEND**

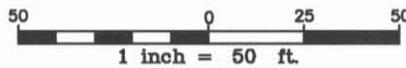
- ⊕ - TEMPORARY WELL
- ⊕ - MONITORING WELL SAMPLE

**FIGURE 1-3**  
**PHASE II CONFIRMATORY INVESTIGATION**  
**CONSTITUENTS EXCEEDING SCREENING**  
**CRITERIA IN SOIL**  
**SWMU 360**  
**CTO-143**  
**MARINE CORPS BASE, CAMP LEJEUNE**  
**NORTH CAROLINA**

SOURCE: MCB CAMP LEJEUNE MARCH 2000



NOTE:  
 Bold - Exceeds 2L standards or USEPA region IX PRGs



**LEGEND**

- TEMPORARY WELL
- MONITORING WELL SAMPLE
- GROUNDWATER FLOW DIRECTION
- GROUNDWATER CONTOUR

**FIGURE 1-4**  
 PHASE II CONFIRMATORY INVESTIGATION  
 CONSTITUENTS EXCEEDING SCREENING  
 CRITERIA IN GROUNDWATER  
 SWMU 360  
 CTO-143  
 MARINE CORPS BASE, CAMP LEJEUNE  
 NORTH CAROLINA

SOURCE: MCB CAMP LEJEUNE MARCH 2000

## **2.0 FIELD INVESTIGATION**

The field program for the RFI was initiated to collect samples for use in the evaluation of the nature of contamination in soil and groundwater identified in the CSI, delineate the extent of any contamination, and to collect the necessary information used to describe the environmental setting at the SWMU. These objectives were met by advancing soil borings, collecting surface and subsurface soil samples, installation of groundwater monitoring wells, groundwater profiling, groundwater sample collection, and a combination of on-site and off-site laboratory analysis. The sections that follow describe the methods used to collect and analyze the samples.

### **2.1 Soil Investigation**

Surface and subsurface soil samples were collected utilizing a tiered perimeter approach around SWMU 360 to determine if soil in the vicinity of the SWMU has been impacted during SWMU-related operations. Samples were collected from borings advanced by a direct-push soil sampler (i.e., Geoprobe) attached to a drill rig operated by Parrott Wolff, Inc. of Hillsboro, North Carolina. Samples collected during the soil investigation were analyzed for VOCs by a mobile lab operated on site by Vaportech Services, Inc. and/or Analytical Mobile Services, Inc. Split samples, SVOC, pesticide and metal samples were sent to Chemtech laboratory in Mountainside, New Jersey. Prior to sampling, utility clearance was completed at all locations by Locating Contractors, Inc. of Jacksonville, North Carolina. In cases where underground or overhead utilities were discovered in close proximity to proposed sample locations, the sample point was moved to a different location. The only location where a significant move was required was SWMU 360-SB13, which was moved approximately fifty feet northeast from the corner of the armory lot to inside the gate to the tank battalion.

The tiered perimeter approach was used as proposed in the Site Specific Work Plans (Baker, 2003). Seven "A-tier" Borings located closest to the former UST area were initially advanced, namely SWMU360-SB01 through SWMU360-SB07 (Figure 2-1). Mobile lab results indicted soil contamination above North Carolina soil to groundwater standards existed in borings SWMU360-SB04, SB05, SB06, and SB07. The contamination was observed in the majority of sample depths in these borings.

Therefore, soil borings SWMU360-SB08 through SWMU360-SB15 were subsequently installed as the "B-Tier" borings. After results were evaluated from the mobile lab, it was observed that soil contamination in the "B-Tier" borings was only detected at soil boring SWMU360-SB14 in one soil sample SWMU360-SB14-06. Therefore, soil contamination found at SWMU 360 was considered bounded and defined by the "B-tier" borings. Test Boring Records were prepared for each soil boring and are presented in Appendix A.

### **2.1.1 Surface and Subsurface Soils**

Surface soil samples were proposed at all "A and B-tier" soil boring locations; however, some borings were located on paved areas where surface soils were not present. Thus, surface soil samples were not collected at soil borings SB13 and SB14 located on paved areas. Surface soil samples were obtained using a new stainless steel spoon prior to advancement of the soil boring. A hole was dug to approximately 1-foot below ground surface (bgs). Soils collected for VOC analysis were collected using two distinctly different methods. For on-site analysis, an open-ended virgin plastic syringe was pushed in a selected area to obtain 7-milliliters (mL) of soil. The sample was then extruded into 3-mL of distilled/de-ionized water in one 20-mL glass vial. The vial was capped with a Teflon<sup>®</sup> lined lid, which was crimped in place. The vial was stored on ice until picked up by the mobile laboratory chemist or dropped off at the mobile laboratory (typically within four hours of collection). For off-site VOC analysis three Encore Samplers were pushed into the sidewall of the hole to obtain soils. Samples were collected in three 5-mL Encore Samplers following SW846 Method 5035. The Encore Samplers were then capped and put into the sealed Encore bags. For off-site analysis of Pesticides and RCRA metals, soil was shaved off the sidewall and homogenized in-situ. These samples were collected from the same general location that VOC samples were collected. Samples were collected using a stainless steel spoon or spatula and placed into one 8-ounce, laboratory-supplied sample container. To minimize the potential for cross-contamination, new stainless steel spoons and/or spatulas were used to handle each soil sample as it was removed from the hole and placed into the sample container(s). All samples were stored on ice in a cooler at temperatures below 4° Celsius (C) until shipped to the laboratory.

The subsurface soil samples were collected from each boring using a direct push sampler. A four foot long Geoprobe<sup>®</sup> Macro Core sampler was continuously driven from ground surface to the water table by a hydraulic drive assembly. The sampler was driven to desired depth and pulled from the hole. The sampler was disassembled and the Geoprobe<sup>®</sup> sleeve handed to the geologist for

logging. Measurements with a Photo Ionization Detector (PID) were collected every foot where possible. A small ¼-inch diameter hole was drilled into the Geoprobe® sleeve ½-foot below the top of sample and a PID measurement was recorded. This was repeated at 1-foot intervals over the length of the sample. Upon completion, the sleeve was cut open length-wise to reveal the soil profile. Samples for on-site and/or off-site analysis were collected from the acetate sleeves based on the location of the highest PID reading, in areas of observable staining, and/or utilizing geological judgment. One sample was collected from each 4-foot Geoprobe® sleeve for on-site analysis and three samples were collected per boring for off-site analysis (see Section 2.1.2). Subsurface soil samples were collected using the same procedures and techniques as surface soil sample collection described above except soil was obtained from the acetate sleeves instead of the open holes dug for the surface soils. Soils were logged noting relative grain size, color, moisture, evidence of contamination, and any other relevant properties following procedures outlined in Appendix A of the Master Project Plans (Baker 2003)(SOP F101 – Borehole and Sample Logging). Discarded soil was placed in five gallon buckets and later transferred to a roll-off box located on-site. The sampler was decontaminated following procedures outlined in Section 2.5 and reassembled prior to use. Borings not converted to temporary piezometers were backfilled with sodium bentonite. The surface was plugged with asphalt or other material similar to the existing surface. A summary of surface and subsurface soil samples collected is presented in Table 2-1.

### **2.1.2 Analytical Program for Soils**

One sample per Geoprobe® sleeve (approximately five subsurface soil samples per boring) were collected for mobile laboratory analysis of VOCs and one sample was collected from each boring for off-site analysis of VOCs at a fixed-based laboratory. Three different analytical methods were used for VOCs. Mobile lab analysis consisted of either a headspace gas chromatograph (GC) method or a gas chromatograph/mass spectrophotometer (GC/MS) (8260B) method. The fixed-based method was Target Compound List (TCL) VOCs (OLMO 4.2). Three samples were collected per boring for fixed-based laboratory analysis of pesticides and RCRA metals. The fixed-based laboratory methods included TCL pesticides (OLMO 4.2) and RCRA metals (OLMO 4.1). The samples were selected based on field observations (e.g., elevated PID readings, discoloration, etc.). The mobile laboratory analysis included benzene, tetrachloroethene (PCE), trichloroethene (TCE), cis-1,2-dichloroethene (cis-DCE), trans-1,2-dichloroethene (trans-DCE), methylene chloride, and 1,1-dichloroethene (1,1-DCE) using a gas chromatograph head space method.

All soil samples retained for analysis were prepared and handled according to USEPA Region IV Standard Operating Procedures (SOPs) as outlined in the Master Project Plans (Baker, 2003). Chain-of-Custody (COC) documentation, which included information such as sample numbers, date, time of sampling, and sampling party accompanied the samples to the laboratory and is provided in Appendix B. Samples were shipped via overnight courier to Chemtech laboratory in Mountainside, New Jersey for analysis.

## **2.2 Groundwater Investigation**

The groundwater investigation at SWMU 360 consisted of the installation of 6 piezometers, groundwater grab sampling using Geoprobe® tools, and the installation/sampling of 11 monitoring wells. Groundwater samples were collected utilizing a tiered perimeter approach around SWMU 360 to determine if groundwater in the vicinity of the SWMU has been impacted during SWMU-related operations. Samples were collected utilizing a Geoprobe® SP-15 discrete sampler (i.e., Geoprobe) attached to a drill rig. The sections that follow describe the methods used to collect and analyze the samples.

### **2.2.1 Piezometer Installation and Groundwater Level Measurements**

Six piezometers were installed at SWMU 360 on July 7, 2003 to determine groundwater flow direction in the surficial aquifer. These piezometers were installed adjacent to soil borings SWMU360-SB05, SWMU360-SB07, SWMU360-SB08, SWMU360-SB09, SWMU360-SB12, and SWMU360-SB15. All piezometers were installed to a depth of 25-feet bgs, which was determined based on the previously logged soil borings. Each piezometer consisted of five feet of one-inch outside diameter (OD), Schedule 40 Polyvinyl Chloride (PVC) screen (0.01-inch manufactured slots) and 15 feet of one inch OD Schedule 40 PVC casing. Each piezometer was installed by driving two-inch OD steel casing with disposable steel drive tip to the desired depth. The piezometer screen and casing were assembled and installed in the open drive casing. As the drive casing was retracted from the ground, the formation was allowed to collapse around the screen annulus (or filter sand was placed around the screen annulus as required). Bentonite pellets were placed in the casing annulus to ground surface. Each piezometer was surveyed according to Section 2.3. (Static Water Level (STL) measurements were collected on July 8, 2003. The piezometers provided information regarding groundwater flow at SWMU 360, and helped to assess the placement of the additional sample locations needed for the delineation of the

groundwater contamination at the site. Table 2-2 presents piezometer construction details, and SWL measurements and corresponding elevations. A graphic representation of the piezometer installation is presented in Appendix A.

### **2.2.2 Groundwater Grab Sampling**

Groundwater grab samples were collected from both "A and B Tiers" soil boring locations which included SWMU360-SB01 through SWMU360-SB15 (Figure 2-1). Analytical results from the mobile lab showed elevated concentrations of chlorinated compounds in the groundwater samples collected from all "A and B Tier" borings except SWMU360-SB01, SB11 and SB12. The extent of contamination extended beyond the borings originally proposed at the SWMU. Therefore, subsequent borings SWMU360-SB16 through SWMU360-SB32 were installed to the east, west, and to the south creating "C, D and E Tiers" based on the same tiered perimeter approach. (see Figure 2-1). Contamination did not extend further to the north based on the results from SWMU360-SB11 and SB12.

After further review of the mobile lab results, it was apparent that groundwater contamination did exist at the SWMU. As a part of the objectives for this RFI, the extent of contamination would be defined. Therefore, groundwater samples collected at depth would be needed to delineate the vertical extent of contamination. It was decided that vertical "profiling" of groundwater would provide analytical data at depth in the aquifer and provide important information on the vertical extent of contamination. Vertical "profiling" would also provide data needed for the proper placement and construction of the groundwater monitoring wells. Boring locations that were selected for vertical profiling included SWMU360-SB02, SB05, SB11, SB13, SB16, SB17, SB21, SB22, SB23, SB28, SB29, SB30, SB31 and SB32.

The groundwater grab samples were collected using a Geoprobe® SP-15 discrete sampler. The sampler consists of a 1-1/2-inch OD stainless steel outer casing with a sliding 1-inch OD, 4-foot-long inner screen (stainless steel with 0.01-inch slots). A drive point is attached to the outer casing and driven to the desired depth using a Geoprobe® hammer. As the casing is retracted the drive point and screen stay in place, exposing the 4-foot screen to the aquifer. At SWMU 360, the Geoprobe® SP-15 discrete sampler was pushed to approximately 6 feet below the water table to collect groundwater samples. At locations where vertical groundwater "profiling" was required; the sampler was pushed down at two more discrete depths to collect deeper groundwater samples. Typical groundwater grab sample intervals from the profiled

locations at SWMU 360 included samples collected from 24 to 28 feet bgs, 30 to 34 feet bgs, and 36 to 40 feet bgs. Actual sample intervals for each location are presented in Table 2-1. Groundwater samples were retrieved using a peristaltic pump and dedicated silicone and polyethylene (PE) tubing for each sample. Groundwater was purged from the sampler for approximately five to ten minutes to obtain samples with reduced turbidity.

Groundwater samples were collected for on-site and/or off-site analysis of VOCs. For on-site analysis, 10-mL of groundwater was collected in one 20-mL vial. The vial was capped with a Teflon<sup>®</sup> lined lid, which was crimped on immediately after sample collection. The vial was stored on ice until picked by the mobile laboratory chemist or dropped off at the mobile laboratory (typically within four hours of collection). For off-site analysis, samples were collected in three 40-mL vials. Samples for off-site analysis were stored on ice in a cooler at a minimum temperature of 4°C until shipped to the laboratory. A summary of groundwater samples collected for on-site and/or off-site analysis is presented in Table 2-1.

### **2.2.3 Monitoring Well Installation and Sampling**

Eleven groundwater monitoring wells were installed at SWMU 360 (see Figure 2-1). The placement of these monitoring wells was based on the information gathered from the groundwater grab sampling conducted prior to well installation. The monitoring wells were installed and sampled using procedures outlined in the Site-Specific Work Plans (Baker 2003a). Specific well installation and low-flow sampling procedures are presented in the Master Project Plans.

The monitoring wells were installed at SWMU 360 for the following reasons:

- Sample points to help define extent of contamination
- Fixed-based analytical data to verify mobile lab data
- Sample collection for analyses of SVOCs, pesticides and RCRA metals
- Taking hydraulic conductivity measurements via slug testing
- Intermediate wells to assess deeper groundwater contamination

The eleven monitoring wells installed at SWMU 360 were placed strategically, based on the groundwater grab sampling, to provide the best information on the extent of contamination. Wells were placed in the source area, up gradient, side gradient and in the down gradient directions based on the groundwater flow results from the six piezometers installed at SWMU

360. Monitoring wells 360-MW08 and 360-MW06 were installed up gradient to evaluate any possible up gradient sources of contamination (if any). Monitoring well 360-MW05 was placed in the side gradient direction (south) to evaluate the extent of groundwater contamination in this direction. Monitoring well 360-MW07 was placed in the side gradient direction near 360-SB11 to confirm the mobile lab results and bound the extent of contamination to the north. Monitoring well clusters 360-MW01, MW01IW and 360-MW02, MW02IW were placed in and near the suspect source area to evaluate the impact in groundwater near the source and vertical extent of groundwater contamination. Monitoring well 360-MW04 and well cluster 360-MW03, MW03IW were installed in the down gradient direction to evaluate the migration and vertical extent of the contamination. See Figure 2-1 for the locations of these eleven groundwater monitoring wells. See Table 2-3 for well construction details.

One Shelby tube sample was collected from each of the soil borings associated with monitoring wells SWMU360-MW01IW, MW05 and MW06. Actual depths and lithologies of these samples are presented in Table 2-4. Data from these Shelby tube samples will be used to provide an indication of the ability of the Constituents of Potential Concern (COPCs) to percolate through the vadose zone and support development and evaluation of corrective measures. The Geotechnical Laboratory Report is presented in Appendix C.

All monitoring wells installed at SWMU 360 were developed prior to collecting groundwater samples. Well development records are presented in Appendix D.

#### **2.2.4 Analytical Program for Groundwater Samples**

One to three groundwater samples per boring were collected for mobile laboratory analysis of VOCs, including benzene, PCE, TCE, cis-DCE, trans-DCE, methylene chloride, and 1,1-DCE using a gas chromatograph head space method. It should be noted that a second mobile laboratory was utilized during the later part of the investigation at SWMU 360. This included all borings included in the "C, D and E Tiers". The second mobile laboratory used a GC/MS that would be the same as a fixed-based SW846 Method (8260B) for analysis of VOCs.

All groundwater samples collected from the groundwater monitoring wells were analyzed using a fixed based laboratory. Samples collected from these wells were analyzed for VOCs, pesticides and RCRA metals. Samples from three of the 11 monitoring wells (SWMU360-MW01, MW02 and MW07) were selected for SVOC analysis. During the Phase II CSI at SWMU 360,

two SVOCs (4-methylphenol and acetophenone) were detected above North Carolina 2L standards in SWMU360-TW04. These samples were collected to verify SVOC contamination (if any) at the SWMU.

All groundwater samples retained for analysis were prepared and handled according to USEPA Region IV SOPs as outlined in the Master Project Plans (Baker, 2003). COC documentation, which included information such as sample numbers, date, time of sampling, and sampling party accompanied the samples to the laboratory and is provided in Appendix B. Samples were shipped via overnight courier to Chemtech laboratory in Mountainside, New Jersey for analysis.

### **2.2.5 Slug Test Procedures**

Slug tests were conducted at all newly installed wells at SWMU 360 and the one existing well 1817 MW01 subsequent to groundwater sample collection. To provide better estimates of hydraulic conductivity using in-situ methods (i.e., slug tests), several steps were implemented in conducting the tests and analysis of the data. These steps were implemented per The Design, Performance and Analysis of Slug Tests (Butler, 1998) and Designing Slug Tests to Improve Estimates of Hydraulic Conductivity (Butler, 2002). For field procedures, the following steps were implemented:

- Starting the data logger prior to placement of slug to insure collection of data at the earliest possible times.
- Conducting multiple tests with two different sized slugs to test for the presence of a “well skin,” which is a fine-grained smear on the borehole created during drilling and not completely removed during development.
- Placement of transducer closer to the water level to remove possible data oscillations associated with highly conductive formations such as the River Bend.

For analysis of the test data, the following steps were performed:

- Compared the multiple test data sets on graph showing normalized displacements vs. time (logarithmic scale) to test for the presence of a well skin.

- Analyzed data using the Bouwer & Rice method at wells with no evidence well skin.
- Analyzed data using the Kansas Geological Society (KGS) method at wells with evidence of a well skin.
- Used the translation method when necessary (Butler, 1998) to eliminate early-time oscillations in the data set.
- Examined the hydraulic conductivity estimates in context of site lithology and other, historic hydraulic conductivity information (e.g., United States Geological Survey [USGS] studies and previous pumping test results).

Well development that is sufficient for groundwater sampling and hydraulic conductivity tests can be different. For groundwater sampling, communication with the aquifer can be established and low turbidity achieved through well development that does not completely remove the fine-grained well skin from the entire well screen interval. The assumption for hydraulic conductivity testing is that the fine-grained well skin is completely removed from the entire well screen interval. This well skin can affect hydraulic conductivity test results. Theoretically, the water level response is independent of the initial displacement. It has been demonstrated by Butler (Butler 1998) that the presence of a well skin will cause the water level to respond differently under different initial displacement conditions. To test for well skin, multiple test data are normalized and compared to each other on a single graph plotting normalized displacement verses time. If the test data sets exhibit similar, closely spaced curves then a well skin is negligible. If the test data sets exhibit dissimilar, widely spaced curves then a well skin is present and affecting the test. If a well skin is present additional development is required, or hydraulic conductivity test analysis can be performed using a solution that accounts for the effects of a well skin.

A summary hydraulic conductivity estimates is presented in Table 3-2. Slug test graphs and the analysis of well skin effects are presented in Appendix E.

### 2.3 Survey

The soil boring locations were surveyed using mapping-grade global positioning system (GPS) equipment operated by trained Baker personnel. The horizontal position of each soil boring was

determined within the North Carolina State Plane Coordinate System. The horizontal accuracy was within approximately three feet. Ground surface elevations of borings were estimated by:

- Survey of adjacent piezometers, or;
- Interpolated from ground surface contouring between known elevations (e.g., piezometers, CSI temporary wells and surveyed monitoring wells).

The temporary piezometers and monitoring wells were surveyed by a Lanier Surveying Company, PLLC licensed in the State of North Carolina for topographic elevation relative to mean sea level (msl) and horizontal position within the North Carolina State Plane Coordinate System. The vertical accuracy of the survey was within 0.01 feet and the horizontal accuracy was within 0.1 feet. It should be noted that the surveyor obtained an elevation from the top of PVC cap, rather than the top of PVC casing (reference point) for the piezometer locations. Baker personnel had to determine the difference between the top of PVC cap and PVC casing to determine a reference point elevation.

#### **2.4 Quality Assurance/Quality Control Samples**

Specific Quality Assurance/Quality Control (QA/QC) requirements are presented in the Master Quality Assurance Project Plans (QAPP), which is contained in the Master Project Plans (Baker 2003). The Master QAPP describes the different levels of sample analysis and the associated QC procedures required with each. Adherence to established USEPA COC procedures during the collection, transport, and analyses of the samples was maintained throughout the project. Laboratory analyses of the samples will conform to accepted QA requirements.

The following QA/QC samples were collected/prepared during the field activities to ensure precision, accuracy, representativeness, completeness, and comparability:

- Equipment rinsate blanks
- Field blanks
- Trip blanks
- Field duplicates
- Matrix Spike/Matrix Spike Duplicates (MS/MSDs)

Table 2-1 provides a summary of QA/QC samples collected, as well as sources of equipment rinsate and field blanks.

## **2.5 Decontamination Procedures**

Specific decontamination procedures are presented in the Master Project Plans (Baker 2003). These procedures were for reusable equipment. Sampling equipment for the RFI at SWMU 360 was generally disposable and not reused and included stainless steel spoons, Geoprobe® Macro Core acetate liners, polyethylene (PE) tubing, and silicone tubing. Reusable equipment included the Geoprobe® Macro Core drive shoe and casing and the SP-15 Groundwater Sampler. Between samples, this equipment was decontaminated by Alquinox® and potable water wash and potable water rinse. Between borings, this equipment was decontaminated by high-pressure steam cleaning.

## **2.6 Investigation Derived Waste**

Investigation derived waste (IDW) included those materials used in the normal course of field activities, including health and safety disposables and disposable sampling equipment. IDW also included materials generated from drilling and sampling activities (i.e., excess soil samples, purge water, and decontamination fluids).

Health and safety disposables generally included sampling gloves, paper towels, and plastic sheeting. Contact with contaminated soil and water was negligible. Health and safety disposables were placed in plastic bags and disposed in Baker's regular trash dumpster located by at Lot 203.

Soil cuttings were not generated during direct push drilling activities. Excess soil samples were minimal and temporarily containerized in United States Department of Transportation (DOT)-approved, 55-drum. The drums were clearly marked to indicate contents, the borehole from which the cuttings were removed, the date, CTO number, and the site. All soil IDW generated during RFI activities at SWMU 360 was combined into one roll-off box placed onsite.

Liquid IDW generated during decontamination, Geoprobe® SP-15 Groundwater Sampler purging and monitoring well development and sampling was combined into two 750 gallon poly tanks placed onsite.

All soil and liquid IDW generated during the RFI activities at SWMU 360 was sampled and disposed of by the Remedial Action Contractor (RAC) subcontractor on the Base (Shaw).

## **2.7 Data Management and Tracking**

Data management activities consisted of data tracking, database entry, and data manipulation. Data tracking followed samples from collection (based on COC forms) through entry of the sample analytical data into the database. The data manager checked that the off-site laboratory received and processed all samples within the required holding times. The data manager also checked that the resultant analytical data (in electronic and hard copy formats) were sent to and received by the independent data validator. Finally, the data manager received the analytical data from independent data validator, who then check for completeness and correctness. Data entry consisted on importing the data into database. Once in the database, the data was manipulated for presentation herein. This activity included creating tables showing positive detections, comparison to screening criteria, data statistics, and tabulation of all data into appendix tables.

An independent data validator was subcontracted for data validation. The laboratory analytical results were evaluated to assess the technical adequacy and usability of the data. The data was technically reviewed based on specifications set forth in the Naval Energy and Environmental Support Activity (NEESA) and USEPA guidance documents.

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**SECTION 2.0**

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*TABLES*

TABLE 2-1

**SUMMARY OF SAMPLES COLLECTED**  
**SWMU 360**  
**RCRA FACILITY INVESTIGATION - CTO 143**  
**MCB, CAMP LEJEUNE, NORTH CAROLINA**

Sample ID	Date Sampled	Sample Interval (Feet)	Media		Analysis					QA/QC Samples taken	Comments
			Soil	Groundwater	Mobile Laboratory VOCs	TCL VOCs (OLMO 4.2)	TCL SVOCs (OLMO 4.2)	TCL Pesticides (OLMO 4.2)	RCRA Metals (ILMO 4.1)		
<b>Environmental</b>											
SWMU360-SB01-00	6/19/2003	0 - 1	X		X						
SWMU360-SB01-02	6/19/2003	3 - 5	X		X						
SWMU360-SB01-03	6/19/2003	5 - 7	X					X	X		
SWMU360-SB01-04	6/19/2003	7 - 9	X		X						
SWMU360-SB01-05	6/19/2003	9 - 11	X					X	X		
SWMU360-SB01-07	6/19/2003	13 - 15	X		X						
SWMU360-SB01-09	6/19/2003	17 - 19	X		X	X		X	X	MS/MSD	
SWMU360-GW01	6/19/2003	24 - 28		X	X						
SWMU360-SB02-00	6/19/2003	0 - 1	X		X						
SWMU360-SB02-01	6/19/2003	1 - 3	X		X						
SWMU360-SB02-02	6/19/2003	3 - 5	X		X			X	X		
SWMU360-SB02-05	6/19/2003	9 - 11	X		X			X	X		
SWMU360-SB02-09	6/19/2003	17 - 19	X		X	X		X	X		
SWMU360-GW02	6/19/2003	23 - 27		X	X						
SWMU360-GW02-02	6/24/2003	30 - 34		X	X						
SWMU360-GW02-03	6/24/2003	36 - 40		X	X						
SWMU360-SB03-00	6/20/2003	0 - 1	X		X						
SWMU360-SB03-01	6/20/2003	1 - 3	X		X			X	X		
SWMU360-SB03-04	6/20/2003	7 - 9	X		X			X	X		
SWMU360-SB03-08	6/20/2003	15 - 17	X		X						
SWMU360-SB03-10	6/20/2003	19 - 21	X		X	X		X	X		
SWMU360-GW03	6/20/2003	24 - 28		X	X						
SWMU360-SB04-00	6/19/2003	0 - 1	X		X						
SWMU360-SB04-02	6/19/2003	3 - 5	X		X	X		X	X	DUP	
SWMU360-SB04-06	6/19/2003	11 - 13	X		X			X	X		
SWMU360-SB04-08	6/19/2003	15 - 17	X		X						
SWMU360-SB04-10	6/19/2003	19 - 21	X		X			X	X		
SWMU360-GW04	6/19/2003	24 - 28		X	X						
SWMU360-SB05-00	6/19/2003	0 - 1	X		X						
SWMU360-SB05-02	6/19/2003	3 - 5	X								
SWMU360-SB05-04	6/19/2003	7 - 9	X		X			X	X		
SWMU360-SB05-06	6/19/2003	11 - 13	X		X	X		X	X		
SWMU360-SB05-08	6/19/2003	15 - 17	X		X			X	X		
SWMU360-GW05	6/19/2003	24 - 28		X	X						
SWMU360-GW05-02	6/24/2003	30 - 34		X	X						
SWMU360-GW05-03	6/24/2003	36 - 40		X	X						
SWMU360-SB06-00	6/19/2003	0 - 1	X		X						
SWMU360-SB06-01	6/19/2003	1 - 3	X		X			X	X		
SWMU360-SB06-02	6/19/2003	3 - 5	X		X						
SWMU360-SB06-04	6/19/2003	7 - 9	X		X						
SWMU360-SB06-06	6/19/2003	11 - 13	X		X						
SWMU360-SB06-08	6/19/2003	15 - 17	X					X	X		
SWMU360-SB06-10	6/19/2003	19 - 21	X		X						
SWMU360-SB06-11	6/19/2003	21 - 23	X		X	X		X	X		
SWMU360-GW06	6/19/2003	27 - 31		X	X						

TABLE 2-1

**SUMMARY OF SAMPLES COLLECTED**  
**SWMU 360**  
**RCRA FACILITY INVESTIGATION - CTO 143**  
**MCB, CAMP LEJEUNE, NORTH CAROLINA**

Sample ID	Date Sampled	Sample Interval (Feet)	Media		Analysis					QA/QC Samples taken	Comments	
			Soil	Groundwater	Mobile Laboratory VOCs	TCL VOCs (OLMO 4.2)	TCL SVOCs (OLMO 4.2)	TCL Pesticides (OLMO 4.2)	RCRA Metals (ILMO 4.1)			
SWMU360-SB07-00	6/19/2003	0 - 1	X		X							
SWMU360-SB07-02	6/19/2003	3 - 5	X		X							
SWMU360-SB07-04	6/19/2003	7 - 9	X		X	X			X	X	DUP	
SWMU360-SB07-06	6/19/2003	11 - 13	X		X							
SWMU360-SB07-08	6/19/2003	15 - 17	X		X				X	X		
SWMU360-SB07-09	6/19/2003		X		X							
SWMU360-SB07-12	6/19/2003	23 - 25	X		X				X	X		
SWMU360-GW07	6/19/2003	24 - 28		X	X							
SWMU360-SB08-00	6/20/2003	0 - 1	X		X							
SWMU360-SB08-01	6/20/2003	1 - 3	X		X				X	X		
SWMU360-SB08-02	6/20/2003	3 - 5	X		X				X	X		
SWMU360-SB08-04	6/20/2003	7 - 9	X		X							
SWMU360-SB08-06	6/20/2003	11 - 13	X		X							
SWMU360-SB08-10	6/20/2003	19 - 21	X		X	X			X	X		
SWMU360-GW08	6/20/2003	26 - 30		X	X							
SWMU360-SB09-00	6/20/2003	0 - 1	X		X							
SWMU360-SB09-01	6/20/2003	1 - 3	X						X	X		
SWMU360-SB09-04	6/20/2003	7 - 9	X		X							
SWMU360-SB09-05	6/20/2003	9 - 11	X		X							
SWMU360-SB09-06	6/20/2003	11 - 13	X			X			X	X		
SWMU360-SB09-07	6/20/2003	13 - 15	X		X							
SWMU360-SB09-09	6/20/2003	17 - 19	X		X							
SWMU360-GW09	6/20/2003	26 - 30		X	X							
SWMU360-SB10-00	6/22/2003	0 - 1	X		X							
SWMU360-SB10-01	6/22/2003	1 - 3	X		X	X			X	X		
SWMU360-SB10-02	6/22/2003	3 - 5	X		X							
SWMU360-SB10-03	6/22/2003	5 - 7	X						X	X		
SWMU360-SB10-04	6/22/2003	7 - 9	X		X							
SWMU360-SB10-05	6/22/2003	9 - 11	X						X	X		
SWMU360-SB10-07	6/22/2003	13 - 15	X		X							
SWMU360-SB10-09	6/22/2003	17 - 19	X		X							
SWMU360-GW10	6/22/2003	27 - 31		X	X							
SWMU360-SB11-00	6/20/2003	0 - 1	X		X							
SWMU360-SB11-03	6/20/2003	5 - 7	X		X				X	X		
SWMU360-SB11-06	6/20/2003	11 - 13	X		X				X	X		
SWMU360-SB11-08	6/20/2003	15 - 17	X		X							
SWMU360-SB11-09	6/20/2003	17 - 19	X		X	X			X	X		
SWMU360-GW11	6/20/2003	24 - 28		X	X							
SWMU360-GW11-02	6/20/2003	30 - 34		X	X							
SWMU360-GW11-03	6/20/2003	36 - 40		X	X							
SWMU360-SB12-00	6/20/2003	0 - 1	X		X							
SWMU360-SB12-04	6/20/2003	7 - 9	X		X	X			X	X	DUP	
SWMU360-SB12-05	6/20/2003	9 - 11	X		X				X	X		
SWMU360-GW12	6/20/2003			X	X							

TABLE 2-1

**SUMMARY OF SAMPLES COLLECTED**  
**SWMU 360**  
**RCRA FACILITY INVESTIGATION - CTO 143**  
**MCB, CAMP LEJEUNE, NORTH CAROLINA**

Sample ID	Date Sampled	Sample Interval (Feet)	Media		Analysis				QA/QC Samples taken	Comments
			Soil	Groundwater	Mobile Laboratory VOCs	TCL VOCs (OLMO 4.2)	TCL SVOCs (OLMO 4.2)	TCL Pesticides (OLMO 4.2)		
SWMU360-SB13-02	6/20/2003	3 - 5	X		X			X	X	
SWMU360-SB13-04	6/20/2003	7 - 9	X		X	X		X	X	DUP
SWMU360-SB13-05	6/20/2003	9 - 11	X		X			X	X	
SWMU360-GW13	6/20/2003	24 - 28		X	X					
SWMU360-GW13-02	6/20/2003	30 - 34		X	X					
SWMU360-GW13-03	6/20/2003	36 - 40		X	X					
SWMU360-SB14-02	6/20/2003	3 - 5	X		X			X	X	
SWMU360-SB14-04	6/20/2003	7 - 9	X		X	X		X	X	
SWMU360-SB14-06	6/22/2003	11 - 13	X		X					
SWMU360-SB14-08	6/22/2003	15 - 17	X		X					
SWMU360-SB14-10	6/22/2003	19 - 21	X		X			X	X	
SWMU360-GW14	6/22/2003	24 - 28		X	X					
SWMU360-SB15-00	6/20/2003	0 - 1	X		X					
SWMU360-SB15-02	6/20/2003	3 - 5	X		X			X	X	
SWMU360-SB15-04	6/20/2003	7 - 9	X		X			X	X	
SWMU360-SB15-05	6/20/2003	9 - 11	X		X	X		X	X	
SWMU360-SB15-06	6/20/2003	11 - 13	X		X					
SWMU360-SB15-10	6/20/2003	19 - 21	X		X					
SWMU360-GW15	6/20/2003	24 - 28		X	X					
SWMU360-SB16-02	6/24/2003	3 - 5	X		X			X	X	
SWMU360-SB16-03	6/24/2003	5 - 7	X		X			X	X	
SWMU360-SB16-05	6/24/2003	9 - 11	X		X					
SWMU360-SB16-07	6/24/2003	13 - 15	X		X					
SWMU360-SB16-09	6/24/2003	17 - 19	X		X	X		X	X	
SWMU360-GW16	6/24/2003	24 - 28		X	X					
SWMU360-GW16-02	6/24/2003	30 - 34		X	X					
SWMU360-GW16-03	6/24/2003	36 - 40		X	X					
SWMU360-SB17	6/24/2003									40 ft, Geology and groundwater only
SWMU360-GW17	6/24/2003	24 - 28		X						No yield, no sample collected
SWMU360-GW17-02	6/24/2003	30 - 34		X	X					
SWMU360-GW17-03	6/24/2003	36 - 40		X	X					Mobile Lab - Vaportech
SWMU360-SB18	7/9/2003									Mobile Lab - Mobile Analytical Services
SWMU360-GW18	7/9/2003	24 - 28		X	X					
SWMU360-SB19	7/8/2003									
SWMU360-GW19	7/8/2003	24 - 28		X	X					
SWMU360-SB20	7/8/2003									
SWMU360-GW20	7/8/2003	24 - 28		X	X					
SWMU360-SB21	7/8/2003									
SWMU360-GW21	7/8/2003	24 - 28		X	X					
SWMU360-GW21-02	7/8/2003	30 - 34		X	X					
SWMU360-GW21-03	7/8/2003	36 - 40		X	X					
SWMU360-SB22	7/8/2003									
SWMU360-GW22	7/8/2003	24 - 28		X	X					
SWMU360-GW22-02	7/8/2003	30 - 34		X	X					
SWMU360-GW22-03	7/8/2003	36 - 40		X	X					

TABLE 2-1

SUMMARY OF SAMPLES COLLECTED  
SWMU 360  
RCRA FACILITY INVESTIGATION - CTO 143  
MCB, CAMP LEJEUNE, NORTH CAROLINA

Sample ID	Date Sampled	Sample Interval (Feet)	Media		Analysis					QA/QC Samples taken	Comments
			Soil	Groundwater	Mobile Laboratory VOCs	TCL VOCs (OLMO 4.2)	TCL SVOCs (OLMO 4.2)	TCL Pesticides (OLMO 4.2)	RCRA Metals (ILMO 4.1)		
SWMU360-SB23	7/8/2003										
SWMU360-GW23	7/8/2003	24 - 28		X	X						
SWMU360-GW23-02	7/8/2003	30 - 34		X	X						
SWMU360-GW23-03	7/8/2003	36 - 40		X	X						
SWMU360-SB24	7/8/2003										
SWMU360-SB24-02	7/8/2003	3 - 5	X		X						
SWMU360-GW24	7/8/2003	24 - 28		X	X						
SWMU360-SB25	7/8/2003										
SWMU360-GW25	7/8/2003	24 - 28		X	X						
SWMU360-SB26	7/9/2003										
SWMU360-GW26	7/9/2003	24 - 28		X	X						
SWMU360-SB27	7/9/2003										
SWMU360-GW27	7/9/2003	24 - 28		X	X						
SWMU360-SB28	7/9/2003										
SWMU360-GW28	7/9/2003	24 - 28		X	X						
SWMU360-GW28-01	7/9/2003	30 - 34		X	X						
SWMU360-GW28-02	7/9/2003	36 - 40		X	X						
SWMU360-SB29	7/10/2003										
SWMU360-GW29	7/10/2003	24 - 28		X	X						
SWMU360-GW29-02	7/10/2003	30 - 34		X	X						
SWMU360-GW29-03	7/10/2003	36 - 40		X	X						
SWMU360-SB30	7/9/2003										
SWMU360-GW30	7/9/2003	24 - 28		X	X						
SWMU360-GW30-01	7/9/2003	30 - 34		X	X						
SWMU360-GW30-02	7/9/2003	36 - 40		X	X						
SWMU360-SB31	7/10/2003										
SWMU360-GW31	7/10/2003	24 - 28		X	X						
SWMU360-GW31-02	7/10/2003	30 - 34		X	X						
SWMU360-GW31-03	7/10/2003	36 - 40		X	X						
SWMU360-SB32	7/12/2003										
SWMU360-GW32	7/12/2003	24 - 28		X	X						
SWMU360-GW32-02	7/12/2003	30 - 34		X	X						
SWMU360-GW32-03	7/12/2003	36 - 40		X	X						
SWMU360-MW01	7/24/2003	18 - 28		X		X	X	X	X	DUP	
SWMU360-MW01IW	7/24/2003	40 - 45		X		X	X	X	X	MS/MSD	
SWMU360-MW02	7/24/2003	18 - 28		X		X	X	X	X		
SWMU360-MW02IW	7/24/2003	40 - 45		X		X	X	X	X		
SWMU360-MW03	7/22/2003	18 - 28		X		X	X	X	X		
SWMU360-MW03IW	7/22/2003	40 - 45		X		X	X	X	X		
SWMU360-MW04	7/23/2003	18 - 28		X		X	X	X	X		
SWMU360-MW05	7/22/2003	15 - 25		X		X	X	X	X		
SWMU360-MW06	7/22/2003	17 - 27		X		X	X	X	X		
SWMU360-MW07	7/22/2003	15 - 25		X		X	X	X	X		
SWMU360-MW08	7/22/2003	16.9 - 26.9		X		X	X	X	X		
7-MW01	7/24/2003	15 - 25		X		X	X	X	X		

TABLE 2-1

**SUMMARY OF SAMPLES COLLECTED**  
**SWMU 360**  
**RCRA FACILITY INVESTIGATION - CTO 143**  
**MCB, CAMP LEJEUNE, NORTH CAROLINA**

Sample ID	Date Sampled	Sample Interval (Feet)	Media		Analysis				QA/QC Samples taken	Comments	
			Soil	Groundwater	Mobile Laboratory VOCs	TCL VOCs (OLMO 4.2)	TCL SVOCs (OLMO 4.2)	TCL Pesticides (OLMO 4.2)			RCRA Metals (ILMO 4.1)
<b>QA/QC Samples</b>											
ER03	6/19/2003					X	X	X	X		gcoprobe sleeve and shoe
ER04	6/20/2003					X	X	X	X		spoon
ER06	6/22/2003					X	X	X	X		spoon
ER08	6/24/2003					X	X	X	X		split spoon
ER09	6/26/2003					X	X	X	X		poly tubing used for groundwater sampling
FB01	6/25/2003					X	X	X	X		Drill rig decon water
FB02	6/26/2003					X	X	X	X		Lab grade water
FB03	6/26/2003					X	X	X	X		Distilled bottled water - Wal-Mart
TB02	6/19/2003					X					311, 360
TB03	6/20/2003					X					360
TB05	6/24/2003					X					269, 360
TB09	7/23/2003					X					360
TB10	7/24/2003					X					360, ER09

TABLE 2-2

TEMPORARY PIEZOMETER CONSTRUCTION DETAILS  
SWMU 360  
RCRA FACILITY INVESTIGATION - CTO 143  
MCB, CAMP LEJEUNE, NORTH CAROLINA

Well Identification	Date Installed	Top of PVC Casing Elevation (feet above msl)	Well Depth (feet bgs)	Screen Interval (feet bgs)	Depth to Sand/Slough (feet bgs)	Depth to Bentonite (feet bgs)	Static Water Level (feet below top of casing)	Static Water Elevation (feet above msl)
360-PZ05	7/7/03	27.53	25.0	20.0 - 25.0	18.0	0.0	21.15	6.38
360-PZ07	7/7/03	27.57	25.0	20.0 - 25.0	19.0	0.0	21.00	6.57
360-PZ08	7/7/03	26.32	25.0	20.0 - 25.0	18.0	0.0	19.00	7.32
360-PZ09	7/7/03	25.56	25.0	20.0 - 25.0	17.5	0.0	18.32	7.24
360-PZ12	7/7/03	27.62	25.0	20.0 - 25.0	18.0	0.0	21.29	6.33
360-PZ15	7/7/03	26.70	25.0	20.0 - 25.0	18.0	0.0	20.09	6.61

TABLE 2-3

**MONITORING WELL CONSTRUCTION DETAILS  
SWMU 360  
RCRA FACILITY INVESTIGATION - CTO 143  
MCB, CAMP LEJEUNE, NORTH CAROLINA**

<b>Well Identification</b>	<b>Date Installed</b>	<b>Top of PVC Casing Elevation (feet above msl)</b>	<b>Ground Surface Elevation (feet above msl)</b>	<b>Well Depth (feet bgs)</b>	<b>Screen Interval (feet bgs)</b>	<b>Depth to Sand/Slough (feet bgs)</b>	<b>Depth to Bentonite (feet bgs)</b>	<b>Static Water Level (feet below top of casing)</b>	<b>Static Water Elevation (feet above msl)</b>
360-MW01	7/13/03	27.25	27.51	28.0	18 - 28	16.0	13.1	20.81	6.44
360-MW01IW	7/12/03	27.41	27.55	45.0	40 - 45	38.0	34.6	20.99	6.42
360-MW02	7/12/03	26.24	26.38	28.0	18 - 28	16.0	14.0	19.54	6.70
360-MW02IW	7/11/03	26.17	26.42	45.0	40 - 45	37.4	34.9	19.55	6.62
360-MW03	7/14/03	24.26	24.62	28.0	18 - 28	16.0	14.0	18.69	5.57
360-MW03IW	7/13/03	24.30	24.66	45.0	40 - 45	39.0	38.0	19.16	5.14
360-MW04	7/13/03	25.71	26.04	28.0	18 - 28	16.0	14.0	19.88	5.83
360-MW05	7/15/03	22.92	23.31	25.0	15 - 25	13.0	11.0	16.37	6.55
360-MW06	7/14/03	24.54	24.85	27.0	17 - 27	15.0	13.0	17.10	7.44
360-MW07	7/10/03	25.25	25.35	25.0	15 - 25	13	11.2	18.72	6.53
360-MW08	7/13/03	26.32	26.68	26.9	16.9 - 26.9	14.8	12	18.52	7.80
*1817-MW01	8/14/97	26.13	26.8	25.0	15 - 25	13	11	19.70	6.43

**NOTES:**

- 1) Surface water levels were taken on 7/22/03.
- 2) \* denotes existing monitoring well install during the Limited Site Assessment conducted by Catlin Engineers and Scientists in 1997.

TABLE 2-4

SUMMARY OF GEOTECHNICAL ANALYTICAL RESULTS  
 SWMU 360  
 RCRA FACILITY INVESTIGATION - CTO - 143  
 MCB, CAMP LEJEUNE, NORTH CAROLINA

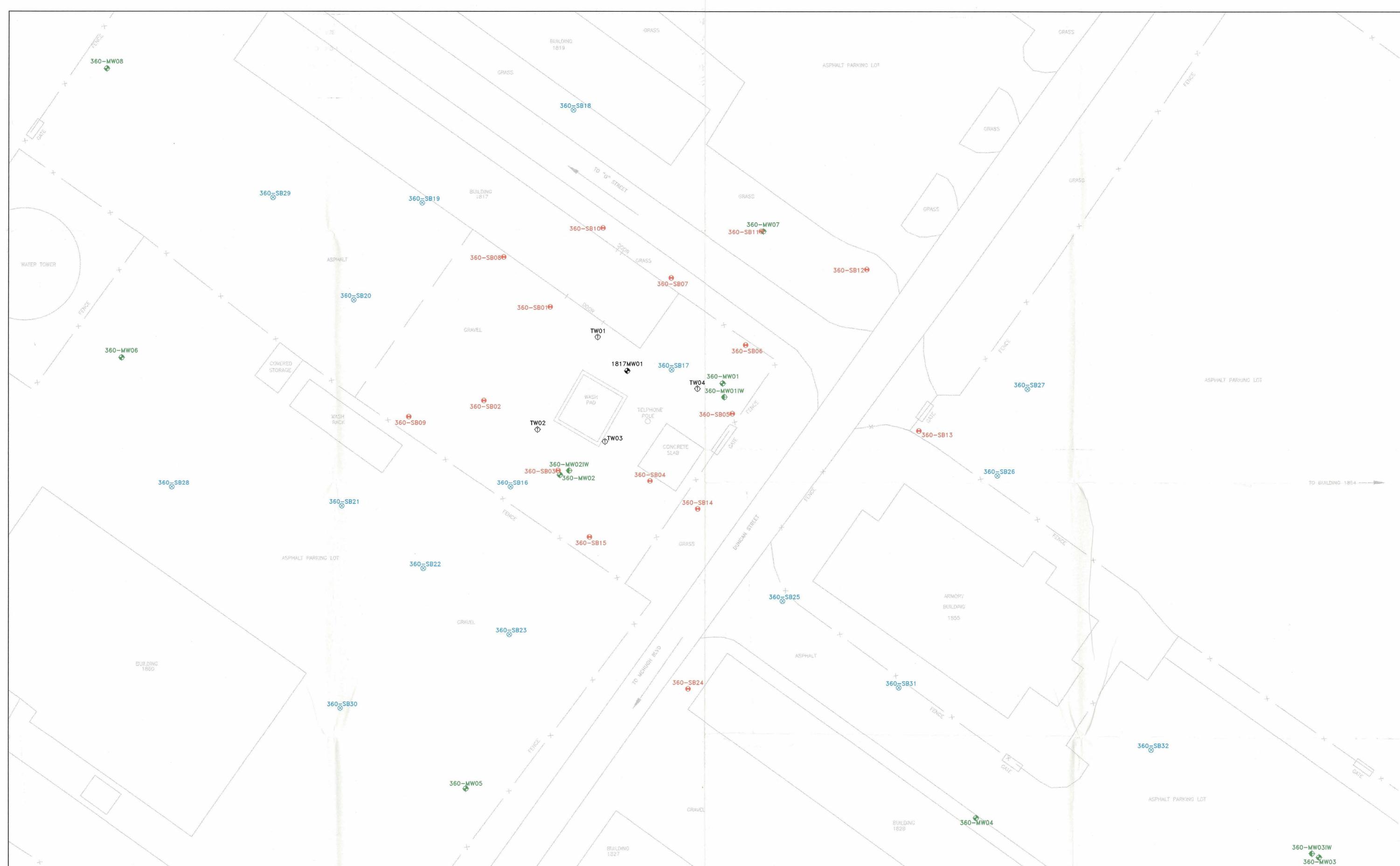
Sample ID	Depth (ft-bgs)	Plastic Limit	Liquid Limit	Plasticity Index	Moisture (%)	Specific Gravity	Vertical Permeability (ft/day)	Classification (USCS)	Modified Bermeister Classification
SWMU360-MW06	1.0 - 3.0	15	28	13	11.4	2.62	0.003	SC	fine SAND & SILT, some clay; damp
SWMU360-MW01IW	17.0 - 19.0	24	53	29	26.5	2.53	0.007	CH	CLAY, trace fine sand & silt; moist
SWMU360-MW05	2.0 - 4.0	19	34	15	11.6	2.56	0.046	SC	fine SAND & SILT, some clay; damp

**Baker**

*Baker Environmental, Inc.*

**SECTION 2.0**

***FIGURES***

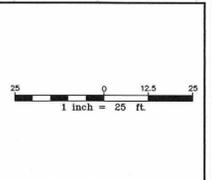
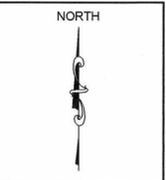


**LEGEND**

- ⊕ - PHASE II TEMPORARY WELL
- ⊕ - EXISTING MONITORING WELL
- ⊕ - MONITORING WELL LOCATION
- ⊕ - INTERMEDIATE MONITORING WELL LOCATION
- ⊕ - SOIL BORING AND GROUND WATER GRAB LOCATION
- ⊕ - GROUND WATER GRAB LOCATION

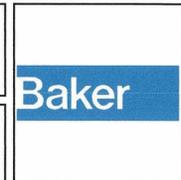
SOURCE: MCB CAMP LEJEUNE MARCH 2000

DRAWN	/RRR
REVIEWED	RMS
S.O.#	28007-143-0000-06001
CADD#	3143RFI_360_BASE



**MARINE CORPS BASE, CAMP LEJEUNE**  
NORTH CAROLINA

**BAKER ENVIRONMENTAL, Inc.**  
Moon Township, Pennsylvania



RCRA FACILITY INVESTIGATION SOIL BORING, GROUNDWATER GRAB AND MONITORING WELL LOCATION MAP SWMU 360, CTO-143	
SCALE	1" = 25'
DATE	8/20/03

FIGURE  
**2-1**

### **3.0 PHYSICAL CHARACTERISTICS**

Sufficiently understanding the nature and extent of contamination as well as fate and transport of those contaminants requires an understanding of the physical environment context in which the contamination occurs. Even if contamination is not evident, a sufficient understanding of the physical environment is required to demonstrate that the samples collected were appropriately located and are representative of the entire site. The subsections that follow present information to support an interpretation of the physical environment.

#### **3.1 Topography and Surface Features**

The overall topography of SWMU 360 area is flat and is developed as storage and maintenance of military equipment and supplies. On a local scale, a small tributary to Codgel's Creek is located towards the northeast and provides some topographic relief in that direction. The Building 1817 compound is a flat, half gravel (eastern portion) and half asphalt paved (western portion), with an elevation of approximately 26 to 28 feet above msl. Building 1817 and its compound occupy part of the block between Duncan and "O" Street just north of McHugh (Main Service Road). The area between McHugh and the compound is occupied by a communications Battalion. There is a slight slope from the Building 1817 compound down into the parking area (asphalt paved) in the communications Battalion. The elevation of Duncan Street in the vicinity of the SWMU is estimated to be approximately 28 feet above msl.

#### **3.2 Water Supply**

Potable water for the base is derived entirely by groundwater. The Base does not have established groundwater preservation areas. However, because the Base controls more than 236 square miles of land, and because much of this land has remained undeveloped, the undeveloped areas serve the function of groundwater preserves. Groundwater usage is roughly eight million gallons per day (gpd) (Cardinell et al., 1993). Groundwater is pumped from approximately 84 water supply wells located within the boundaries of the Base. According to Base personnel, groundwater is treated at five plants located at Hadnot Point, Holcomb Boulevard, Marine Corps Air Station (MCAS) New River, Courthouse Bay, and Onslow Beach having a maximum total capacity of 15.8 million gpd. However, the base population only requires 6.5 million gpd.

The water supply wells at the base withdraw water from the Castle Hayne aquifer. The Castle Hayne aquifer is a highly permeable, semi-confined aquifer that can yield several hundred to 1,000 gpm. The wells (8-inch diameter) at the Base average 162 feet in depth and yield 174 gallons per minute (gpm) (Harned, et al., 1989). The water is typically a hard, calcium bicarbonate type. Information concerning the supply wells was derived from the Wellhead Management Program Engineering Study 91-36 (Geophex, 1991), the Preliminary Draft Report Wellhead Monitoring Study 92-34 (Greenhorne and O'Mara, Inc., 1992), and interviews with Base personnel.

The Camp Lejeune Wellhead Protection Plan (AH Environmental Consultants, 2002) was prepared to update the existing wellhead protection areas for the current well fields on the Base. After review of this plan, it was noted that SWMU 360 is not located in close proximity to any active supply wells on the Base. See Figure 3-1 for a map of the supply well locations in relationship to SWMU 360.

### **3.3 Surface Water Hydrology**

Surface water flow across the SWMU 360 area is controlled. Due to the built up nature of the study area, rainwater runoff is collected in roof gutters, storm water sewer inlets in parking areas, and in drainage ditches along roads. Direct infiltration occurs in grassy and gravel areas surrounding the Building 1817 compound. The wash pad associated with SWMU 360 is design to capture water from vehicle wash downs, and to an extent, captures some rainwater. Water in the wash pad drains to the oil/water separator, which in turn drains to the sanitary sewer.

### **3.4 Geologic and Hydrogeologic Framework**

Site-specific geologic and hydrogeologic information was obtaining through logging of soil samples from 32 soil borings and 11 monitoring wells advanced at SWMU 360. This site-specific geology and hydrogeology is placed in context of a regional framework in the sections that follow.

#### **3.4.1 Regional Framework**

The Base is located within the Tidewater region of the Atlantic Coastal Plain physiographic province. The sediments of the Atlantic Coastal Plain consist mostly of interbedded sands, silts,

clays, calcareous clays, shell beds, sandstone, and limestone. These sediments are layered in interfingering beds and lenses that gently dip and thicken to the southeast to a combined thickness of approximately 1,500 feet. The sediments were deposited in marine or near-shore environments and range in age from early Cretaceous to Quaternary time. Regionally, the sediments comprise 10 aquifers and nine confining units, which overlie igneous and metamorphic basement rocks of the pre-Cretaceous age. Seven of these aquifers and their associated confining units are present at the Base (Cardinell, et al., 1993). Table 3-1 presents a generalized stratigraphic column for Jones and Onslow Counties, North Carolina. A hydrogeologic section location plan and hydrogeologic cross-sections of the Base are presented in the Hydrogeologic Framework of U.S. Marine Corps Base at Camp Lejeune, North Carolina (Cardinell et al., 1993).

USGS studies performed by Harned, et al., 1989 and Cardinell, et al., 1993 indicate that the base is underlain by sand and limestone aquifers separated by confining units of silt and clay. These aquifers include the surficial (water table), Castle Hayne, Beaufort, Peedee, Black Creek, and upper and lower Cape Fear. Less permeable clay and silt beds function as confining units or semi-confining units that separate the aquifers and impede the flow of groundwater between aquifers.

Historically, only the upper two aquifers have been impacted by Base activity, namely the surficial aquifer and the Castle Hayne aquifer. The surficial unit consists of interfingering beds of sand, clay, sandy clay, and silt that contain some peat and shells in the undifferentiated formation. According to information presented by the USGS, the undifferentiated formation/surficial aquifer is approximately 15 to 25 feet thick in the vicinity of the Hadnot Point industrial area. Although this aquifer is classified as GA (i.e., existing or a potential source of drinking water supply for humans), it is not used as a potable water source at the Base because of its low yielding production rates (typically less than three gpm). The Belgrade formation consists of clay, sandy clay, and silt beds and is part of the Castle Hayne Confining unit. This formation however, tends to be semi-confining due to its content of very fine-grained material. The thickness of this unit ranges from approximately 0 to 26 feet, typically averages 9 feet where present, with no discernible thickness trend. The Castle Hayne aquifer primarily resides within the River Bend Formation, which consists of sand, cemented shells, and limestone. The upper portion of the aquifer primarily consists of calcareous sands with some thin clay and silt beds. The sand becomes increasingly more limy with depth. The lower portion of the aquifer consists of partially unconsolidated limestone and sandy limestone interbedded with clay and sand. In addition, buried paleostream channels containing various deposits exist within the aquifer. According to

information presented by the USGS, the Castle Hayne aquifer is approximately 350 feet thick in the vicinity of the Hadnot Point industrial area.

Recharge to the surficial aquifer is by rainfall. The 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. Most of the surficial groundwater is discharged to local streams, but some water passes through the underlying semi-confining unit. Recharge is estimated to average 30 percent of an average rainfall of 52 inches per year. The remaining 70 percent of rainfall is lost as surface runoff or evapotranspiration. Water levels in wells tapping the surficial aquifer vary seasonally. The water table is generally highest in the winter and spring, and lowest in the summer and early fall. Recharge of the Castle Hayne aquifer at the Base is primarily received from the surficial aquifer. Natural discharge is to the New River and its major tributaries. Although the Castle Hayne aquifer provides approximately seven million gallons of water to the Base, groundwater pumping has not significantly affected natural head gradients in the aquifer.

Hydraulic conductivities of the surficial and Castle Hayne aquifers have been estimated through various studies and have been found to vary significantly from study to study as well as spatially. The estimated lateral hydraulic conductivity for the surficial aquifer is 50 feet per day (ft/d) and is based on a general composition of fine sand mixed with some silt and clay (Cardinal, et al., 1993). Baker compiled and studied data from aquifer pumping tests at the Base in 1994 to evaluate aquifer characteristics and production capacities. The technical memorandum is provided as Appendix F. The information contained in this memorandum pertains primarily to the surficial aquifer. Average pumping rates were established between 0.5 to three gpm, with a hydraulic conductivity estimate range from 0.5 to 1.4 ft/d. Estimated hydraulic conductivity values range from 14 to 91 ft/d. See Table 3-2 for the summary of hydraulic conductivity estimates.

#### **3.4.2 Site-Specific Framework**

The subsections that follow provide a discussion of geology, hydrogeology, and provide a summary of findings.

#### 3.4.2.1 Geology

Four cross sections were prepared for the SWMU 360 RFI report to represent subsurface geology (Figure 3-2). Cross Section A-A' begins at monitoring well SWMU360-MW08 and traverses to the southeast, to monitoring well cluster SWMU360-MW03 and MW03IW (Figure 3-3). Cross Section B-B' begins at boring SWMU360-SB28 and traverses to the northeast, to boring SWMU360-SB18 (Figure 3-3). Cross Section C-C' begins at boring SWMU360-SB30 and traverses to the northeast, to boring SWMU360-SB11 and monitoring well SWMU360-MW07 (Figure 3-4). Cross Section D-D' begins at monitoring well SWMU360-MW05 and traverses to the northeast, to boring SWMU360-SB27 (Figure 3-4). The paragraphs that follow discuss the cross section geology.

The subsurface geology in the vicinity of SWMU 360 exhibits some heterogeneity. Fine sand and varying amounts of silt predominate. Some thin clay lenses are also present within the fine sand unit and a thin clay layer (from approximately 15-feet to 20 feet bgs) exists across the study area as seen in cross section A-A'. Evidence of the River Bend formation, zones of fine to coarse calcareous sands and shell fragments, exists in the northeastern part of the study area and is absent to the southwest as seen in cross sections B-B', C-C' and D-D'. This geological feature exhibits evidence of a paleo-channel existing across the site. A paleo-channel is a buried historical stream channel. Evidence of paleo-channels in the Castle Hayne aquifer has been documented in seismic-reflection surveys completed in the Hadnot Point area at Camp Lejeune (Cardinell et al., 1993). This is also consistent with the shallow groundwater flow and the contaminant plume geometry seen in the results from this investigation.

All the cross sections show that fine sand is generally present as the uppermost unit across the study area and thin clay lenses scattered throughout the study area. The minor constituents of this fine sand appear to vary from trace to some silt and trace to no clay.

Three Shelby Tube samples were collected at SWMU 360. The samples were collected from SWMU360-MW05 (2 to 4 feet bgs), SWMU360-MW06 (one to 3 feet bgs) and SWMU360-MW01IW (17 to 19 feet bgs). It should be noted that due to the predominant fine sand lithology at SWMU 360, Shelby Tube samples were difficult to collect in most areas because of the low percentage of cohesive soils (i.e. silts and clays). Therefore samples had to be taken in areas identified as having increased amounts of silt and/or clay in order to obtain a viable Shelby Tube sample. Samples collected from SWMU360-MW05 and SWMU360-MW06 were

taken to represent the varying silty sand found in the shallow southern portions of the study area. Results from these samples showed similar geotechnical characteristics and the laboratory soil classification was fine sand and silt with some clay (see Table 2-4). The sample collected from SWMU360-MW01IW was taken to represent the clay layer identified from approximately 12 to 25 feet bgs across the northern portion of the study area. Laboratory results showed geotechnical characteristics typical of clay and the laboratory soil classification was clay with trace fine sand and silt. See Table 2-4 for the Summary of Geotechnical Analytical Results. The Geotechnical Laboratory Report is presented in Appendix C.

#### 3.4.2.2 Hydrogeology

Groundwater at SWMU 360 was either encountered in the fine sand within 12 to 26 feet of the ground surface or just below the clay unit observed across the study area. Groundwater flow direction and gradient were determined in the field through the use of piezometers (Section 2.2.1). These piezometers were installed to verify groundwater flow direction to guide the field investigation. SWL measurements are representative of the surficial aquifer and were taken on July 7, 2003 and converted to elevations (Table 2-2). Groundwater flow was interpreted in the field to generally flow in a southeast direction. Figure 3-5 shows the groundwater potentiometric surface as interpreted by the project geologist. This groundwater flow map was generated using the SWL measurements collected from the monitoring wells at SWMU 360 on July 22, 2003. Groundwater flows to the southeast across the study area. Based on this single monitoring event the hydraulic gradient varies slightly across the study area.

There was no real evidence of a confining unit acting on the study area. There was evidence of a clay layer and some clay lenses across the site. The clay units did not exhibit any effects on the groundwater elevations seen in the piezometers and monitoring wells. However, the clay layer seen across the site could affect the downward migration of contaminants. Contaminants would flow horizontally across the top of this clay until this clay layer pinches out or until a preferential pathway is encountered. With the evidence of a paleo-channel existing on the site, it can be inferred that contaminant migration would be across the clay horizontally until encountering the paleo-channel and then contaminants would flow southeast in the direction of the surficial groundwater flow.

At SWMU 360, three to four slug tests were performed using two different sized slugs. The first set of graphs in Appendix E show the normalized displacement data for the multiple tests at each

well. Six of 12 well plots exhibit evidence of a well skin (e.g., SWMU360-MW01 cluster). The other six well plots do not exhibit evidence of a well skin (e.g., SWMU360-MW02 cluster). Accordingly, a solution was chosen that accounts for wells exhibiting evidence of a well skin. This solution is the Hyder et al. (1994) Solution of a Slug Test (KGS Model). The Bouwer and Rice Solution (1976) were used for all other wells. Aqtesolv<sup>®</sup> v3.5 was used to facilitate the KGS and Bouwer and Rice analyses. The second set of graphs in Appendix E shows the test data and type curve, the input data, and the hydraulic conductivity estimate (as "Kr"). These results have been summarized and sorted by aquifer on Table 3-3 for convenience.

The surficial and Castle Hayne aquifers were encountered at SWMU 360. Hydraulic conductivity estimates in the surficial aquifer range from 1.5 ft/d to 7.6 ft/d, with an average of 4.2 ft/d. The hydraulic conductivity in the surficial aquifer is fairly consistent across the site. Hydraulic conductivity estimates in the Castle Hayne aquifer range from 0.6 ft/d to 36.6 ft/d, with an average of 18.3 ft/d. The hydraulic conductivity varies by two orders of magnitude in the Castle Hayne aquifer.



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**SECTION 3.0**

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*TABLES*

TABLE 3-1

**GEOLOGIC AND HYDROGEOLOGIC UNITS IN THE COASTAL PLAIN OF NORTH CAROLINA  
SWMU 360  
RCRA FACILITY INVESTIGATION - CTO 143  
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 <sup>(1)</sup>	Yorktown Confining Unit
			Yorktown Aquifer
	Miocene	Eastover Formation <sup>(1)</sup>	Pungo River Confining Unit
		Pungo River Formation <sup>(1)</sup>	Pungo River Aquifer
		Belgrade Formation <sup>(2)</sup>	Castle Hayne Confining Unit
	Oligocene	River Bend Formation	Castle Hayne Aquifer
	Eocene	Castle Hayne Formation	Beaufort Confining Unit <sup>(3)</sup>
Palocene	Beaufort Formation	Beaufort Aquifer	
Cretaceous	Upper Cretaceous	Peedee Formation	Peedee Confining Unit
			Peedee Aquifer
		Black Creek and Middendorf Formations	Black Creek Confining Unit
			Black Creek Aquifer
	Cape Fear Formation		Upper Cape Fear Confining Unit
			Upper Cape Fear Aquifer
			Lower Cape Fear Confining Unit
			Lower Cape Fear Aquifer
Lower Cretaceous <sup>(1)</sup>	Unnamed Deposits <sup>(1)</sup>	Lower Cretaceous Confining Unit	
		Lower Cretaceous Aquifer <sup>(1)</sup>	
Pre-Cretaceous Basement Rocks		---	---

Notes:

<sup>(1)</sup> Geologic and hydrologic units not present beneath Camp Lejeune.

<sup>(2)</sup> Constitutes part of the surficial aquifer and Castle Hayne confining unit in the study area.

<sup>(3)</sup> Estimated to be confined to deposits of Paleocene age in the study area.

Source: Cardinell, et al., 1993

TABLE 3-2

**SUMMARY OF HYDRAULIC CONDUCTIVITY ESTIMATES**  
**SWMU 360**  
**RCRA FACILITY INVESTIGATION**  
**MCB, CAMP LEJEUNE, NORTH CAROLINA**

Well Name	Test Date	Hydraulic Conductivity Estimate						Well Skin?	Lithology
		R1	R2	R3	F1	F2	Avg.		
<i>Surficial aquifer</i>									
360-MW02	7/26/2003	4.0	2.8 <sup>(1)</sup>	NT	NT	NT	3.4	N	F Sand, trace silt & F Sand/Clay layers
360-MW02IW	7/26/2003	1.5	1.5	NT	1.4	1.4	1.5	N	F Sand, trace silt
360-MW05	7/25/2003	(3)	(3)	NT	NT	NT	--	Y	F Sand, little to some silt
360-MW06	7/25/2003	4.0	2.9	5.2	NT	NT	4.0	N	F Sand, little silt
360-MW08	7/26/2003	7.9	7.4	7.4	NT	NT	7.6	Y	Clay and F Sand layers
1817-MW01 <sup>(4)</sup>	7/26/2003	4.5 <sup>(1)</sup>	3.6	4.8 <sup>(1)</sup>	NT	NT	4.3	Y	No information
Average hydraulic conductivity in the Surficial aquifer at SWMU 360							4.2		
<i>Castle Hayne aquifer</i>									
360-MW01	7/26/2003	26.4	38.4	44.9	NT	NT	36.6	Y	F/C Sand (C-H)
360-MW01IW	7/26/2003	1.8	4.0	NT	4.2	32.7	10.7	Y	F/C Sand and Gravel (C-H)
360-MW03	7/26/2003	63.1	32.7	31.2	NT	NT	42.3		F/C Gravel and F/C Sand (C-H)
360-MW03IW	7/26/2003	0.5	0.5	NT	0.6	0.6	0.6	N	F/C Gravel and F Sand layers (C-H)
360-MW04 <sup>(2)</sup>	7/26/2003	22.2	14.4	17.2	NT	NT	17.9	N	F Sand, trace shell frag & silt (C-H)
360-MW07	7/26/2003	25.8	26.8	24.5	NT	NT	25.7	N	F/C Sand, some f/c gravel (C-H)
Avg hydraulic conductivity in the Castle Hayne aquifer at SWMU 360							22.3		

## Notes:

K values are in feet per day (ft/day)

"R1" refers to rising-head test #1, "F2" refers to falling-head test #2, etc.

<sup>(1)</sup> Average of two lines

<sup>(2)</sup> The KGS model did not fit R3 data, Bouwer & Rice used

<sup>(3)</sup> Test not valid, water level failed to recover to the initial level

<sup>(4)</sup> The KGS model fit R2 data, however estimates for R1 & R3 inconsistent with R2 and site lithology, and two orders of magnitude lower than historical estimates of that formation. Used Bouwer & Rice for R1 & R3. Used Bouwer & Rice for R1 & R3.

NT - No test performed

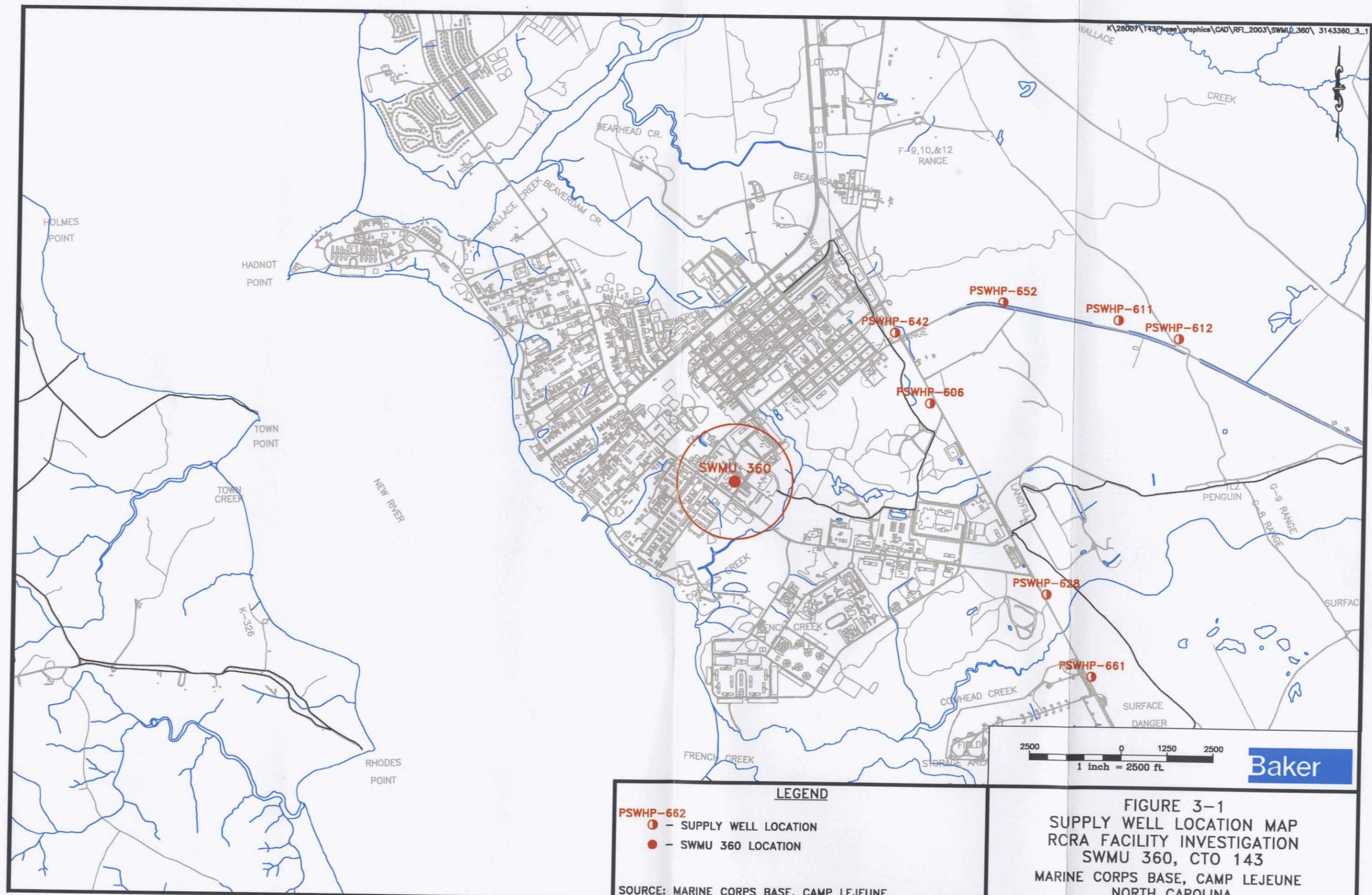
C-H - Sediments of the Castle Hayne aquifer



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**SECTION 3.0**

***FIGURES***

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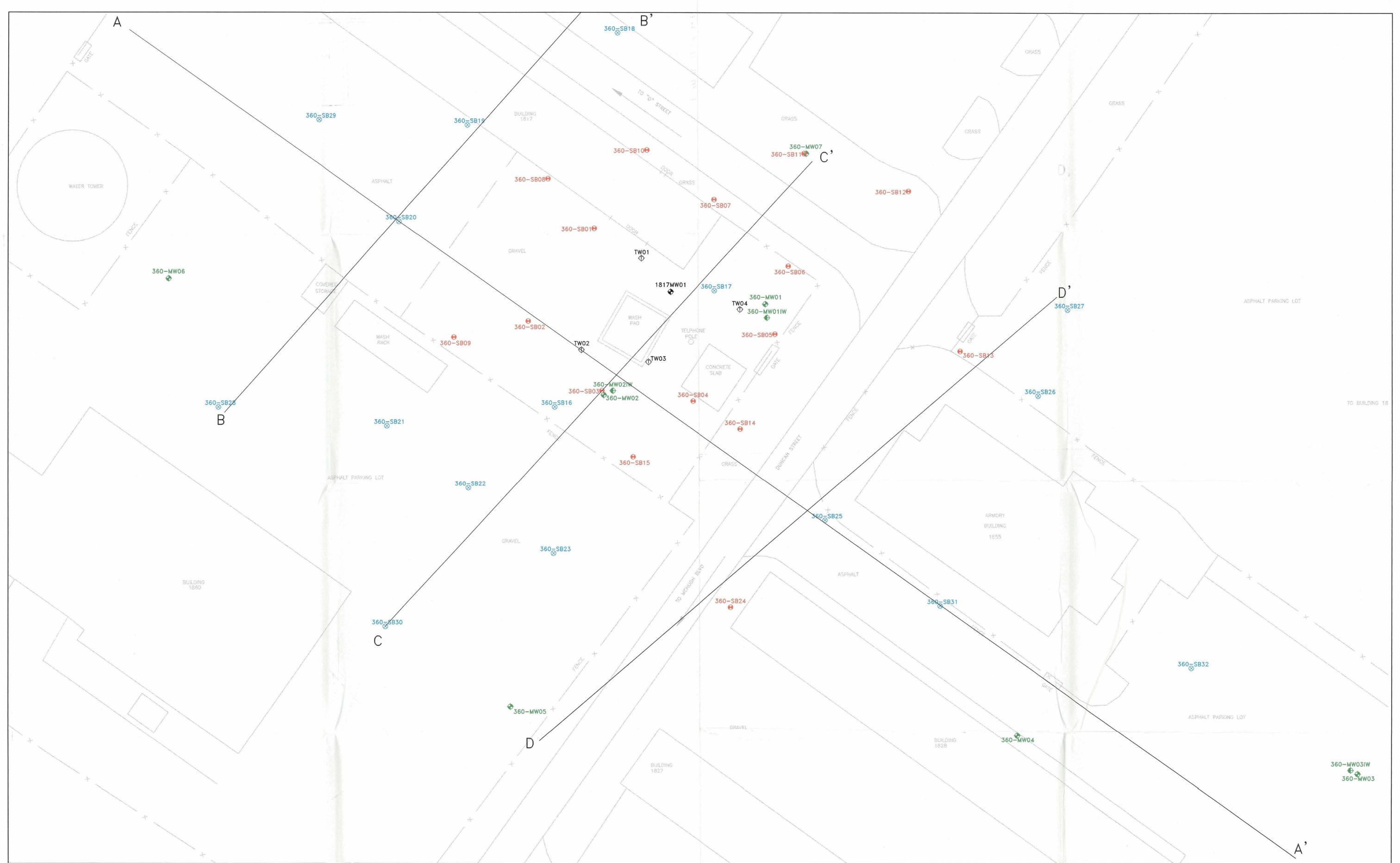


**LEGEND**

PSWHP-662  
 ● - SUPPLY WELL LOCATION  
 ● - SWMU 360 LOCATION

SOURCE: MARINE CORPS BASE, CAMP LEJEUNE

**FIGURE 3-1**  
 SUPPLY WELL LOCATION MAP  
 RCRA FACILITY INVESTIGATION  
 SWMU 360, CTO 143  
 MARINE CORPS BASE, CAMP LEJEUNE  
 NORTH CAROLINA

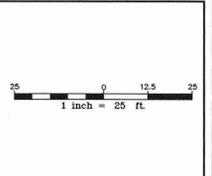
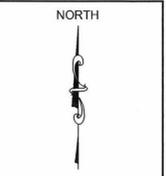


**LEGEND**

- ⊕ - PHASE II TEMPORARY WELL
- ⊕ - EXISTING MONITORING WELL
- ⊕ - MONITORING WELL LOCATION
- ⊕ - DEEP MONITORING WELL LOCATION
- ⊕ - SOIL BORING AND GROUND WATER GRAB LOCATION
- ⊕ - GROUND WATER GRAB LOCATION

SOURCE: MCB CAMP LEJEUNE MARCH 2000

DRAWN	/RRR
REVIEWED	RMS
S.O.#	26007-143-0000-06001
CADD#	3143360_3.2



**MARINE CORPS BASE, CAMP LEJEUNE**  
NORTH CAROLINA

**BAKER ENVIRONMENTAL, Inc.**  
Moon Township, Pennsylvania

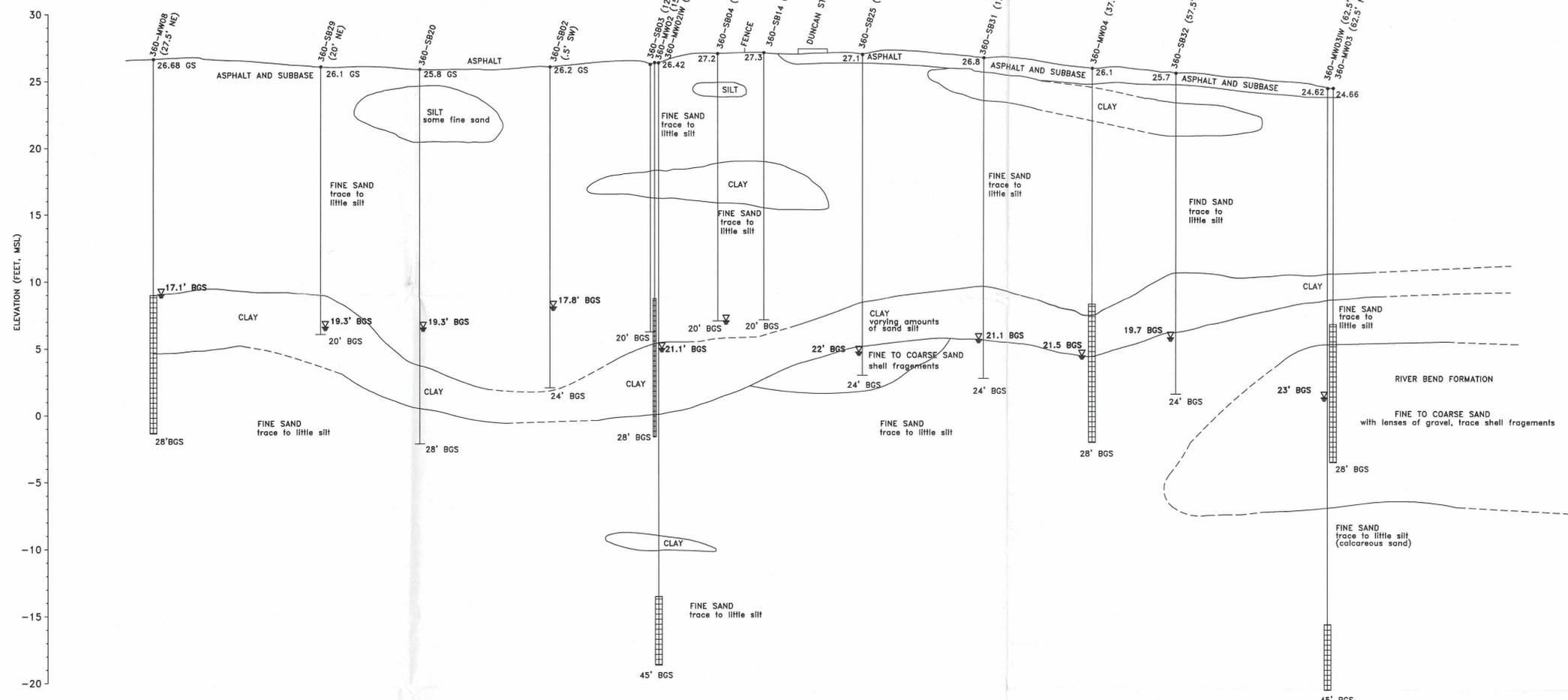


RCRA FACILITY INVESTIGATION CROSS SECTION LOCATION MAP	
SWMU 360, CTO-143	
SCALE	1" = 25'
DATE	OCTOBER 2003

FIGURE  
**3-2**

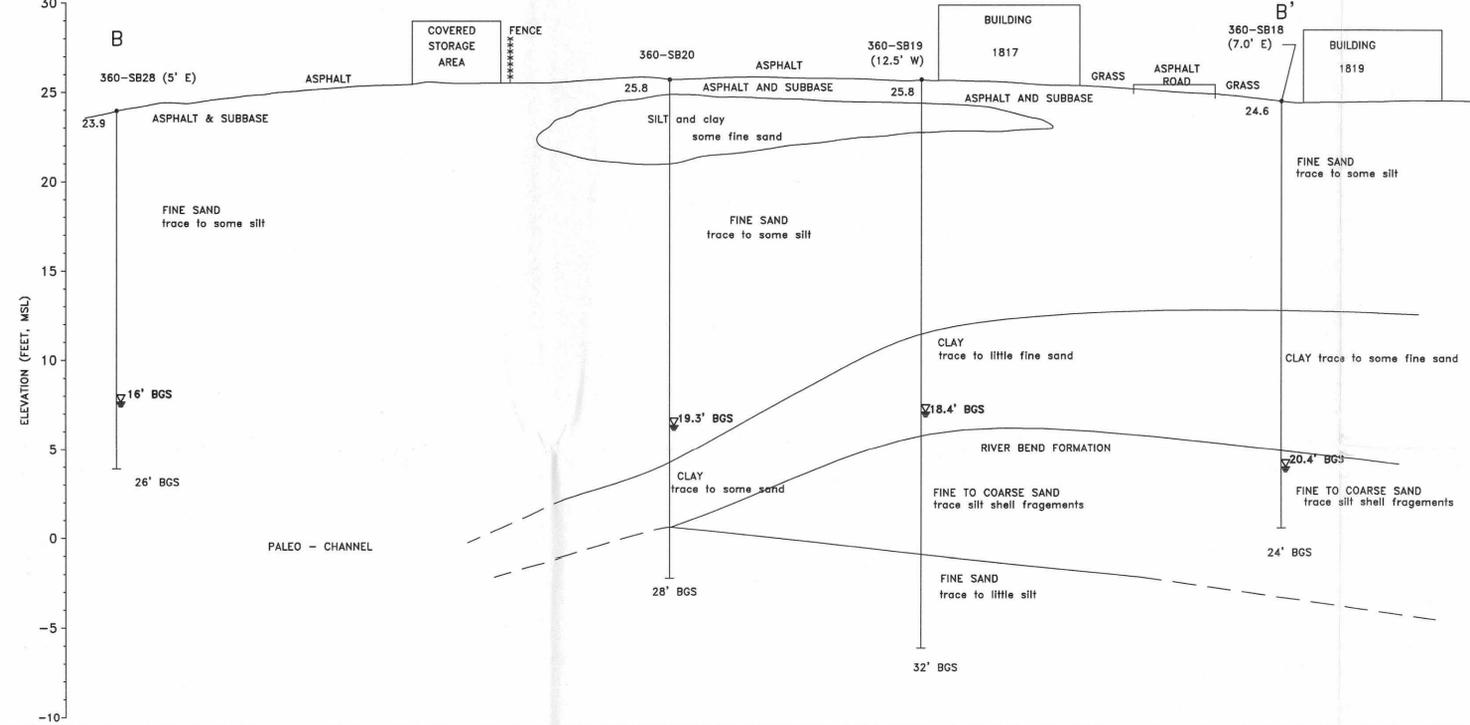
NORTHWEST

SOUTHEAST



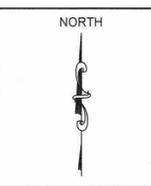
SOUTHWEST

NORTHEAST



REVISIONS

DRAWN JWS/RRR  
 REVIEWED RMS  
 S.O.# 26007-143  
 CADD# 3143360\_3\_3



MARINE CORPS BASE, CAMP LEJEUNE  
NORTH CAROLINA

BAKER ENVIRONMENTAL, Inc.  
Coraopolis, Pennsylvania



CROSS SECTION A-A' AND B-B'

SCALE AS SHOWN

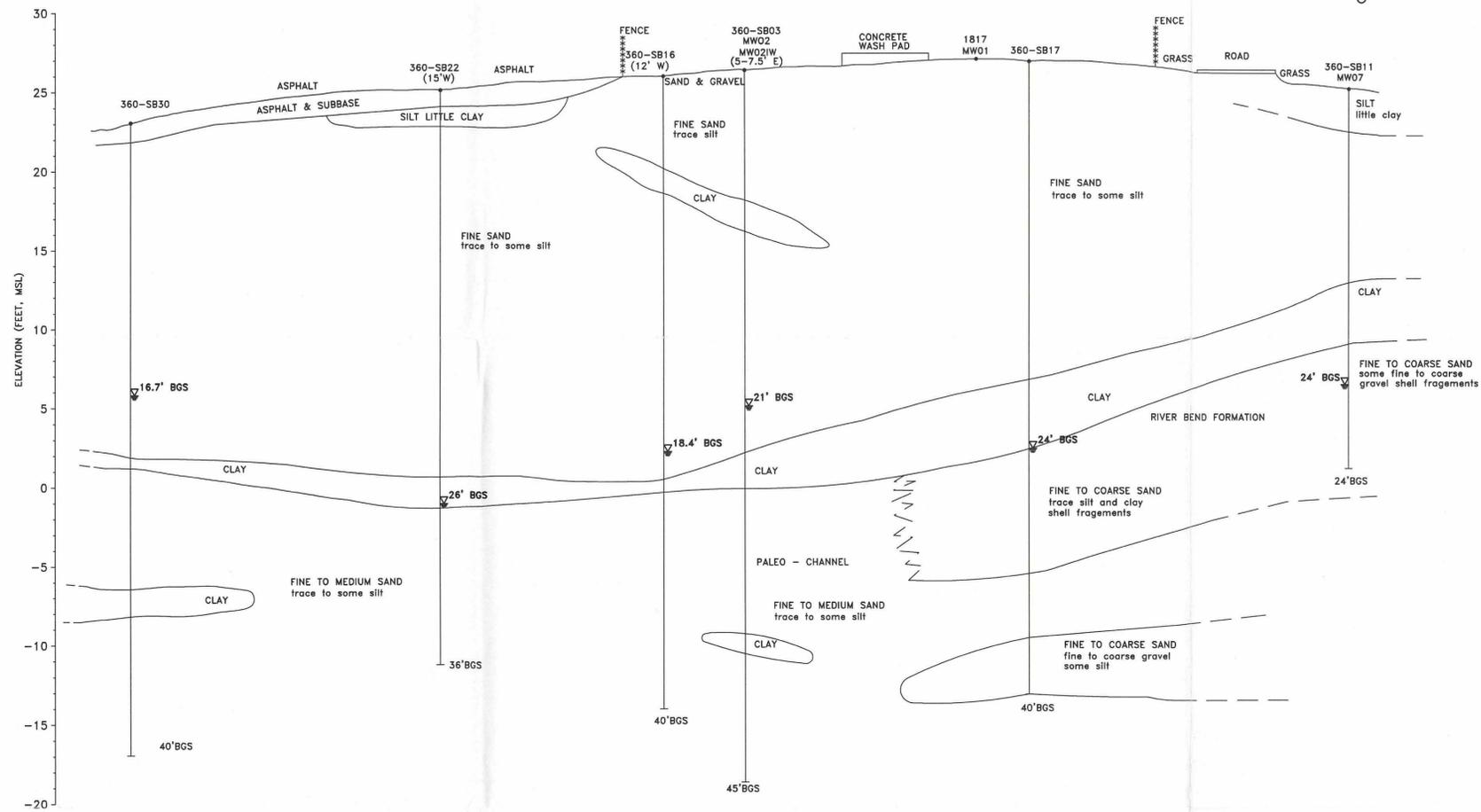
DATE NOVEMBER 2003

SHEET NO.

3-3

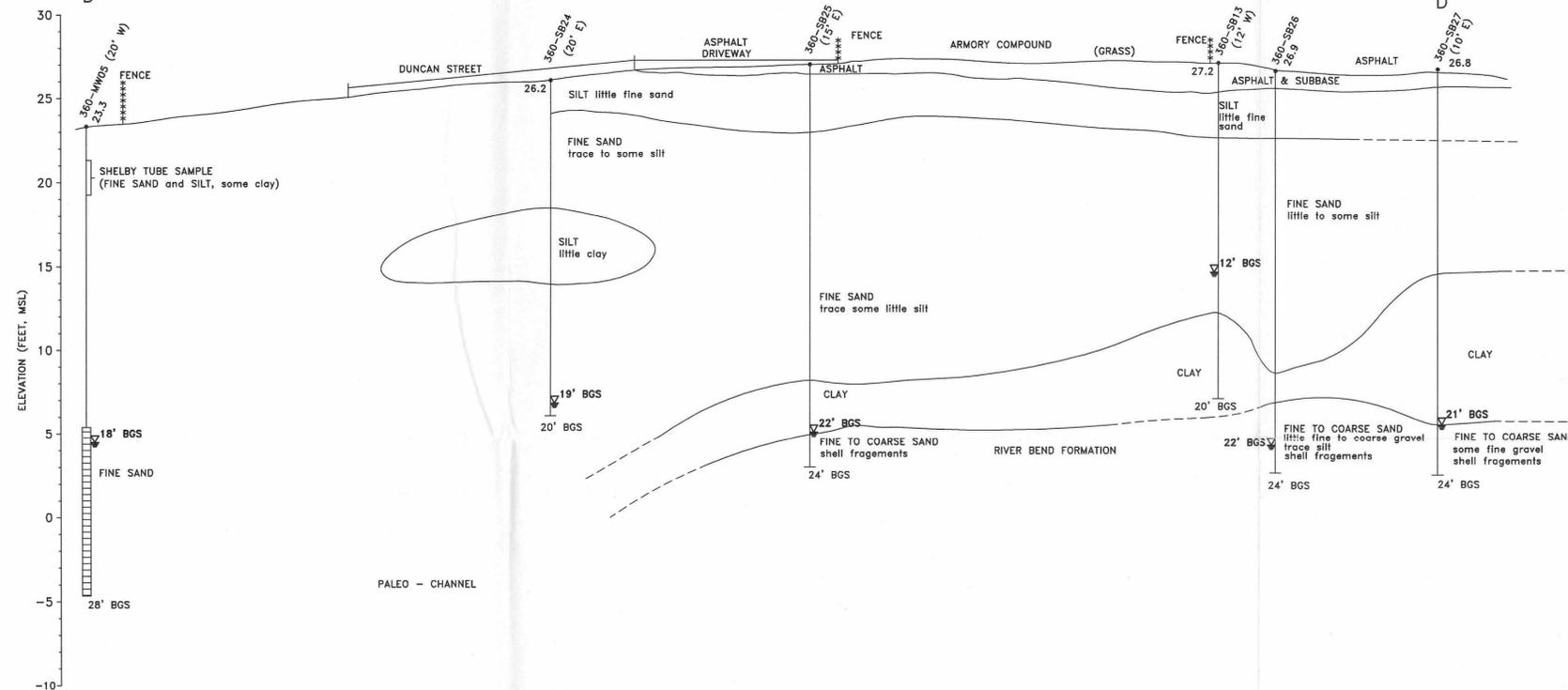
SOUTHWEST C

NORTHEAST C'



SOUTHWEST D

NORTHEAST D'



REVISIONS

DRAWN JWS/RRR  
 REVIEWED RMS  
 S.O.# 26007-143  
 CADD# 3143360\_3\_4

NORTH



MARINE CORPS BASE, CAMP LEJEUNE  
 NORTH CAROLINA

BAKER ENVIRONMENTAL, Inc.  
 Coraopolis, Pennsylvania

Baker

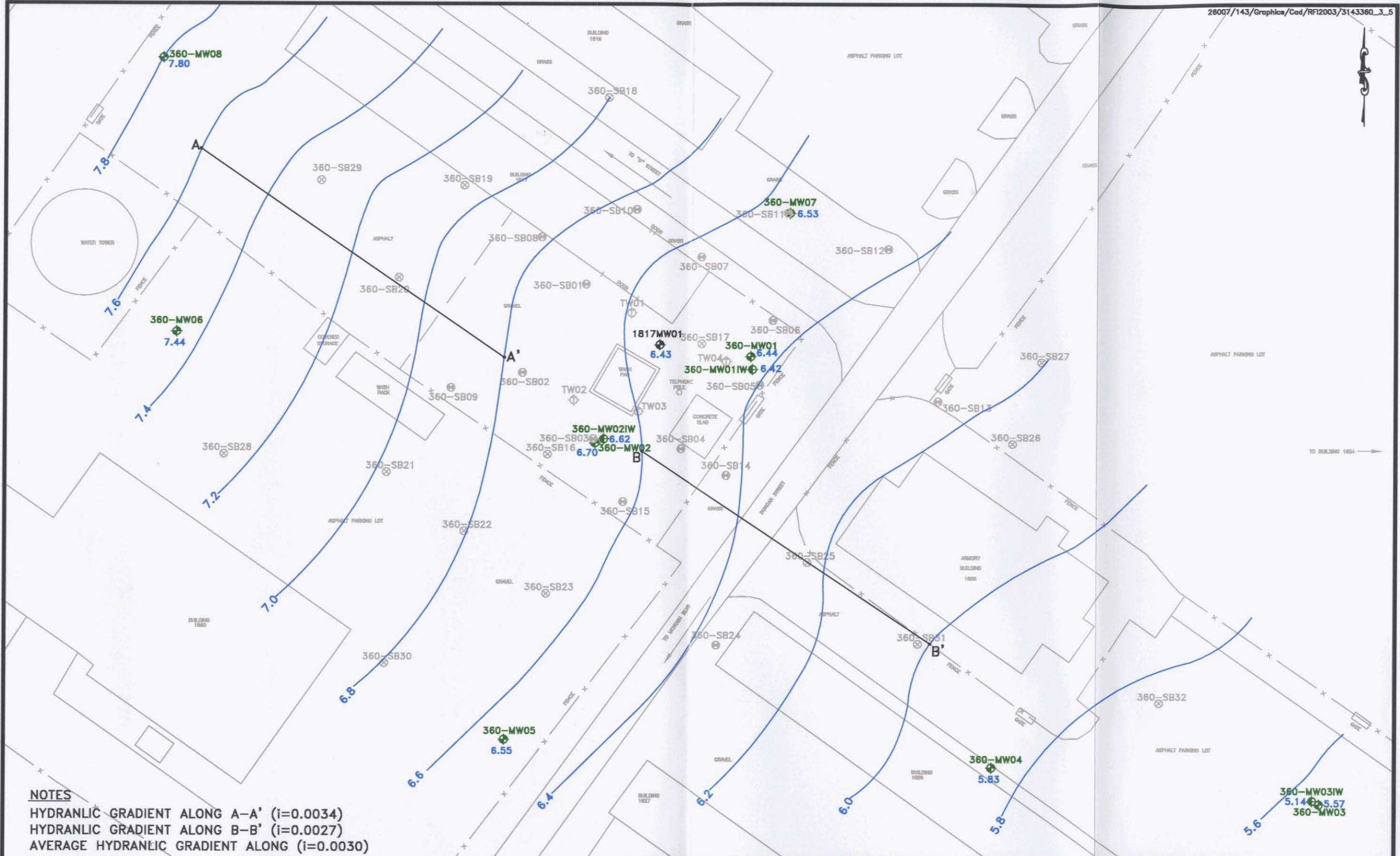
CROSS SECTION C-C' AND D-D'

SCALE AS SHOWN

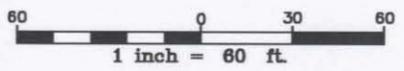
DATE NOVEMBER 2003

SHEET NO.

3-4



**NOTES**  
 HYDRANLIC GRADIENT ALONG A-A' (i=0.0034)  
 HYDRANLIC GRADIENT ALONG B-B' (i=0.0027)  
 AVERAGE HYDRANLIC GRADIENT ALONG (i=0.0030)



**Baker**

- LEGEND**
- ⊕ - PHASE II TEMPORARY WELL
  - ⊗ - EXISTING MONITORING WELL
  - ⊙ - MONITORING WELL LOCATION
  - ⊕ - INTERMEDIATE MONITORING WELL LOCATION
  - ⊗ - SOIL BORING AND GROUND WATER GRAB LOCATION
  - ⊙ - GROUND WATER GRAB LOCATION
- MARINE CORPS BASE, CAMP LEJEUNE

**FIGURE 3-5**  
 GROUNDWATER CONTOUR MAP  
 SURFICIAL AQUIFER POTENTIOMETRIC SURFACE  
 RCRA FACILITY INVESTIGATION  
 SWMU 360, CTO-143  
 MARINE CORPS BASE, CAMP LEJEUNE  
 NORTH CAROLINA

#### 4.0 ANALYTICAL RESULTS AND EXTENT OF CONTAMINATION

This section presents information regarding the nature and extent of contamination related to SMWU 360. This contaminant characterization was accomplished by mobile and fixed-base laboratory analysis of soil and groundwater samples. Sections 4.1 through 4.3 discuss data quality, comparison criteria, and provide information regarding data usability. Section 4.4 discusses the nature and extent of the constituents of concern.

##### 4.1 Data Quality

This RFI consisted of field-based analysis of VOCs in soil and groundwater and fixed-base analysis for VOCs, SVOCs, pesticides and metals analysis. Fixed-base laboratory data were validated using procedures established by the National Functional Guidelines for Organic and Inorganic Analyses (USEPA, 1994). Validation of the analytical data, through established procedures, served to reduce the inherent uncertainties associated with its usability. Data qualified as "J" were retained as estimated values. Estimated analytical results within a data set are common and considered usable by the USEPA. Data may be qualified as estimated for several reasons, including an exceedence of holding times, high or low surrogate recovery, or intra-sample variability. In addition, values may be assigned an estimated "J" qualifier if the reported value is below the Contract Required Detection Limit (CRDL) or the Contract Required Quantitation Limit (CRQL).

Additional data qualifiers were employed during the validation of data. Compounds that were not detected were assigned the "U" qualifier and those non-detected compounds that had inaccurate or imprecise quantitation limits were assigned the "UJ" qualifier.

Split samples were collected to assess the reliability of the mobile laboratory. Samples were split for analysis via SW-846 Method 8260B (OLMO 4.2) at a fixed-base laboratory. Approximately 20 percent of samples collected for the mobile laboratory were split with the fixed-base laboratory. Table 4-1 compares sample split data. An examination of Table 4-1 shows that the split data indicates that mobile laboratory results were generally higher than results seen in the fixed-based laboratory results. That is an indication that the mobile laboratory results provided conservative information to make field decisions in terms of investigation direction and termination.

Groundwater grab samples collected and analyzed for VOCs by both of the mobile laboratories utilized during this investigation were used as field based tools to guide the groundwater investigation. No split samples for VOCs in groundwater were collected during the investigation at SWMU 360. However, fixed-based laboratory analysis of VOCs in groundwater at the eleven groundwater monitoring wells was used to verify and confirm extent of groundwater contamination at SWMU 360. The results from both mobile laboratories, even though two different methods of analysis were used, correlated well between the two mobile labs and with the results from the eleven monitoring wells. Therefore, the VOC results in groundwater were considered viable and were used to determine the extent of groundwater contamination.

#### **4.1.1 Laboratory and Non-Site Related Contaminants**

Some organic and inorganic constituents detected in soil and groundwater at SWMU 360 can be attributed to non-site related conditions or activities. Two primary sources of non-site related results include laboratory contaminants and naturally occurring inorganic elements. In addition, non-site related operational activities and conditions might contribute to "on-site" contamination. A discussion of non-site related analytical results is provided in the sections that follow, and includes laboratory contaminants, non-site related contaminants, and naturally occurring inorganic elements.

Blank samples provide a measure of contamination that has been introduced into a sample set during the collection, transportation, preparation, and/or analysis of samples. To remove non-site related contaminants from further consideration, the concentrations of chemicals detected in blanks were compared with concentrations of the same chemicals detected in environmental samples. These blank samples include trip blanks, rinsate blanks, and field blanks. Rinsate blanks were collected from the sampling equipment to ensure that decontamination procedures were effective in cleaning the field equipment. Field blanks were collected from the potable water source used during drilling (FB01), laboratory grade water (FB02) and distilled water purchased and used for decontamination purposes (FB03). Table 4-2 provides a summary of all compounds detected in blank samples.

Common laboratory contaminants (i.e., acetone, 2-butanone, methylene chloride, toluene, and phthalate esters) were considered as positive results in field samples only when observed concentrations exceeded ten times the maximum concentration detected in any blank. If the concentration of a common laboratory contaminant was less than ten times the maximum blank

concentration, then it was concluded that the chemical was not detected in that particular sample unless the history of the site included the use of that chemical (USEPA, 1989). The only two common laboratory contaminants found in blank samples for SWMU 360 were acetone at 17 to 23 micrograms per liter ( $\mu\text{g/L}$ ) and methylene chloride ranging from 2.2 to 4.5  $\mu\text{g/L}$ .

Other constituents contained in blanks that are not considered common laboratory contaminants were considered as positive results in field samples only when observed concentrations exceeded five times the maximum concentration detected in any blank (USEPA, 1989). All TCL compounds of less than five times the maximum level of contamination noted in any blank were considered to be not detected in that sample. The detections of VOCs (bromodichloromethane, chloroform and dibromochloromethane) typically are associated with disinfection byproducts and may be related to the use of base potable water during equipment decontamination. The maximum concentrations of all other detected blank contaminants were as follows:

Bromodichloromethane	10 $\mu\text{g/L}$
Chloroform	21 $\mu\text{g/L}$
Dibromochloromethane	4.9 $\mu\text{g/L}$
Barium (total)	1.2J $\mu\text{g/L}$
Cadmium (total)	0.46J $\mu\text{g/L}$
Chromium (total)	4.8J $\mu\text{g/L}$
Selenium (total)	3.5J $\mu\text{g/L}$
Silver (total)	2.5J $\mu\text{g/L}$

#### 4.1.2 Naturally Occurring Inorganic Elements

A soil base background study was conducted at MCB, Camp Lejeune in June and July 2000. A subsequent base-wide groundwater investigation was conducted in March and April 2002 to establish background concentrations. Naturally occurring inorganics constituents occur ubiquitously in soil and groundwater; therefore, distinguishing between background levels and site-related concentrations is difficult. Because many naturally occurring inorganic constituents also may be of anthropogenic origin, an appropriate number of background samples were obtained to distinguish naturally occurring concentrations.

As a part of the background soil investigation, a total of 50 surface soil samples and 50 subsurface soil samples were collected from 50 soil borings in areas that had no known history of any activity that may bias inorganic concentrations in surface and subsurface soils (Baker, 2001a). All soil samples were analyzed for Target Analyte List (TAL) inorganics (Method 601 OB/7471A) and pH (ASTM Standard D 4972-95A, US EPA Method 9045). The inorganic analysis results were subsequently validated.

In general, inorganic constituents were detected at similar levels of concentration in the surface and subsurface samples collected as part of this investigation. There were observed differences between the datasets but these differences are primarily based upon the soil type in each soil horizon. As the soils were separated into datasets based on their soil type, it became apparent that the majority of the constituents were more prevalent in the fine-grained soils (clay and silts) than in coarse-grained soils (sands). This was an expected finding since metals are known to adsorb onto clays through the formation of ionic bonds.

For the groundwater investigation, temporary groundwater monitoring wells were installed in 25 of the 50 locations previously selected for the soil investigation to provide spatial coverage across the Base (Baker, 2002a). Two clustered monitoring wells were installed at each of the 25 locations. Each cluster contained one shallow well (upper surficial aquifer) and one deep well (lower surficial aquifer) for a total of 50 temporary wells. Samples were collected from the monitoring wells and analyzed for TAL inorganics analysis utilizing Method 601 OB/7471A. The inorganic analysis results were subsequently validated.

In general, similar inorganics were detected in both the shallow and deeper portions of the surficial aquifer during this investigation. The deeper portion of the surficial aquifer appeared to have a higher concentration of inorganics than the shallow portion.

The surface soil and subsurface soil data sets were segregated according to soil type. Groundwater data sets were segregated according to depth. After the data sets had been segregated, statistical analysis was performed on the background soil and groundwater sample set. This was done to determine distribution of the data, to identify outliers, to determine means and standard deviations, and to compare data sets of different lithology and depth.

An Area of Concern (AOC) background study was also conducted at the Base in June and July 2000 (Baker, 2001b). AOCs were established based on geographical location, geology, and type

of SWMU(s). The purpose of this investigation was to establish a background concentration for the group of SWMUs within the AOCs that would be representative of conditions immediately surrounding to the SWMU (resultant of Base activities in that area). This investigation differed from the base-wide investigation in that the purpose of this data set was to establish a background for the area of the base where these SWMUs were located. These samples should reflect impacts on the area from Base activities not associated with the SWMU. An inorganic constituent could be eliminated as a COPC if its concentration is less than AOC background; arguing that the concentration is a result of Base activities in that AOC and is not directly associated with the SWMU.

Surface and subsurface soil samples were collected from 165 borings. All soil samples were analyzed for TAL inorganics (EPA Method 6010B/7471A), pH (ASTM Standard D 4972-95A, USEPA Method 9045), and TOC (SSTM Standard D 2178) for select samples. These results were also statistically evaluated.

#### **4.2 Comparison Criteria and Standards**

Constituent concentrations in surface and subsurface soil are compared to three main criteria; USEPA Region IX PRGs, North Carolina Soil-to-Groundwater values (STGCs), and background. Within the background criterion are base-wide background and AOC 7 background. Constituent concentrations in groundwater are compared to two main criteria; North Carolina Water Groundwater Quality Standards (2L Standards) and base-wide background. The paragraphs that follow discuss details regarding each screening criteria.

**Region IX Residential Soil and Tap Water PRGs - (USEPA, 2003a)** - Region IX PRGs are risk-based tools for evaluating and cleaning up contaminated sites. They are being used to streamline and standardize all stages of the risk decision-making process. The Region IX PRGs combines current EPA toxicity values with "standard" exposure factors to estimate constituent concentration in environmental media (soil, water, and air) that are considered protective of humans, including sensitive groups, over a lifetime. Chemical concentrations above these levels would not automatically trigger a response action; however, exceeding a PRG suggests that further evaluation of the potential risks that may be posed by site contamination is appropriate.

The PRG concentrations can be used to screen pollutants in environmental media, trigger further investigation, and provide an initial cleanup goal if applicable. The land use in and around

SWMU 360 is more industrial than residential. However, some surrounding areas are utilized for military housing. Therefore, residential PRGs were used to take the conservative approach assessing SWMU 360.

**North Carolina Soil-to-Groundwater Concentrations – (NC, 1996).** Soil-to-Groundwater concentrations numbers are determined by North Carolina and are based on the current Groundwater Protection Standard (2L) or Interim Maximum Allowable Concentrations (IMAC). If there are no 2L or IMAC, Soil-to-Groundwater concentrations were calculated using the recommended 2L, or if not available the Maximum Contaminant Levels Goals (MCLG), which is based on a  $10^{-6}$  carcinogenic risk.

**North Carolina Water Quality Standards for Groundwater (NC, 2002) – North Carolina Water Quality Standards (NCWQS)** 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. The NCWQS is also known as the 2L Standard.

**Base Background (Soil and Groundwater)/AOC-Specific Background (Soil) -** It was apparent from statistical analysis that inorganic constituent were normally or log-normally distributed. Constituents with frequent non-detections were neither normally nor log-normally distributed. Base background screening criteria for normally distributed constituents or neither distribution pattern was based on the arithmetic mean, plus two standard deviations. Base background screening criteria for log-normally distributed constituents was based on the log arithmetic mean, plus two standard deviations. The following background criteria were used to evaluate the site-specific data and are presented in Appendix G:

- Base Background – fine sand surface soil data set
- Base Background - sand subsurface soil data set
- Base Background - shallow groundwater data set
- Base Background - deep groundwater data set
- AOC-Specific Background – AOC 7 surface and subsurface soil data set

The following decision process has been adopted for this report to screen each constituent to determine if an evaluation of the nature and extent of that constituent is warranted:

- If a constituent exceeds PRGs, and/or STGCs, and background (inorganics only), that constituent might be related to SWMU activity, and an evaluation of the nature and extent will be performed (Section 4.5).
- If a constituent exceeds PRGs and/or STGCs, but not background that constituent likely represents background conditions and is not related to SWMU activity. An evaluation of the nature and extent will not be performed.
- If a constituent does not exceed PRGs, STGCs, or background an evaluation of the nature and extent that constituent will not be performed.
- If a constituent exceeds background but not PRGs and/or STGCs that constituent might be related to SWMU activity, but poses no risk to human health or groundwater. An evaluation of the nature and extent will not be performed.

Human health and ecological risk assessments generally follow guidelines that are independent of any discussion regarding the nature and extent of contamination. Thus, the list of COPCs may differ between the nature and extent and the risk assessments. Resolution of any differences will be performed in Section 8.0, Conclusions and Recommendations.

#### **4.3 Data Usability**

Data usability refers to the validity of the data and how the data is used to determine the extent of contamination. The data validation did not report on any significant problems with the data set. For soils and groundwater, the mobile laboratory was able to achieve method detection limits below PRGs, STGCs, NC 2L Standards and Region IX Tap Water standards. However, the fixed-base laboratory was not able to achieve method detection limits below PRGs, STGCs, NC 2L Standards and Region IX Tap Water standards for a few VOCs (Benzene, chloroform, TCE, and PCE) in soil and groundwater. The fixed-based laboratory did achieve instrument detection limits below the PRGs, STGCs, NC 2L Standards and Region IX Tap Water standards for these compounds. The detections of these compounds were reported as such.

In accordance to NC 2L Groundwater Quality Standards, the extent of the VOC constituents will be to “practical quantitation limits” (detection limits). The extent of metal constituents will be based on background comparisons.

The Phase II CSI data was used to remove SWMUs from further investigation, or to screen (reduce) the list of constituents for subsequent investigations. Thus, the CSI data is not intended to be re-evaluated in this nature and extent section, but rather to supplement the RFI data in establishing the nature and extent of contamination. Section 1.3 identifies COPCs from previous investigations, which are discussed Section 4.4.3 in context of the RFI data. Sections 6.2 and 7.2 discuss which data sets were used in the risk assessments, and how the data was applied.

#### **4.4 Nature and Extent of Contamination**

This section presents the results of the soil and groundwater investigations performed at SWMU 360. Summaries of detections obtained from the mobile laboratory and fixed-base laboratories are presented in Table 4-3 through Table 4-8. A complete summary of laboratory analytical data is presented in Appendix H.

##### **4.4.1 Soil Investigation**

The mobile lab data was used to determine the extent of subsurface soil contamination. As mentioned previously, the results of split samples indicate that the concentrations reported by the mobile laboratory were higher than the results obtained from the fixed-based laboratory. Therefore, the area of subsurface soil contamination found at SWMU 360 should be considered conservative. Actual extent of contamination may be smaller.

The soil investigation at SWMU 360 was conducted in a tiered perimeter approach. Surface and subsurface soil samples were collected around SWMU 360 to determine if soil in the vicinity of the SWMU has been impacted during SWMU-related operations. Soil samples were collected as previously described in Section 2.1 and Section 2.1.1. Mobile lab results indicated no surface soil contamination existed at SWMU 360. However, mobile lab results indicated subsurface soil contamination above North Carolina STGCs existed in several "A-tier" borings. Therefore, "B-Tier" soil borings were subsequently installed. After results were evaluated from the mobile lab, it was observed that the soil contamination was only detected in one "B-Tier" soil boring SWMU360-SB14 in one soil sample SWMU360-SB14-06. Therefore, soil contamination found at SWMU 360 was considered bounded and defined by the "B-tier" borings.

Soil contamination at SWMU 360 consists mainly of PCE. PCE was detected at concentrations exceeding the STGCs in SWMU360-SB04, SB05, SB06, SB07, and SB14. Concentrations of PCE ranging from 13 to 118 micrograms per kilogram ( $\mu\text{g}/\text{kg}$ ) were detected in these borings (see Figure 4-1). The STGC for PCE is  $7.42 \mu\text{g}/\text{kg}$ . Exceedences of the STGC exist from the near surface (one to 3 feet bgs) down to the groundwater interface (approximately 21 feet bgs) in soil borings SWMU360-SB06 and SB07. These two borings exhibit the highest exceedences of PCE found on site in subsurface soil. This gives evidence that there may be another source for soil contamination around these borings located approximately 40 to 60 feet north/northeast of the former UST at SWMU 360. Two subsurface soil samples from each soil boring SWMU360-SB04 and SB05 have exceedences of PCE ranging from 22 to  $64 \mu\text{g}/\text{kg}$  and found from 7 to 21 feet bgs. The only other exceedence was observed in subsurface soil sample SWMU360-SB14-06 (11 to 13 feet bgs), PCE was detected at  $17 \mu\text{g}/\text{kg}$ .

TCE was detected in only one subsurface soil sample exceeding the STGC of  $18.3 \mu\text{g}/\text{kg}$ . TCE was detected at  $23 \mu\text{g}/\text{kg}$  in subsurface soil sample SWMU360-SB07-04.

Arsenic was detected in 20 of the 46 subsurface soil samples collected for RCRA metals at SWMU 360. All of these detections exceeded the USEPA Region IX PRG of 0.39 milligrams per kilogram ( $\text{mg}/\text{kg}$ ). Some of these detections exceeded background criteria AOC 7 at  $2.93 \text{ mg}/\text{kg}$  and Base Background for Subsurface Sands at  $1.62 \text{ mg}/\text{kg}$ . However, only two subsurface soil samples SWMU360-SB06-11 and SWMU360-SB07-12 exceeded all four of the screening criteria including the North Carolina soil to groundwater standard of  $5.24 \text{ mg}/\text{kg}$  (See Figure 4-2).

#### **4.4.2 Groundwater Investigation**

The groundwater investigation at SWMU 360 was conducted using the same tiered perimeter approach as the soil investigation. Groundwater grab samples were collected around SWMU 360 to determine if groundwater in the vicinity of the SWMU has been impacted during SWMU-related operations. Groundwater grab samples were collected from both "A and B Tiers" soil boring locations which included SWMU360-SB01 through SWMU360-SB15. Groundwater grab samples were collected as described in Section 2.2.2. Analytical results from the mobile lab showed elevated concentrations of chlorinated compounds in the groundwater samples collected from most of the "A and B Tier" borings. Therefore, subsequent borings SWMU360-SB16 through SWMU360-SB32 were installed to the east, west, and to the south creating "C, D, and E Tiers." During the investigation it was observed that groundwater contamination at depth

would need to be assessed to delineate the vertical extent of contamination. It was decided that vertical "profiling" of groundwater would provide important information on the extent of contamination and the data needed for the proper placement and construction of the groundwater monitoring wells.

Groundwater contamination at SWMU 360 consists mainly of TCE and PCE. These constituents were detected at concentrations exceeding the NC 2L standards and the Region IX PRGs for tap water at many of the sample locations across the study area. In order to better describe the groundwater contamination at SWMU 360, the shallow groundwater contamination will be discussed in the following paragraphs and then followed by a discussion of the intermediate groundwater contamination. This discussion of groundwater contamination will then be summarized in Section 4.4.3.

Shallow groundwater contamination at SWMU 360 exists across the entire study area. The highest concentrations of TCE, PCE, and cis-DCE were located around the area of the former UST in existing monitoring well 1817-MW01. This well was installed during the "Limited Site Assessment" conducted by Catlin Engineers and Scientists in 1997. Concentrations of PCE at 5100 µg/L, TCE at 460 µg/L and cis-DCE at 750 µg/L were detected in this monitoring well (Figure 4-3). These higher concentrations provide evidence that the former UST at SWMU 360 may be the primary source of contamination. See Figure 4-4, 4-5 and 4-6 for a graphical representation of the shallow groundwater plumes at SWMU 360.

Groundwater grab samples collected from 360-SB01, SB03 and SB05 showed the next highest concentrations of PCE, TCE and cis-DCE. The groundwater grab sample from 360-SB05 had concentrations of PCE at 211.7 µg/L, TCE at 30 µg/L and cis-DCE at 80 µg/L. The groundwater grab sample from 360-SB01 had concentrations of PCE at 160 µg/L, TCE at 13 µg/L and cis-DCE at 42 µg/L. PCE was not detected above criteria at 360-SB03. However, the groundwater grab sample from 360-SB03 had concentrations of TCE at 55 µg/L and cis-DCE at 316 µg/L (Figure 4-3).

Groundwater grab samples collected from down gradient locations 360-SB25, SB31, SB32 and the groundwater sample at MW04 showed elevated concentrations of PCE and TCE. Concentrations of PCE ranging from 13 to 17 µg/L and TCE ranging from 5 to 13 µg/L were detected at these sample locations. These elevated concentrations in the groundwater show that the extent of shallow groundwater contamination is not bounded in the down gradient direction

(southeast). However, TCE and PCE were not detected in the groundwater sample at 360-MW03. This monitoring well does somewhat bound the contamination to the southeast. However, not enough data has been collected to effectively delineate the shallow groundwater contamination in the down gradient direction (see Figure 4-4 and 4-5).

Groundwater grab results from 360-SB11, SB12 and SB18 showed shallow groundwater contamination did not extend any further to the north. These locations bounded the shallow groundwater contamination in this direction. Groundwater grab results from 360-SB26 and SB27 has somewhat bounded shallow groundwater contamination to the northeast direction. An additional sample point placed between 360-SB26 and 360-MW03 should verify and define the extent of contamination to the northeast. Other sample locations that provide boundaries of the shallow groundwater contamination include 360-SB23, SB24, SB30 and MW05. These locations bound the shallow groundwater contamination to the south (Figure 4-3).

Soil borings 360-SB21 and 360-SB28 were advanced within the communications compound to delineate the extent of groundwater contamination in the side gradient direction (south). Groundwater grab results from 360-SB21 and SB28 had elevated concentrations of PCE exceeding the NC 2L standards. Concentrations of PCE from 1 to 4 µg/L were detected in these samples.

Groundwater grab results from up gradient locations 360-SB01, SB02, SB08, SB09, SB10, SB19, SB20, SB29 and the groundwater sample from 360-MW08 showed concentrations of TCE exceeding both the NC 2L standards and Region IX PRG tap water criteria. Concentrations of TCE ranging from 3 to 13 µg/L were detected in these samples. These concentrations of TCE give evidence that a separate up gradient groundwater plume may exist at the site (Figure 4-5).

The deeper groundwater investigation at SWMU 360 was limited during this RFI. Groundwater samples were only collected down to 40 feet with the exception of the three intermediate monitoring wells, which were installed at 45 feet in depth. Therefore, a true assessment of deep groundwater contamination at this site cannot be conducted at this time. Vertical "profiling" was conducted at several locations including SWMU360-SB02, SB05, SB11, SB13, SB16, SB17, SB21, SB22, SB23, SB28, SB29, SB30, SB31 and SB32. Groundwater samples collected from these borings were limited to three samples per boring. Most of the groundwater samples collected from these locations (with some minor variability in depths) were collected from depths of 24 to 28 feet, 30 to 34 feet and 36 to 40 feet. These groundwater samples have provided a

good start to understanding what is going on at depth in and around SWMU 360. The following paragraphs reference the deepest sample intervals collected during this investigation.

The deeper groundwater grab results from locations 360-SB05, SB17, SB21, SB31, SB32 and the groundwater sample from MW01IW had elevated concentrations of PCE. Concentrations ranging from one to 10 µg/L were detected at these locations (Figure 4-7). All of these samples exceeded the NC 2L standard for PCE of 0.7 µg/L and the Region IX PRG tap water standard of 0.66 µg/L. The PCE contamination in these deeper samples has been bounded in the up gradient direction by 360-SB29 (Figure 4-8). Contamination has also been bounded to the northeast by 360-SB11 and SB13 and to the south by 360-SB16, SB23, and MW02IW. However, PCE contamination has not been defined in the down gradient direction (southeast), directly north, and also at depth.

The deeper groundwater grab results from locations 360-SB02, SB16, SB21, SB22, SB29, SB31, SB32 and the groundwater sample from MW02IW had elevated concentrations of TCE. Concentrations ranging from 4 to 10 µg/L were detected at these locations. All of these samples exceeded the NC 2L standard for TCE of 2.8 µg/L and the Region IX PRG tap water standard of 0.028 µg/L. These concentrations of TCE give evidence that the separate up gradient groundwater plume also exists at depth (Figure 4-9). The deeper groundwater samples collected at down gradient locations 360-SB31 and SB32 show that TCE contamination exists at depth. As with the PCE, the deeper groundwater contamination in the down gradient direction is not bounded and additional sampling is necessary to define the extent of contamination.

#### **4.4.3 Summary**

Previous investigations gave indication of organic and inorganic contamination in subsurface soil, including PCE, methylene chloride, bromoform, arsenic, and dieldrin. The findings of this RFI show that releases from SWMU 360 have impacted the surrounding subsurface soil.

In summary, earlier indications of potentially significant subsurface soil contamination at SWMU 360 were indicated in the RFI findings:

Indications of PCE contamination in subsurface soil were identified in soil borings 360-TW01A-10 (60 µg/kg), 360-TW04-06 (10 µg/kg), and 360-TW04A-11 (25 µg/kg) during the

Phase II CSI (Figure 1-3). This contamination was verified in the RFI at SWMU 360. PCE contamination of subsurface soils exists in the northeast corner of the compound as indicated in 360-SB04, SB05, SB06 and SB07 (Figure 4-1). Concentrations of PCE ranging from 13 to 118 µg/kg were detected in these borings. The North Carolina soil to groundwater standard for PCE is 7.42 µg/kg. These exceedences of the North Carolina soil to groundwater standards exist from the near surface down to the groundwater interface.

Arsenic was detected in one subsurface soil sample (360-TW04A-11 at 7.3 mg/kg) exceeding the STGC and PRG during the Phase II CSI (Figure 1-3). Arsenic was detected in 20 of the 46 subsurface soil samples collected during the RFI. All of the twenty detections of arsenic were found to exceed the PRG value of 0.39 mg/kg. However, only two of these 20 detections were found to exceed the STGC of 5.24 mg/kg. The three detections of arsenic exceeding the STGC were located in deeper subsurface soil samples collected from 21 to 25 feet bgs. The depth of these detections indicates that they are not caused by surface or near-surface releases. Therefore, these detections would not be related to the former UST and SWMU operations. The area-wide mean concentration of arsenic in soil is less than the STGC, indicating it would not impact groundwater.

Dieldrin was detected during the Phase II CSI in subsurface soil sample 360-TW01-01 (from one to 3 feet bgs) at a concentration exceeding the NC STGC. No pesticides were detected in surface or subsurface soil samples collected during the RFI at SWMU 360. This dieldrin exceedance is not related to SWMU operations and is likely to be attributable to pesticide application around Building 1817.

Previous investigations gave indication of organic contamination in groundwater, including PCE, TCE, cis-DCE, 4-methylphenol, acetophenone, alpha-BHC, Aldrin, alpha-chlordane, beta-BHC, 4,4'-DDE, 4,4'-DDT, gamma-chlordane, Heptachlor, and Heptachlor epoxide. The findings of this RFI show that releases from SWMU 360 have impacted the surrounding groundwater.

In summary, earlier indications of potentially significant groundwater contamination at SWMU 360 were indicated in the RFI findings:

- Indications of PCE contamination in groundwater was identified in groundwater samples collected from 360-TW01 (89 µg/L), TW03 (27 µg/L), and TW04 (800 µg/L) during the Phase II CSI at SWMU 360 (Figure 1-4). This contamination was verified in the RFI at

SWMU 360. PCE contamination was identified at concentrations ranging from 0.8 µg/L to 5100 µg/L. The highest concentration of PCE contamination (5100 µg/L) exists in 1817-MW01 located in the area of former UST at SWMU 360. This suggests that the primary source for the PCE contamination in groundwater was indeed the former UST at SWMU 360. The PCE contamination has been defined horizontally in all directions except for the down gradient direction (southeast) (Figure 4-4 and 4-8). However, the vertical extent of PCE contamination at SWMU 360 has not been defined due to the lack of deeper groundwater samples collected during this investigation. PCE contamination was also found in groundwater samples collected at 360-SB21 and SB28. Further investigation is needed inside the communications compound (south of SWMU 360) to assess and verify this separate groundwater issue.

- Indications of TCE contamination in groundwater was identified in groundwater samples collected from 360-TW01 (24 µg/L), TW02 (5 µg/L), TW03 (6 µg/L), and TW04 (75 µg/L) during the Phase II CSI at SWMU 360 (Figure 1-4). This contamination was verified in the RFI at SWMU 360. TCE contamination was identified at concentrations ranging from 3 µg/L to 460 µg/L. The highest concentration of TCE contamination (460 µg/L) exists in 1817-MW01 located in the area of former UST at SWMU 360 suggesting that the primary source for the TCE contamination in groundwater was indeed the former UST at SWMU 360. However, concentrations of TCE at up gradient locations 360-SB01, SB02, SB08, SB09, SB10, SB19, SB20, SB29 and groundwater results from MW08 (Figures 4-3 and 4-5) indicate another source for TCE contamination not related to SWMU 360. This TCE contamination also is detected in the intermediate groundwater samples collected up gradient of the UST (Figures 4-7 and 4-9). TCE contamination at SWMU 360 has been defined in the shallow groundwater in the side gradient directions. However, as with the up gradient direction, TCE contamination in the down gradient direction has not been bounded horizontally or vertically. Additional investigation is needed to assess and delineate the extent of TCE contamination horizontally and vertically in both the up gradient direction (northwest) and the down gradient direction (southeast) of SWMU 360.
- Cis-DCE and vinyl chloride were detected at concentrations exceeding comparison criteria during this RFI at SWMU 360 (Figures 4-3 and 4-7). The presence of these constituents provides evidence that biodegradation of the parent compound PCE has

occurred in groundwater. The exceedences of cis-DCE (80 to 750 µg/L) exist within the footprint of the PCE and TCE contamination found at SWMU 360 (Figures 4-6 and 4-10). However, the detections of vinyl chloride (one to 2 µg/L) exist in the intermediate groundwater samples collected at 360-SB21 and SB29 (Figure 4-7). Vinyl chloride was not detected above screening criteria in any of the monitoring wells at SWMU 360. These locations are up gradient of the SWMU and should be assessed during an additional investigation.

- Two semivolatiles (4-methylphenol, acetophenone) were detected during the Phase II CSI in groundwater (360-TW04) at concentrations exceeding the NC 2L standards (Figure 1-4). Three groundwater samples were analyzed for semivolatiles from 360-MW01, MW02, and MW07. No semivolatiles were detected at these locations during this RFI. Therefore, semivolatiles have been bounded and defined to exist locally at 360-TW04. Because semivolatiles were not confirmed in the groundwater at SWMU 360, it is possible that turbidity during sampling in this temporary well could have caused artificially elevated concentrations of semivolatiles.
- Some pesticides were detected at concentrations exceeding the NC 2L standards in 360-TW01, TW02, and TW04 (Figure 1-4) during the Phase II CSI. These pesticides were not detected in any of the groundwater samples collected during this RFI. Again, suspect turbidity in these temporary wells could have caused artificially elevated concentrations of pesticides during the Phase II CSI.
- The presence of methylene chloride, chloroform, and bromoform in environmental samples in all investigation phases may be linked to non-site related sources:
  - Methylene chloride was again detected during the RFI, and at similar levels as the Phase I and II CSIs. It is important to note that methylene chloride (a common laboratory contaminant) was also detected in several of the blank samples during the RFI and the Phase II CSI. Because detections of methylene chloride in soil samples are similar to blank sample detections and was frequently detected in blank samples, it is reasonable to conclude that methylene chloride is not SWMU related.
  - Chloroform was not detected in environmental samples collected during the RFI, but was detected in blank samples. Additionally, chloroform was detected in blank

samples from the Phase II CSI. This is an indication that the chloroform detections are not SWMU related. Professional experience indicates that chloroform is a by-product of water chlorination and has frequently been detected in potable water sources on the Base.

- Bromoform was not detected during the RFI in any environmental or blank samples. Because bromoform was not detected in any blank samples, it is difficult to dismiss its presence in the environmental samples as non-site related. However, professional experience indicates that bromoform is also a by-product of water chlorination. As with chloroform, bromoform has frequently been detected in potable water sources on Base.



*Baker Environmental, Inc.*

**SECTION 4.0**

***TABLES***



TABLE 4-1

**MOBILE AND FIXED-BASE LABORATORIES SPLIT SAMPLE COMPARISON  
VOCs IN SUBSURFACE SOIL  
RCRA FACILITY INVESTIGATION - SWMU 360  
MCB, CAMP LEJEUNE, NORTH CAROLINA**

Constituent	SWMU360-SB01-09 06-19-2003		SWMU360-SB02-09 6/19/2003		SWMU360-SB03-10 06-19-2003		SWMU360-SB04-02 6/19/2003	
	Sample	Split	Sample	Split	Sample	Split	Sample	Split
1,1-Dichloroethene	2 U	11 U	2 U	11 U	2	12 U	2 U	12 U
Benzene	2 U	12 U	2 U	11 U	2 U	12 U	1	1.5 J
cis-1,2-Dichloroethene	2 U	12 U	2 U	11 U	2 U	12 U	23	13
Methylene Chloride	2 U	12 U	2 U	11 U	2 U	12 U	2 U	12 U
Tetrachloroethene	6	1.4 J	2 U	11 U	3	12 U	2 U	11 U
trans-1,2-Dichloroethene	2 U	12 U	2 U	11 U	2 U	12 U	2 U	0.92 J
Trichloroethene	2 U	12 U	2 U	11 U	2 U	12 U	2 U	12 U
Constituent	SWMU360-SB05-06 6/19/2003		SWMU360-SB06-11 6/19/2003		SWMU360-SB07-04 6/19/2003		SWMU360-SB08-10 6/20/2003	
	Sample	Split	Sample	Split	Sample	Split	Sample	Split
1,1-Dichloroethene	2 U	11 U	2 U	11 U	2 U	11 U	2 U	11 U
Benzene	2 U	11 U	2 U	11 U	2 U	11 U	2 U	11 U
cis-1,2-Dichloroethene	2 U	11 U	8	11 U	2 U	11 U	2 U	11 U
Methylene Chloride	2 U	11 U	2 U	11 U	2 U	11 U	2 U	11 U
Tetrachloroethene	5	11 U	84	7.9 J	13	11 U	2 U	11 U
trans-1,2-Dichloroethene	2 U	11 U	2 U	11 U	2 U	11 U	2 U	11 U
Trichloroethene	2 U	11 U	4	11 U	2 U	11 U	2 U	11 U
Constituent	SWMU360-SB10-01 6/22/2003		SWMU360-SB11-09 6/20/2003		SWMU360-SB12-04 6/20/2003		SWMU360-SB13-04 06-23-2003	
	Sample	Split	Sample	Split	Sample	Split	Sample	Split
1,1-Dichloroethene	2 U	11 U	2 U	11 U	2 U	11 U	2 U	11 U
Benzene	2 U	11 U	2 U	11 U	2 U	11 U	2 U	11 U
cis-1,2-Dichloroethene	2 U	11 U	2 U	11 U	2 U	11 U	2 U	11 U
Methylene Chloride	2 U	11 U	2 U	11 U	2 U	11 U	2 U	11 U
Tetrachloroethene	7	11 U	6	11 U	2 U	11 U	2 U	11 U
trans-1,2-Dichloroethene	2 U	11 U	2 U	11 U	2 U	11 U	2 U	11 U
Trichloroethene	2 U	11 U	2 U	11 U	2 U	11 U	2 U	11 U
Constituent	SWMU360-SB14-04 6/20/2003		SWMU360-SB15-05 6/20/2003		SWMU360-SB16-09 6/24/2003			
	Sample	Split	Sample	Split	Sample	Split		
1,1-Dichloroethene	2 U	11 U	2 U	11 U	5	11 U		
Benzene	2 U	11 U	2 U	11 U	2 U	11 U		
cis-1,2-Dichloroethene	12	11 U	2 U	11 U	2 U	11 U		
Methylene Chloride	2 U	11 U	2 U	11 U	2 U	11 U		
Tetrachloroethene	2 U	11 U	6	11 U	2 U	11 U		
trans-1,2-Dichloroethene	2	11 U	2 U	11 U	2 U	11 U		
Trichloroethene	3	11 U	2 U	11 U	2 U	11 U		

## Notes:

U - not detected above the method detection limit

J - value estimated; detected below the method detection limit

TABLE 4-2

POSITIVE DETECTION IN BLANK SAMPLES  
 SWMU 360  
 RCRA FACILITY INVESTIGATION  
 MCB, CAMP LEJEUNE, NORTH CAROLINA

Constituent	Blank Samples collected for SWMU 360												
	ER03	ER04	ER06	ER08	ER09	FB01	FB02	FB03	TB02	TB03	TB05	TB09	TB10
<b>Volatiles (ug/L)</b>													
Acetone	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	23	17	10 U	10 U	10 U
Bromodichloromethane	10 U	10 U	10 U	10 U	10 U	10	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Chloroform	10 U	10 U	10 U	10 U	10 U	21	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Dibromochloromethane	10 U	10 U	10 U	10 U	10 U	4.9 J	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Methylene Chloride	3.8 J	4.5 J	3.9 J	10 U	2.2 J	10 U	10 U	10 U	2.3 J	2.4 J	10 U	10 U	10 U
<b>Metals (ug/L)</b>													
Barium	10 U	10 U	10 U	1.2 J	10 U	0.8 U	0.8 U	0.8 U	NA	NA	NA	NA	NA
Cadmium	10 U	10 U	10 U	0.46 J	10 U	0.4 U	0.4 U	0.4 U	NA	NA	NA	NA	NA
Chromium	4.8 J	4.6 J	4.4 J	10 U	10 U	0.6 U	0.6 U	0.6 U	NA	NA	NA	NA	NA
Selenium	10 U	10 U	10 U	3.5 J	10 U	3 U	3 U	3 U	NA	NA	NA	NA	NA
Silver	2.5 J	2.3 J	2.1 J	10 U	10 U	1 U	1 U	1 U	NA	NA	NA	NA	NA

Notes:

ER - Equipment Rinsate

FB - Field Blank

TB - Trip Blank

U - Not detected above the method detection limit

J - Value estimated; detected below the method detection limit

NA - Not analyzed

TABLE 4-3

SURFACE SOIL ANALYTICAL RESULTS SUMMARY - MOBILE LAB DATA  
SWMU 360  
RCRA FACILITY INVESTIGATION - CTO-0143  
MCB, CAMP LEJEUNE, NORTH CAROLINA

Site Sample I.D.	SWMU360-SB01-00	SWMU360-SB02-00	SWMU360-SB03-00	SWMU360-SB04-00	SWMU360-SB05-00	SWMU360-SB06-00	SWMU360-SB07-00
Sample Date	06-19-2003	06-19-2003	06-19-2003	06-19-2003	06-19-2003	06-19-2003	06-19-2003
Depth Range	0-1	0-1	0-1	0-1	0-1	0-1	0-1

Volatiles (ug/kg)

No Hits Detected

TABLE 4-3

**SURFACE SOIL ANALYTICAL RESULTS SUMMARY - MOBILE LAB DATA**  
**SWMU 360**  
**RCRA FACILITY INVESTIGATION - CTO-0143**  
**MCB, CAMP LEJEUNE, NORTH CAROLINA**

Site Sample I.D.	SWMU360-SB08-00	SWMU360-SB09-00	SWMU360-SB10-00	SWMU360-SB11-00	SWMU360-SB12-00	SWMU360-SB15-00
Sample Date	06-20-2003	06-20-2003	06-22-2003	06-20-2003	06-20-2003	06-20-2003
Depth Range	0-1	0-1	0-1	0-1	0-1	0-1

**Volatiles (ug/kg)**

**No Hits Detected**

TABLE 4-4

SUBSURFACE SOILS COMPARISON SUMMARY - MOBILE LAB DATA  
 SWMU 360  
 RCRA FACILITY INVESTIGATION - CTO-0143  
 MCB, CAMP LEJEUNE, NORTH CAROLINA

Site Sample I.D.	USEPA Region IX PRGs Residential	NC Soil to Groundwater Standards	SWMU360-SB01-01 06-19-2003 1-3	SWMU360-SB01-02 06-19-2003 3-5	SWMU360-SB01-04 06-19-2003 7-9	SWMU360-SB01-07 06-19-2003 13-15	SWMU360-SB01-09 06-19-2003 17-19	SWMU360-SB02-01 06-19-2003 1-3
<b>Volatiles (ug/kg)</b>								
1,1-Dichloroethene	120000	44.5	2 U	2 U	2 U	2 U	2 U	2 U
Benzene	600	5.62	2 U	2 U	2 U	2 U	2 U	2 U
cis-1,2-Dichloroethene	43000	350	2 U	2 U	2 U	2 U	2 U	2 U
Tetrachloroethene	1500	7.42	2 U	2 U	2 U	2 U	6	6
Trichloroethene	53	18.3	2 U	3	2 U	2 U	2 U	2 U
trans-1,2-Dichloroethene	69000	380	2 U	2 U	2 U	2 U	2 U	2 U

Notes: Shaded - Exceeds USEPA Region IX PRGs  
 Bold - Exceeds NC DENR soil to groundwater comparison criteria  
 J - Analyte detected. Report value is estimated.  
 U - Not Detected

TABLE 4-4

**SUBSURFACE SOILS COMPARISON SUMMARY - MOBILE LAB DATA**  
**SWMU 360**  
**RCRA FACILITY INVESTIGATION - CTO-0143**  
**MCB, CAMP LEJEUNE, NORTH CAROLINA**

Site Sample I.D.	USEPA Region IX PRGs Residential	NC Soil to Groundwater Standards	SWMU360-SB02-02 06-19-2003 3-5	SWMU360-SB02-05 06-19-2003 9-11	SWMU360-SB02-09 06-19-2003 17-19	SWMU360-SB03-01 06-19-2003 1-3	SWMU360-SB03-02 06-19-2003 3-5	SWMU360-SB03-05 06-19-2003 9-11
<b>Volatiles (ug/kg)</b>								
1,1-Dichloroethene	120000	44.5	2 U	2 U	2 U	2 U	2 U	2 U
Benzene	600	5.62	2 U	2 U	2 U	2 U	2 U	2 U
cis-1,2-Dichloroethene	43000	350	2 U	2 U	2 U	2 U	2 U	2 U
Tetrachloroethene	1500	7.42	5	2 U	2 U	2 U	2 U	2 U
Trichloroethene	53	18.3	2 U	2 U	2 U	2 U	2 U	2 U
trans-1,2-Dichloroethene	69000	380	2 U	2 U	2 U	2 U	2 U	2 U

Notes: Shaded - Exceeds USEPA Region I  
 Bold - Exceeds NC DENR soil to g  
 J - Analyte detected. Report value :  
 U - Not Detected

TABLE 4-4

SUBSURFACE SOILS COMPARISON SUMMARY - MOBILE LAB DATA  
 SWMU 360  
 RCRA FACILITY INVESTIGATION - CTO-0143  
 MCB, CAMP LEJEUNE, NORTH CAROLINA

Site Sample I.D.	USEPA Region IX PRGs Residential	NC Soil to Groundwater Standards	SWMU360-SB03-10 06-19-2003 19-21	SWMU360-SB04-02 06-19-2003 3-5	SWMU360-SB04-06 06-19-2003 11-13	SWMU360-SB04-08 06-19-2003 15-17	SWMU360-SB04-10 06-19-2003 19-21	SWMU360-SB05-01 06-19-2003 1-3
<b>Volatiles (ug/kg)</b>								
1,1-Dichloroethene	120000	44.5	2	2 U	2 U	2 U	9	2 U
Benzene	600	5.62	2 U	2 U	5	5	2 U	2 U
cis-1,2-Dichloroethene	43000	350	2 U	23	213	237	12	2 U
Tetrachloroethene	1500	7.42	3	2 U	2 U	<b>34</b>	<b>22</b>	2 U
Trichloroethene	53	18.3	2 U	2 U	2 U	3	2 U	2 U
trans-1,2-Dichloroethene	69000	380	2 U	2 U	3	4	2 U	2 U

Notes: Shaded - Exceeds USEPA Region I  
 Bold - Exceeds NC DENR soil to g  
 J - Analyte detected. Report value :  
 U - Not Detected

TABLE 4-4

SUBSURFACE SOILS COMPARISON SUMMARY - MOBILE LAB DATA  
 SWMU 360  
 RCRA FACILITY INVESTIGATION - CTO-0143  
 MCB, CAMP LEJEUNE, NORTH CAROLINA

Site Sample I.D.	USEPA Region * IX PRGs Residential	NC Soil to Groundwater Standards	SWMU360-SB05-04 06-19-2003 7-9	SWMU360-SB05-06 06-19-2003 11-13	SWMU360-SB05-08 06-19-2003 15-17	SWMU360-SB06-01 06-19-2003 1-3	SWMU360-SB06-02 06-19-2003 3-5	SWMU360-SB06-04 06-19-2003 7-9
<b>Volatiles (ug/kg)</b>								
1,1-Dichloroethene	120000	44.5	2 U	2 U	2 U	2 U	2 U	3
Benzene	600	5.62	2 U	2 U	2 U	2 U	2 U	2 U
cis-1,2-Dichloroethene	43000	350	6	2 U	8	2 U	2 U	2 U
Tetrachloroethene	1500	7.42	<b>46</b>	5	<b>64</b>	<b>118</b>	<b>20</b>	<b>19</b>
Trichloroethene	53	18.3	3	2 U	4	2 U	2 U	2 U
trans-1,2-Dichloroethene	69000	380	2 U	2 U	2 U	2 U	2 U	2 U

Notes: Shaded - Exceeds USEPA Region I  
 Bold - Exceeds NC DENR soil to g  
 J - Analyte detected. Report value :  
 U - Not Detected

TABLE 4-4

**SUBSURFACE SOILS COMPARISON SUMMARY - MOBILE LAB DATA**  
**SWMU 360**  
**RCRA FACILITY INVESTIGATION - CTO-0143**  
**MCB, CAMP LEJEUNE, NORTH CAROLINA**

Site Sample I.D.	USEPA Region IX PRGs Residential	NC Soil to Groundwater Standards	SWMU360-SB06-06 06-19-2003 11-13	SWMU360-SB06-10 06-19-2003 19-21	SWMU360-SB06-11 06-19-2003 21-23	SWMU360-SB07-02 06-19-2003 3-5	SWMU360-SB07-04 06-19-2003 7-9	SWMU360-SB07-06 06-19-2003 11-13
<b>Volatiles (ug/kg)</b>								
1,1-Dichloroethene	120000	44.5	2 U	2 U	2 U	2 U	2 U	2 U
Benzene	600	5.62	2 U	2 U	2 U	2 U	2 U	2 U
cis-1,2-Dichloroethene	43000	350	2 U	9	8	3	2 U	2 U
Tetrachloroethene	1500	7.42	2 U	<b>105</b>	<b>84</b>	<b>44</b>	<b>13</b>	2 U
Trichloroethene	53	18.3	2 U	5	4	<b>23</b>	2 U	2 U
trans-1,2-Dichloroethene	69000	380	2 U	2 U	2 U	2 U	2 U	2 U

Notes: Shaded - Exceeds USEPA Region I  
 Bold - Exceeds NC DENR soil to g  
 J - Analyte detected. Report value :  
 U - Not Detected

TABLE 4-4

SUBSURFACE SOILS COMPARISON SUMMARY - MOBILE LAB DATA  
 SWMU 360  
 RCRA FACILITY INVESTIGATION - CTO-0143  
 MCB, CAMP LEJEUNE, NORTH CAROLINA

Site Sample I.D.	USEPA Region IX PRGs Residential	NC Soil to Groundwater Standards	SWMU360-SB07-08 06-19-2003 15-17	SWMU360-SB07-09 06-19-2003 17-19	SWMU360-SB07-12 06-19-2003 23-25	SWMU360-SB08-01 06-20-2003 1-3	SWMU360-SB08-02 06-20-2003 3-5	SWMU360-SB08-04 06-20-2003 7-9
<b>Volatiles (ug/kg)</b>								
1,1-Dichloroethene	120000	44.5	2 U	2 U	2 U	2 U	2 U	2 U
Benzene	600	5.62	2 U	2 U	2 U	2 U	2 U	2 U
cis-1,2-Dichloroethene	43000	350	2 U	2 U	10	2 U	2 U	2 U
Tetrachloroethene	1500	7.42	<b>64</b>	<b>82</b>	<b>38</b>	2 U	2 U	2 U
Trichloroethene	53	18.3	2	3	3	2 U	2 U	2 U
trans-1,2-Dichloroethene	69000	380	2 U	2 U	2 U	2 U	2 U	2 U

Notes: Shaded - Exceeds USEPA Region I  
 Bold - Exceeds NC DENR soil to g  
 J - Analyte detected. Report value :  
 U - Not Detected

TABLE 4-4

SUBSURFACE SOILS COMPARISON SUMMARY - MOBILE LAB DATA  
 SWMU 360  
 RCRA FACILITY INVESTIGATION - CTO-0143  
 MCB, CAMP LEJEUNE, NORTH CAROLINA

Site Sample I.D.	USEPA Region IX PRGs Residential	NC Soil to Groundwater Standards	SWMU360-SB08-06 06-20-2003 11-13	SWMU360-SB08-10 06-20-2003 19-21	SWMU360-SB09-04 06-20-2003 7-9	SWMU360-SB09-05 06-20-2003 9-11	SWMU360-SB09-07 06-20-2003 13-15	SWMU360-SB09-09 06-20-2003 17-19
<b>Volatiles (ug/kg)</b>								
1,1-Dichloroethene	120000	44.5	2	2 U	3	2 U	2 U	2 U
Benzene	600	5.62	2 U	2 U	2 U	2 U	2 U	2 U
cis-1,2-Dichloroethene	43000	350	2 U	2 U	2 U	2 U	2 U	2 U
Tetrachloroethene	1500	7.42	2 U	2 U	2 U	2 U	2 U	2 U
Trichloroethene	53	18.3	2 U	2 U	2 U	2 U	2 U	2 U
trans-1,2-Dichloroethene	69000	380	2 U	2 U	2 U	2 U	2 U	2 U

Notes: Shaded - Exceeds USEPA Region I  
 Bold - Exceeds NC DENR soil to g  
 J - Analyte detected. Report value :  
 U - Not Detected

TABLE 4-4

SUBSURFACE SOILS COMPARISON SUMMARY - MOBILE LAB DATA  
 SWMU 360  
 RCRA FACILITY INVESTIGATION - CTO-0143  
 MCB, CAMP LEJEUNE, NORTH CAROLINA

Site Sample I.D.	USEPA Region IX PRGs Residential	NC Soil to Groundwater Standards	SWMU360-SB10-01 06-22-2003 1-3	SWMU360-SB10-02 06-22-2003 3-5	SWMU360-SB10-04 06-22-2003 7-9	SWMU360-SB10-07 06-22-2003 13-15	SWMU360-SB10-09 06-22-2003 17-19	SWMU360-SB11-03 06-20-2003 5-7
<b>Volatiles (ug/kg)</b>								
1,1-Dichloroethene	120000	44.5	2 U	2 U	2 U	2 U	2 U	2 U
Benzene	600	5.62	2 U	2 U	2 U	2 U	2 U	2 U
cis-1,2-Dichloroethene	43000	350	2 U	2 U	2 U	2 U	2 U	2 U
Tetrachloroethene	1500	7.42	7	3	2	6	5	2 U
Trichloroethene	53	18.3	2 U	2 U	2 U	2 U	2 U	2 U
trans-1,2-Dichloroethene	69000	380	2 U	2 U	2 U	2 U	2 U	2 U

Notes: Shaded - Exceeds USEPA Region I  
 Bold - Exceeds NC DENR soil to g  
 J - Analyte detected. Report value :  
 U - Not Detected

TABLE 4-4

**SUBSURFACE SOILS COMPARISON SUMMARY - MOBILE LAB DATA  
SWMU 360  
RCRA FACILITY INVESTIGATION - CTO-0143  
MCB, CAMP LEJEUNE, NORTH CAROLINA**

Site Sample I.D.	USEPA Region IX PRGs Residential	NC Soil to Groundwater Standards	SWMU360-SB11-06 06-20-2003 11-13	SWMU360-SB11-08 06-20-2003 15-17	SWMU360-SB11-09 06-20-2003 17-19	SWMU360-SB12-04 06-20-2003 7-9	SWMU360-SB12-05 06-20-2003 9-11	SWMU360-SB13-02 06-20-2003 3-5
<b>Volatiles (ug/kg)</b>								
1,1-Dichloroethene	120000	44.5	2 U	2 U	2 U	2 U	2 U	2 U
Benzene	600	5.62	2 U	2 U	2 U	2 U	2 U	2 U
cis-1,2-Dichloroethene	43000	350	2 U	2 U	2 U	2 U	2 U	2 U
Tetrachloroethene	1500	7.42	4	3	6	2 U	2 U	2 U
Trichloroethene	53	18.3	2 U	2 U	2 U	2 U	2 U	2 U
trans-1,2-Dichloroethene	69000	380	2 U	2 U	2 U	2 U	2 U	2 U

Notes: Shaded - Exceeds USEPA Region I  
 Bold - Exceeds NC DENR soil to g  
 J - Analyte detected. Report value :  
 U - Not Detected

TABLE 4-4

**SUBSURFACE SOILS COMPARISON SUMMARY - MOBILE LAB DATA**  
**SWMU 360**  
**RCRA FACILITY INVESTIGATION - CTO-0143**  
**MCB, CAMP LEJEUNE, NORTH CAROLINA**

Site Sample I.D.	USEPA Region I IX PRGs Residential	NC Soil to Groundwater Standards	SWMU360-SB13-04 06-20-2003 7-9	SWMU360-SB13-05 06-20-2003 9-11	SWMU360-SB14-02 06-20-2003 3-5	SWMU360-SB14-04 06-20-2003 7-9	SWMU360-SB14-06 06-20-2003 11-13	SWMU360-SB14-08 06-20-2003 15-17
<b>Volatiles (ug/kg)</b>								
1,1-Dichloroethene	120000	44.5	2 U	2 U	2 U	2 U	2	2 U
Benzene	600	5.62	2 U	2 U	2 U	2 U	2 U	2 U
cis-1,2-Dichloroethene	43000	350	2 U	2 U	2 U	12	3	1
Tetrachloroethene	1500	7.42	2 U	2 U	2 U	2 U	17	2
Trichloroethene	53	18.3	2 U	2 U	2 U	3	2 U	2 U
trans-1,2-Dichloroethene	69000	380	2 U	2 U	2 U	2	2 U	2 U

Notes: Shaded - Exceeds USEPA Region I  
 Bold - Exceeds NC DENR soil to g  
 J - Analyte detected. Report value :  
 U - Not Detected

TABLE 4-4

**SUBSURFACE SOILS COMPARISON SUMMARY - MOBILE LAB DATA**  
**SWMU 360**  
**RCRA FACILITY INVESTIGATION - CTO-0143**  
**MCB, CAMP LEJEUNE, NORTH CAROLINA**

Site Sample I.D.	USEPA Region IX PRGs Residential	NC Soil to Groundwater Standards	SWMU360-SB14-10 06-20-2003 19-21	SWMU360-SB15-02 06-20-2003 3-5	SWMU360-SB15-04 06-20-2003 7-9	SWMU360-SB15-05 06-20-2003 9-11	SWMU360-SB15-06 06-20-2003 11-13	SWMU360-SB15-10 06-20-2003 19-21
<b>Volatiles (ug/kg)</b>								
1,1-Dichloroethene	120000	44.5	2	2 U	2 U	2 U	2 U	2 U
Benzene	600	5.62	2 U	2 U	2 U	2 U	2 U	2 U
cis-1,2-Dichloroethene	43000	350	2 U	2 U	2 U	2 U	2 U	2 U
Tetrachloroethene	1500	7.42	2 U	2 U	2 U	2 U	2 U	2 U
Trichloroethene	53	18.3	2 U	2 U	2 U	2 U	2 U	2 U
trans-1,2-Dichloroethene	69000	380	2 U	2 U	2 U	2 U	2 U	2 U

Notes: Shaded - Exceeds USEPA Region I  
 Bold - Exceeds NC DENR soil to g  
 J - Analyte detected. Report value :  
 U - Not Detected

TABLE 4-4

**SUBSURFACE SOILS COMPARISON SUMMARY - MOBILE LAB DATA**  
**SWMU 360**  
**RCRA FACILITY INVESTIGATION - CTO-0143**  
**MCB, CAMP LEJEUNE, NORTH CAROLINA**

Site Sample I.D.	USEPA Region IX PRGs Residential	NC Soil to Groundwater Standards	SWMU360-SB16-02 06-24-2003 3-5	SWMU360-SB16-03 06-24-2003 5-7	SWMU360-SB16-05 06-24-2003 9-11	SWMU360-SB16-07 06-24-2003 13-15	SWMU360-SB16-09 06-24-2003 17-19	Region 9 PRG	NC Soil to Groundwater
<b>Volatiles (ug/kg)</b>									
1,1-Dichloroethene	120000	44.5	2 U	2 U	2 U	2 U	5	0	0
Benzene	600	5.62	2 U	2 U	2 U	2 U	2 U	0	0
cis-1,2-Dichloroethene	43000	350	2 U	2 U	2 U	2 U	2 U	0	0
Tetrachloroethene	1500	7.42	2 U	2 U	2 U	2 U	2 U	0	15
Trichloroethene	53	18.3	2 U	2 U	2 U	2 U	2 U	0	1
trans-1,2-Dichloroethene	69000	380	2 U	2 U	2 U	2 U	2 U	0	0

Notes: Shaded - Exceeds USEPA Region I  
 Bold - Exceeds NC DENR soil to g  
 J - Analyte detected. Report value:  
 U - Not Detected

**SUBSURFACE SOIL COMPARISON SUMMARY  
SWMU 360  
RCRA FACILITY INVESTIGATION - CTO-0143  
MCB, CAMP LEJEUNE, NORTH CAROLINA**

SAMPLE ID	USEPA Region	North Carolina	Background Criteria	Base Background	SWMU360-SB01-03	SWMU360-SB01-05	SWMU360-SB01-09	SWMU360-SB02-02
SAMPLE DATE	IX-PRGs	Soil to	AOC 7	Criteria	06-19-2003	06-19-2003	06-19-2003	06-19-2003
DEPTH RANGE	Residential	Groundwater Stds		Subsurface-Sand	5-7	9-11	17-19	3-5
<b>VOLATILES (ug/kg)</b>								
2-Butanone	7300000	692	NE	NE	NA	NA	12 U	NA
Acetone	1600000	2810	NE	NE	NA	NA	16 U	NA
Benzene	600	5.62	NE	NE	NA	NA	12 U	NA
Carbon Disulfide	360000	4940	NE	NE	NA	NA	12 U	NA
cis-1,2-Dichloroethene	43000	NE	NE	NE	NA	NA	12 U	NA
Ethyl Benzene	8900	241	NE	NE	NA	NA	12 U	NA
Isopropylbenzene	NE	NE	NE	NE	NA	NA	12 U	NA
m/p-Xylenes	270000	4960	NE	NE	NA	NA	12 U	NA
Methylcyclohexane	2600000	NE	NE	NE	NA	NA	12 U	NA
o-Xylene	270000	4960	NE	NE	NA	NA	12 U	NA
Tetrachloroethene	1500	7.42	NE	NE	NA	NA	1.4 J	NA
Toluene	520000	7270	NE	NE	NA	NA	12 U	NA
trans-1,2-Dichloroethene	69000	380	NE	NE	NA	NA	12 U	NA
<b>METALS (mg/kg)</b>								
Arsenic	0.39	5.24	2.93	1.62	0.67 U	0.89 J	1 J	0.97 J
Barium	5400	848	19.36	22.0	26 J	18.3 J	4.3 J	11.4 J
Cadmium	37	2.72	NE	NE	0.1 U	0.09 U	0.1 U	0.09 U
Chromium	210	27.2	27.39	16.3	8.6	9.7	2.5 U	7
Lead	400	270	15.18	8.16	6.6 J	6.8 J	2.8 J	4.1 J
Selenium	390	12.2	0.67	0.687	0.72 U	0.69 U	0.73 U	0.64 U

NOTES:

- Shaded - Exceeds USEPA Region IX PRGs
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**SUBSURFACE SOIL COMPARISON SUMMARY  
SWMU 360  
RCRA FACILITY INVESTIGATION - CTO-0143  
MCB, CAMP LEJEUNE, NORTH CAROLINA**

SAMPLE ID	USEPA Region	North Carolina	Background Criteria	Base Background	SWMU360-SB02-05	SWMU360-SB02-09	SWMU360-SB03-01	SWMU360-SB03-04
SAMPLE DATE	IX PRGs	Soil to	AOC 7	Criteria	06-19-2003	06-19-2003	06-20-2003	06-20-2003
DEPTH RANGE	Residential	Groundwater Stds		Subsurface-Sand	9-11	17-19	1-3	7-9
<b>VOLATILES (ug/kg)</b>								
2-Butanone	730000	692	NE	NE	NA	11 U	NA	NA
Acetone	1600000	2810	NE	NE	NA	11 U	NA	NA
Benzene	600	5.62	NE	NE	NA	11 U	NA	NA
Carbon Disulfide	360000	4940	NE	NE	NA	11 U	NA	NA
cis-1,2-Dichloroethene	43000	NE	NE	NE	NA	11 U	NA	NA
Ethyl Benzene	8900	241	NE	NE	NA	11 U	NA	NA
Isopropylbenzene	NE	NE	NE	NE	NA	11 U	NA	NA
m/p-Xylenes	270000	4960	NE	NE	NA	11 U	NA	NA
Methylcyclohexane	2600000	NE	NE	NE	NA	11 U	NA	NA
o-Xylene	270000	4960	NE	NE	NA	11 U	NA	NA
Tetrachloroethene	1500	7.42	NE	NE	NA	11 U	NA	NA
Toluene	520000	7270	NE	NE	NA	11 U	NA	NA
trans-1,2-Dichloroethene	69000	380	NE	NE	NA	11 U	NA	NA
<b>METALS (mg/kg)</b>								
Arsenic	0.39	5.24	2.93	1.62	<b>1.9 J</b>	0.63 U	<b>1.3 J</b>	0.63 U
Barium	5400	848	19.36	22.0	5.2 J	11.2 J	11.9 J	13.3 J
Cadmium	37	2.72	NE	NE	0.09 U	0.09 U	0.58 J	0.09 U
Chromium	210	27.2	27.39	16.3	2.9	2.7	6.5	6.1
Lead	400	270	15.18	8.16	3.1 J	2.9 J	<b>23.4 J</b>	4.6 J
Selenium	390	12.2	0.67	0.687	0.66 U	0.68 U	0.64 U	0.68 U

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**SUBSURFACE SOIL COMPARISON SUMMARY  
SWMU 360  
RCRA FACILITY INVESTIGATION - CTO-0143  
MCB, CAMP LEJEUNE, NORTH CAROLINA**

SAMPLE ID	USEPA Region IX PRGs	North Carolina Soil to Groundwater Stds	Background Criteria AOC 7	Base Background Criteria Subsurface-Sand	SWMU360-SB03-10 06-20-2003 19-21	SWMU360-SB04-02 06-19-2003 3-5	SWMU360-SB04-06 06-19-2003 11-13	SWMU360-SB04-10 06-19-2003 19-21
<b>VOLATILES (ug/kg)</b>								
2-Butanone	7300000	692	NE	NE	12 U	3.8 J	NA	NA
Acetone	1600000	2810	NE	NE	12 U	21 U	NA	NA
Benzene	600	5.62	NE	NE	12 U	1.5 J	NA	NA
Carbon Disulfide	360000	4940	NE	NE	12 U	11 U	NA	NA
cis-1,2-Dichloroethene	43000	NE	NE	NE	12 U	13	NA	NA
Ethyl Benzene	8900	241	NE	NE	12 U	63	NA	NA
Isopropylbenzene	NE	NE	NE	NE	12 U	6.1 J	NA	NA
m/p-Xylenes	270000	4960	NE	NE	12 U	230	NA	NA
Methylcyclohexane	2600000	NE	NE	NE	12 U	1.3 J	NA	NA
o-Xylene	270000	4960	NE	NE	12 U	100	NA	NA
Tetrachloroethene	1500	7.42	NE	NE	12 U	11 U	NA	NA
Toluene	520000	7270	NE	NE	12 U	9.7 J	NA	NA
trans-1,2-Dichloroethene	69000	380	NE	NE	12 U	0.92 J	NA	NA
<b>METALS (mg/kg)</b>								
Arsenic	0.39	5.24	2.93	1.62	<b>3.2</b>	1.2 J	0.72 J	0.61 U
Barium	5400	848	19.36	22.0	4.3 J	14.3 J	13.2 J	3.4 J
Cadmium	37	2.72	NE	NE	0.09 U	0.09 U	0.09 U	0.09 U
Chromium	210	27.2	27.39	16.3	3.3	4.5	14.7	1 J
Lead	400	270	15.18	8.16	2.3 J	3.8 J	7.7 J	1.2 J
Selenium	390	12.2	0.67	0.687	0.68 U	0.66 U	0.66 U	0.65 U

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**SUBSURFACE SOIL COMPARISON SUMMARY  
SWMU 360  
RCRA FACILITY INVESTIGATION - CTO-0143  
MCB, CAMP LEJEUNE, NORTH CAROLINA**

SAMPLE ID	USEPA Region	North Carolina	Background Criteria	Base Background	SWMU360-SB05-04	SWMU360-SB05-06	SWMU360-SB05-08	SWMU360-SB06-01
SAMPLE DATE	IX PRGs	Soil to	<u>AOC 7</u>	Criteria	06-19-2003	06-19-2003	06-19-2003	06-19-2003
DEPTH RANGE	Residential	Groundwater Stds		Subsurface-Sand	7-9	11-13	15-17	1-3
<b>VOLATILES (ug/kg)</b>								
2-Butanone	7300000	692	NE	NE	NA	11 U	NA	NA
Acetone	1600000	2810	NE	NE	NA	11 U	NA	NA
Benzene	600	5.62	NE	NE	NA	11 U	NA	NA
Carbon Disulfide	360000	4940	NE	NE	NA	11 U	NA	NA
cis-1,2-Dichloroethene	43000	NE	NE	NE	NA	11 U	NA	NA
Ethyl Benzene	8900	241	NE	NE	NA	11 U	NA	NA
Isopropylbenzene	NE	NE	NE	NE	NA	11 U	NA	NA
m/p-Xylenes	270000	4960	NE	NE	NA	11 U	NA	NA
Methylcyclohexane	2600000	NE	NE	NE	NA	11 U	NA	NA
o-Xylene	270000	4960	NE	NE	NA	11 U	NA	NA
Tetrachloroethene	1500	7.42	NE	NE	NA	11 U	NA	NA
Toluene	520000	7270	NE	NE	NA	11 U	NA	NA
trans-1,2-Dichloroethene	69000	380	NE	NE	NA	11 U	NA	NA
<b>METALS (mg/kg)</b>								
Arsenic	0.39	5.24	2.93	1.62	0.64 U	0.6 U	0.59 U	0.62 U
Barium	5400	848	19.36	22.0	7.2 J	3.5 J	2.8 J	6.4 J
Cadmium	37	2.72	NE	NE	0.09 U	0.09 U	0.08 U	0.09 U
Chromium	210	27.2	27.39	16.3	4.5 U	0.57 U	1.1 U	0.5 U
Lead	400	270	15.18	8.16	3.7 J	1.6 J	0.79 J	2.6 J
Selenium	390	12.2	0.67	0.687	0.68 U	0.64 U	0.63 U	0.66 U

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**SUBSURFACE SOIL COMPARISON SUMMARY  
SWMU 360  
RCRA FACILITY INVESTIGATION - CTO-0143  
MCB, CAMP LEJEUNE, NORTH CAROLINA**

SAMPLE ID	USEPA Region	North Carolina	Background Criteria	Base Background	SWMU360-SB06-08	SWMU360-SB06-11	SWMU360-SB07-04	SWMU360-SB07-08
SAMPLE DATE	IX PRGs	Soil to	AOC 7	Criteria	06-19-2003	06-19-2003	06-19-2003	06-19-2003
DEPTH RANGE	Residential	Groundwater Stds		Subsurface-Sand	15-17	21-23	7-9	15-15
<b>VOLATILES (ug/kg)</b>								
2-Butanone	7300000	692	NE	NE	NA	11 U	11 U	NA
Acetone	1600000	2810	NE	NE	NA	19 U	11 U	NA
Benzene	600	5.62	NE	NE	NA	11 U	11 U	NA
Carbon Disulfide	360000	4940	NE	NE	NA	11 U	11 U	NA
cis-1,2-Dichloroethene	43000	NE	NE	NE	NA	11 U	11 U	NA
Ethyl Benzene	8900	241	NE	NE	NA	11 U	11 U	NA
Isopropylbenzene	NE	NE	NE	NE	NA	11 U	11 U	NA
m/p-Xylenes	270000	4960	NE	NE	NA	11 U	11 U	NA
Methylcyclohexane	2600000	NE	NE	NE	NA	11 U	11 U	NA
o-Xylene	270000	4960	NE	NE	NA	11 U	11 U	NA
Tetrachloroethene	1500	7.42	NE	NE	NA	7.9 J	11 U	NA
Toluene	520000	7270	NE	NE	NA	11 U	11 U	NA
trans-1,2-Dichloroethene	69000	380	NE	NE	NA	11 U	11 U	NA
<b>METALS (mg/kg)</b>								
Arsenic	0.39	5.24	2.93	1.62	0.62 U	<b>7.9</b>	0.62 U	0.6 U
Barium	5400	848	19.36	22.0	4.2 J	6.2 J	11 J	4.7 J
Cadmium	37	2.72	NE	NE	0.09 U	0.11 J	0.09 U	0.09 U
Chromium	210	27.2	27.39	16.3	1.3 U	5.4	3.8 U	0.97 U
Lead	400	270	15.18	8.16	1.7 J	0.67 J	3.9 J	0.76 J
Selenium	390	12.2	0.67	0.687	0.67 U	0.67 U	0.66 U	0.64 U

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**SUBSURFACE SOIL COMPARISON SUMMARY  
SWMU 360  
RCRA FACILITY INVESTIGATION - CTO-0143  
MCB, CAMP LEJEUNE, NORTH CAROLINA**

SAMPLE ID	USEPA Region	North Carolina	Background Criteria	Base Background	SWMU360-SB07-12	SWMU360-SB08-01	SWMU360-SB08-02	SWMU360-SB08-10
SAMPLE DATE	IX PRGs	Soil to	AOC 7	Criteria	06-19-2003	06-20-2003	06-20-2003	06-20-2003
DEPTH RANGE	Residential	Groundwater Stds		Subsurface-Sand	23-25	1-3	3-5	19-21
<b>VOLATILES (ug/kg)</b>								
2-Butanone	7300000	692	NE	NE	NA	NA	NA	11 U
Acetone	1600000	2810	NE	NE	NA	NA	NA	11 U
Benzene	600	5.62	NE	NE	NA	NA	NA	11 U
Carbon Disulfide	360000	4940	NE	NE	NA	NA	NA	11 U
cis-1,2-Dichloroethene	43000	NE	NE	NE	NA	NA	NA	11 U
Ethyl Benzene	8900	241	NE	NE	NA	NA	NA	11 U
Isopropylbenzene	NE	NE	NE	NE	NA	NA	NA	11 U
m/p-Xylenes	270000	4960	NE	NE	NA	NA	NA	11 U
Methylcyclohexane	2600000	NE	NE	NE	NA	NA	NA	11 U
o-Xylene	270000	4960	NE	NE	NA	NA	NA	11 U
Tetrachloroethene	1500	7.42	NE	NE	NA	NA	NA	11 U
Toluene	520000	7270	NE	NE	NA	NA	NA	11 U
trans-1,2-Dichloroethene	69000	380	NE	NE	NA	NA	NA	11 U
<b>METALS (mg/kg)</b>								
Arsenic	0.39	5.24	2.93	1.62	<b>6.3</b>	<b>2.2 J</b>	<b>1.2 J</b>	<b>0.73 J</b>
Barium	5400	848	19.36	22.0	11.9 J	16.8 J	20.6 J	8.9 J
Cadmium	37	2.72	NE	NE	0.1 U	0.09 U	0.1 U	0.09 U
Chromium	210	27.2	27.39	16.3	3.8 U	12.3	11.7	11.8
Lead	400	270	15.18	8.16	2.4 J	6.4 J	5.8 J	3 J
Selenium	390	12.2	0.67	0.687	0.74 U	<b>0.84 J</b>	<b>0.87 J</b>	0.66 U

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**SUBSURFACE SOIL COMPARISON SUMMARY  
SWMU 360  
RCRA FACILITY INVESTIGATION - CTO-0143  
MCB, CAMP LEJEUNE, NORTH CAROLINA**

SAMPLE ID	USEPA Region IX PRGs	North Carolina Soil to Groundwater Stds	Background Criteria AOC 7	Base Background Criteria Subsurface-Sand	SWMU360-SB09-01 06-20-2003 1-3	SWMU360-SB09-06 06-20-2003 11-13	SWMU360-SB10-01 06-22-2003 0-1	SWMU360-SB10-03 06-22-2003 5-7
<b>VOLATILES (ug/kg)</b>								
2-Butanone	7300000	692	NE	NE	NA	11 U	11 U	NA
Acetone	1600000	2810	NE	NE	NA	11 U	11 UJ	NA
Benzene	600	5.62	NE	NE	NA	11 U	11 U	NA
Carbon Disulfide	360000	4940	NE	NE	NA	11 U	11 U	NA
cis-1,2-Dichloroethene	43000	NE	NE	NE	NA	11 U	11 U	NA
Ethyl Benzene	8900	241	NE	NE	NA	11 U	11 U	NA
Isopropylbenzene	NE	NE	NE	NE	NA	11 U	11 U	NA
m/p-Xylenes	270000	4960	NE	NE	NA	11 U	11 U	NA
Methylcyclohexane	2600000	NE	NE	NE	NA	11 U	11 U	NA
o-Xylene	270000	4960	NE	NE	NA	11 U	11 U	NA
Tetrachloroethene	1500	7.42	NE	NE	NA	11 U	11 U	NA
Toluene	520000	7270	NE	NE	NA	11 U	11 U	NA
trans-1,2-Dichloroethene	69000	380	NE	NE	NA	11 U	11 U	NA
<b>METALS (mg/kg)</b>								
Arsenic	0.39	5.24	2.93	1.62	0.98 J	0.64 U	0.62 U	0.72 J
Barium	5400	848	19.36	22.0	11.4 J	12.4 J	8.5 J	29.4 J
Cadmium	37	2.72	NE	NE	0.09 U	0.09 U	0.09 U	0.1 U
Chromium	210	27.2	27.39	16.3	11.3	3.2	0.13 U	0.14 U
Lead	400	270	15.18	8.16	4.5 J	2.6 J	2.9	4.3
Selenium	390	12.2	0.67	0.687	0.69 U	0.68 U	0.67 UJ	0.72 UJ

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SWMU 360  
RCRA FACILITY INVESTIGATION - CTO-0143  
MCB, CAMP LEJEUNE, NORTH CAROLINA**

SAMPLE ID	USEPA Region	North Carolina	Background Criteria	Base Background	SWMU360-SB10-05	SWMU360-SB11-03	SWMU360-SB11-06	SWMU360-SB11-09
SAMPLE DATE	IX PRGs	Soil to	AOC 7	Criteria	06-22-2003	06-20-2003	06-20-2003	06-20-2003
DEPTH RANGE	Residential	Groundwater Stds		Subsurface-Sand	9-11	5-7	11-13	17-19
<b>VOLATILES (ug/kg)</b>								
2-Butanone	7300000	692	NE	NE	NA	NA	NA	11 U
Acetone	1600000	2810	NE	NE	NA	NA	NA	11 U
Benzene	600	5.62	NE	NE	NA	NA	NA	11 U
Carbon Disulfide	360000	4940	NE	NE	NA	NA	NA	11 U
cis-1,2-Dichloroethene	43000	NE	NE	NE	NA	NA	NA	11 U
Ethyl Benzene	8900	241	NE	NE	NA	NA	NA	11 U
Isopropylbenzene	NE	NE	NE	NE	NA	NA	NA	11 U
m/p-Xylenes	270000	4960	NE	NE	NA	NA	NA	11 U
Methylcyclohexane	2600000	NE	NE	NE	NA	NA	NA	11 U
o-Xylene	270000	4960	NE	NE	NA	NA	NA	11 U
Tetrachloroethene	1500	7.42	NE	NE	NA	NA	NA	11 U
Toluene	520000	7270	NE	NE	NA	NA	NA	11 U
trans-1,2-Dichloroethene	69000	380	NE	NE	NA	NA	NA	11 U
<b>METALS (mg/kg)</b>								
Arsenic	0.39	5.24	2.93	1.62	0.65 U	0.6 U	0.65 J	4.5
Barium	5400	848	19.36	22.0	14.2 J	10.9 J	2.6 J	15.2 J
Cadmium	37	2.72	NE	NE	0.09 U	0.09 U	0.09 U	0.08 U
Chromium	210	27.2	27.39	16.3	0.14 U	3.4	1.9 J	9.7
Lead	400	270	15.18	8.16	2.5	2.7 J	1.5	0.87
Selenium	390	12.2	0.67	0.687	0.7 UJ	0.64 U	0.7 UJ	0.63 UJ

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SWMU 360  
RCRA FACILITY INVESTIGATION - CTO-0143  
MCB, CAMP LEJEUNE, NORTH CAROLINA**

SAMPLE ID	USEPA Region	North Carolina	Background Criteria	Base Background	SWMU360-SB12-04	SWMU360-SB12-05	SWMU360-SB13-02	SWMU360-SB13-04
SAMPLE DATE	IX PRGs	Soil to	AOC 7	Criteria	06-20-2003	06-20-2003	06-20-2003	06-20-2003
DEPTH RANGE	Residential	Groundwater Stds		Subsurface-Sand	7-9	9-11	3-5	7-9
<b>VOLATILES (ug/kg)</b>								
2-Butanone	7300000	692	NE	NE	11 U	NA	NA	11 U
Acetone	1600000	2810	NE	NE	11 U	NA	NA	11 U
Benzene	600	5.62	NE	NE	11 U	NA	NA	11 U
Carbon Disulfide	360000	4940	NE	NE	11 U	NA	NA	11 U
cis-1,2-Dichloroethene	43000	NE	NE	NE	11 U	NA	NA	11 U
Ethyl Benzene	8900	241	NE	NE	11 U	NA	NA	11 U
Isopropylbenzene	NE	NE	NE	NE	11 U	NA	NA	11 U
m/p-Xylenes	270000	4960	NE	NE	11 U	NA	NA	11 U
Methylcyclohexane	2600000	NE	NE	NE	11 U	NA	NA	11 U
o-Xylene	270000	4960	NE	NE	11 U	NA	NA	11 U
Tetrachloroethene	1500	7.42	NE	NE	11 U	NA	NA	11 U
Toluene	520000	7270	NE	NE	11 U	NA	NA	11 U
trans-1,2-Dichloroethene	69000	380	NE	NE	11 U	NA	NA	11 U
<b>METALS (mg/kg)</b>								
Arsenic	0.39	5.24	2.93	1.62	0.58 U	0.64 U	0.68 U	0.63 U
Barium	5400	848	19.36	22.0	2.8 J	3 J	8.4 J	11.7 J
Cadmium	37	2.72	NE	NE	0.08 U	0.09 U	0.1 U	0.09 U
Chromium	210	27.2	27.39	16.3	1.4 J	1 J	0.15 U	2.2 J
Lead	400	270	15.18	8.16	0.96	0.69	3.7	2.6
Selenium	390	12.2	0.67	0.687	0.63 UJ	0.69 UJ	0.73 UJ	0.67 UJ

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SWMU 360  
RCRA FACILITY INVESTIGATION - CTO-0143  
MCB, CAMP LEJEUNE, NORTH CAROLINA**

SAMPLE ID	USEPA Region	North Carolina	Background Criteria	Base Background	SWMU360-SB13-05	SWMU360-SB14-02	SWMU360-SB14-04	SWMU360-SB14-10
SAMPLE DATE	IX PRGs	Soil to	AOC 7	Criteria	06-20-2003	06-20-2003	06-20-2003	06-22-2003
DEPTH RANGE	Residential	Groundwater Stds		Subsurface-Sand	9-11	3-5	7-9	19-21
<b>VOLATILES (ug/kg)</b>								
2-Butanone	7300000	692	NE	NE	NA	NA	11 U	NA
Acetone	1600000	2810	NE	NE	NA	NA	11 U	NA
Benzene	600	5.62	NE	NE	NA	NA	11 U	NA
Carbon Disulfide	360000	4940	NE	NE	NA	NA	11 U	NA
cis-1,2-Dichloroethene	43000	NE	NE	NE	NA	NA	11 U	NA
Ethyl Benzene	8900	241	NE	NE	NA	NA	11 U	NA
Isopropylbenzene	NE	NE	NE	NE	NA	NA	11 U	NA
m/p-Xylenes	270000	4960	NE	NE	NA	NA	11 U	NA
Methylcyclohexane	2600000	NE	NE	NE	NA	NA	11 U	NA
o-Xylene	270000	4960	NE	NE	NA	NA	11 U	NA
Tetrachloroethene	1500	7.42	NE	NE	NA	NA	11 U	NA
Toluene	520000	7270	NE	NE	NA	NA	11 U	NA
trans-1,2-Dichloroethene	69000	380	NE	NE	NA	NA	11 U	NA
<b>METALS (mg/kg)</b>								
Arsenic	0.39	5.24	2.93	1.62	0.64 U	<b>1.9 J</b>	0.6 U	0.58 U
Barium	5400	848	19.36	22.0	12.6 J	17 J	10 J	5.4 J
Cadmium	37	2.72	NE	NE	0.09 U	0.09 U	0.09 U	0.08 U
Chromium	210	27.2	27.39	16.3	0.14 U	10.7	2.2	0.12 U
Lead	400	270	15.18	8.16	1	6.1	1.7 J	1.2
Selenium	390	12.2	0.67	0.687	0.69 UJ	0.71 UJ	0.64 U	0.62 UJ

NOTES:

- Shaded - Exceeds USEPA Region IX PRGs
- Bold - Exceeds NC DENR soil to groundwater comparison criteria
- Underline - Exceeds AOC background concentrations
- Boxed - Exceeds base background concentrations
- AOC comparison - AOC 7 Subsurface Soil
- Base comparison - Sand Data Set for Subsurface Soil
- U - Not Detected
- J - Analyte detected. Report value is estimated.
- NA - Not analyzed
- NE - Not established

**SUBSURFACE SOIL COMPARISON SUMMARY  
SWMU 360  
RCRA FACILITY INVESTIGATION - CTO-0143  
MCB, CAMP LEJEUNE, NORTH CAROLINA**

SAMPLE ID	USEPA Region	North Carolina	Background Criteria	Base Background	SWMU360-SB15-02	SWMU360-SB15-04	SWMU360-SB15-05	SWMU360-SB16-02
SAMPLE DATE	IX PRGs	Soil to	AOC 7	Criteria	06-20-2003	06-20-2003	06-20-2003	06-24-2003
DEPTH RANGE	Residential	Groundwater Stds		Subsurface-Sand	3-5	7-9	9-11	3-5
<b>VOLATILES (ug/kg)</b>								
2-Butanone	7300000	692	NE	NE	NA	NA	11 U	NA
Acetone	1600000	2810	NE	NE	NA	NA	11 U	NA
Benzene	600	5.62	NE	NE	NA	NA	11 U	NA
Carbon Disulfide	360000	4940	NE	NE	NA	NA	11 U	NA
cis-1,2-Dichloroethene	43000	NE	NE	NE	NA	NA	11 U	NA
Ethyl Benzene	8900	241	NE	NE	NA	NA	11 U	NA
Isopropylbenzene	NE	NE	NE	NE	NA	NA	11 U	NA
m/p-Xylenes	270000	4960	NE	NE	NA	NA	11 U	NA
Methylcyclohexane	2600000	NE	NE	NE	NA	NA	11 U	NA
o-Xylene	270000	4960	NE	NE	NA	NA	11 U	NA
Tetrachloroethene	1500	7.42	NE	NE	NA	NA	11 U	NA
Toluene	520000	7270	NE	NE	NA	NA	11 U	NA
trans-1,2-Dichloroethene	69000	380	NE	NE	NA	NA	11 U	NA
<b>METALS (mg/kg)</b>								
Arsenic	0.39	5.24	2.93	1.62	<b>1.6 J</b>	<b>0.95 J</b>	0.64 U	0.62 U
Barium	5400	848	19.36	22.0	15.7 J	11.1 J	12 J	7.6 J
Cadmium	37	2.72	NE	NE	0.09 U	0.09 U	0.11 J	0.09 U
Chromium	210	27.2	27.39	16.3	10.2	5	7.2	0.13 U
Lead	400	270	15.18	8.16	4.7 J	3.5 J	<b>14.5 J</b>	5.9 J
Selenium	390	12.2	0.67	0.687	0.71 U	0.67 U	0.68 U	0.67 U

NOTES:

- Shaded - Exceeds USEPA Region IX PRGs
- Bold - Exceeds NC DENR soil to groundwater comparison criteria
- Underline - Exceeds AOC background concentrations
- Boxed - Exceeds base background concentrations
- AOC comparison - AOC 7 Subsurface Soil
- Base comparison - Sand Data Set for Subsurface Soil
- U - Not Detected
- J - Analyte detected. Report value is estimated.
- NA - Not analyzed
- NE - Not established

**SUBSURFACE SOIL COMPARISON SUMMARY**  
**SWMU 360**  
**RCRA FACILITY INVESTIGATION - CTO-0143**  
**MCB, CAMP LEJEUNE, NORTH CAROLINA**

SAMPLE ID	USEPA Region	North Carolina	Background Criteria	Base Background	SWMU360-SB16-03	SWMU360-SB16-09
SAMPLE DATE	IX PRGs	Soil to	AOC 7	Criteria	06-24-2003	06-24-2003
DEPTH RANGE	Residential	Groundwater Stds		Subsurface-Sand	5-7	17-19
<b>VOLATILES (ug/kg)</b>						
2-Butanone	730000	692	NE	NE	NA	11 U
Acetone	1600000	2810	NE	NE	NA	26
Benzene	600	5.62	NE	NE	NA	11 U
Carbon Disulfide	360000	4940	NE	NE	NA	2 J
cis-1,2-Dichloroethene	43000	NE	NE	NE	NA	11 U
Ethyl Benzene	8900	241	NE	NE	NA	11 U
Isopropylbenzene	NE	NE	NE	NE	NA	11 U
m/p-Xylenes	270000	4960	NE	NE	NA	11 U
Methylcyclohexane	2600000	NE	NE	NE	NA	11 U
o-Xylene	270000	4960	NE	NE	NA	11 U
Tetrachloroethene	1500	7.42	NE	NE	NA	11 U
Toluene	520000	7270	NE	NE	NA	11 U
trans-1,2-Dichloroethene	69000	380	NE	NE	NA	11 U
<b>METALS (mg/kg)</b>						
Arsenic	0.39	5.24	2.93	1.62	0.62 U	0.62 U
Barium	5400	848	19.36	22.0	7.3 J	9.9 J
Cadmium	37	2.72	NE	NE	0.09 U	0.09 U
Chromium	210	27.2	27.39	16.3	0.13 U	0.13 U
Lead	400	270	15.18	8.16	1.9 J	5.4 J
Selenium	390	12.2	0.67	0.687	0.66 U	0.66 U

NOTES:

- Shaded - Exceeds USEPA Region IX PRGs
- Bold - Exceeds NC DENR soil to groundwater comparison criteria
- Underline - Exceeds AOC background concentrations
- Boxed - Exceeds base background concentrations
- AOC comparison - AOC 7 Subsurface Soil
- Base comparison - Sand Data Set for Subsurface Soil
- U - Not Detected
- J - Analyte detected. Report value is estimated.
- NA - Not analyzed
- NE - Not established

TABLE 4-6

GROUNDWATER COMPARISON SUMMARY - MOBILE LAB DATA  
 SWMU 360  
 RCRA FACILITY INVESTIGATION - CTO-0143  
 MCB, CAMP LEJEUNE, NORTH CAROLINA

Site Sample I.D. Sample Date	USEPA Region IX PRGs TAP Water	NC 2L Groundwater Protection Std (ug/l)	SWMU360-GW01 06-19-2003	SWMU360-GW02 06-19-2003	SWMU360-GW02-02 06-24-2003	SWMU360-GW02-03 06-24-2003	SWMU360-GW03 06-19-2003	SWMU360-GW04 06-19-2003
<b>Volatiles (ug/l)</b>								
1,1-Dichloroethene	340	7	1 U	1	1	2	7	1 U
1,2,3-Trichloropropane	0.0056	0.005	NA	NA	NA	NA	NA	NA
Chloroform	6.2	0.19	NA	NA	NA	NA	NA	NA
cis-1,2-Dichloroethene	61	70	1 U	46	50	59	<b>316</b>	18
Tetrachloroethene	0.66	0.7	0.6	0.5 U	0.5 U	0.5 U	0.5 U	<b>6</b>
Toluene	720	1000	NA	NA	NA	NA	NA	NA
trans-1,2-Dichloroethene	120	70	1 U	1 U	1 U	1 U	4	1 U
Trichloroethene	0.028	2.8	1 U	<b>7</b>	<b>8</b>	<b>10</b>	<b>55</b>	<b>1</b>
Vinyl Chloride	0.02	0.015	NA	NA	NA	NA	NA	NA

Notes: Shaded - Exceeds USEPA Region IX PRGs  
 Bold - Exceeds NC DENR soil to groundwater comparison criteria  
 J - Analyte detected. Report value is estimated.  
 U - Not Detected  
 NA - Not analyzed

TABLE 4-6

GROUNDWATER COMPARISON SUMMARY - MOBILE LAB DATA  
 SWMU 360  
 RCRA FACILITY INVESTIGATION - CTO-0143  
 MCB, CAMP LEJEUNE, NORTH CAROLINA

Site Sample I.D. Sample Date	USEPA Region IX PRGs TAP Water	NC 2L Groundwater Protection Stds (ug/l)	SWMU360-GW05 06-19-2003	SWMU360-GW05-02 06-24-2003	SWMU360-GW05-03 06-24-2003	SWMU360-GW06 06-19-2003	SWMU360-GW07 06-19-2003	SWMU360-GW08 06-20-2003
<b>Volatiles (ug/l)</b>								
1,1-Dichloroethene	340	7	1 U	1	1 U	1 U	1 U	2
1,2,3-Trichloropropane	0.0056	0.005	NA	NA	NA	NA	NA	NA
Chloroform	6.2	0.19	NA	NA	NA	NA	NA	NA
cis-1,2-Dichloroethene	61	70	<b>80</b>	42	5	32	17	44
Tetrachloroethene	0.66	0.7	<b>211.7</b>	<b>7.5</b>	<b>1.1</b>	<b>2.4</b>	<b>0.3</b>	0.5 U
Toluene	720	1000	NA	NA	NA	NA	NA	NA
trans-1,2-Dichloroethene	120	70	1 U	1 U	1 U	1 U	1 U	1 U
Trichloroethene	0.028	2.8	<b>30</b>	<b>7</b>	1 U	<b>5</b>	<b>2</b>	<b>6</b>
Vinyl Chloride	0.02	0.015	NA	NA	NA	NA	NA	NA

Notes:

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- Bold - Exceeds NC DENR soil to groundwater comparison criteria
- J - Analyte detected. Report value is estimated.
- U - Not Detected
- NA - Not analyzed

TABLE 4-6

**GROUNDWATER COMPARISON SUMMARY - MOBILE LAB DATA**  
**SWMU 360**  
**RCRA FACILITY INVESTIGATION - CTO-0143**  
**MCB, CAMP LEJEUNE, NORTH CAROLINA**

Site Sample I.D.	USEPA Region	NC 2L	SWMU360-GW09	SWMU360-GW10	SWMU360-GW11	SWMU360-GW11-02	SWMU360-GW11-03	SWMU360-GW12	
Sample Date	IX PRGs	Groundwater Protection	06-20-2003	06-22-2003	06-20-2003	06-20-2003	06-20-2003	06-20-2003	
	TAP Water	Stds (ug/l)							
<b>Volatiles (ug/l)</b>									
1,1-Dichloroethene	340	7	1 U	1 U	1 U	1 U	1 U	1 U	
1,2,3-Trichloropropane	0.0056	0.005	NA	NA	NA	NA	NA	NA	
Chloroform	6.2	0.19	NA	NA	NA	NA	NA	NA	
cis-1,2-Dichloroethene	61	70	23	26	4	3	1	1	
Tetrachloroethene	0.66	0.7	0.5 U	0.6	0.5 U	0.5 U	0.5 U	0.5 U	
Toluene	720	1000	NA	NA	NA	NA	NA	NA	
trans-1,2-Dichloroethene	120	70	1 U	1 U	1 U	1 U	1 U	1 U	
Trichloroethene	0.028	2.8	4	3	1 U	1 U	1 U	1 U	
Vinyl Chloride	0.02	0.015	NA	NA	NA	NA	NA	NA	

Notes:

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- J - Analyte detected. Report value is estimated.
- U - Not Detected
- NA - Not analyzed

TABLE 4-6

**GROUNDWATER COMPARISON SUMMARY - MOBILE LAB DATA**  
**SWMU 360**  
**RCRA FACILITY INVESTIGATION - CTO-0143**  
**MCB, CAMP LEJEUNE, NORTH CAROLINA**

Site Sample I.D. Sample Date	USEPA Region IX PRGs TAP Water	NC 2L Groundwater Protection Stds (ug/l)	SWMU360-GW13 06-20-2003	SWMU360-GW13-02 06-20-2003	SWMU360-GW13-03 06-20-2003	SWMU360-GW14 06-20-2003	SWMU360-GW15 06-20-2003	SWMU360-GW16 06-24-2003
<b>Volatiles (ug/l)</b>								
1,1-Dichloroethene	340	7	1 U	1 U	1 U	1 U	1 U	1 U
1,2,3-Trichloropropane	0.0056	0.005	NA	NA	NA	NA	NA	NA
Chloroform	6.2	0.19	NA	NA	NA	NA	NA	NA
cis-1,2-Dichloroethene	61	70	1 U	3	4	15	1 U	40
Tetrachloroethene	0.66	0.7	<b>5.5</b>	0.5	0.5 U	<b>3.5</b>	<b>2.5</b>	0.5 U
Toluene	720	1000	NA	NA	NA	NA	NA	NA
trans-1,2-Dichloroethene	120	70	1 U	1 U	1 U	1 U	1 U	1 U
Trichloroethene	0.028	2.8	1 U	1 U	1 U	<b>2</b>	<b>1</b>	<b>7</b>
Vinyl Chloride	0.02	0.015	NA	NA	NA	NA	NA	NA

Notes:

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- J - Analyte detected. Report value is estimated.
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TABLE 4-6

GROUNDWATER COMPARISON SUMMARY - MOBILE LAB DATA  
 SWMU 360  
 RCRA FACILITY INVESTIGATION - CTO-0143  
 MCB, CAMP LEJEUNE, NORTH CAROLINA

Site Sample I.D. Sample Date	USEPA Region IX PRGs TAP Water	NC 2L Groundwater Protection Stds (ug/l)	SWMU360-GW16-02 06-24-2003	SWMU360-GW16-03 06-24-2003	SWMU360-GW17-02 06-24-2003	SWMU360-GW17-03 06-24-2003	SWMU360-gw18 07-09-2003	SWMU360-gw19 07-09-2003
<b>Volatiles (ug/l)</b>								
1,1-Dichloroethene	340	7	1 U	1	1	1 U	2 U	1 J
1,2,3-Trichloropropane	0.0056	0.005	NA	NA	NA	NA	2 U	2 U
Chloroform	6.2	0.19	NA	NA	NA	NA	2 U	2 U
cis-1,2-Dichloroethene	61	70	20	54	43	4	2 J	28
Tetrachloroethene	0.66	0.7	0.5 U	0.5 U	4.5	5.2	2 U	2 U
Toluene	720	1000	NA	NA	NA	NA	2 U	2
trans-1,2-Dichloroethene	120	70	1 U	1 U	1 U	1 U	2 U	2 U
Trichloroethene	0.028	2.8	4	9	7	1	2 U	6
Vinyl Chloride	0.02	0.015	NA	NA	NA	NA	2 U	2 U

Notes:  
 Shaded - Exceeds USEPA Region IX PRGs  
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 J - Analyte detected. Report value is estimated.  
 U - Not Detected  
 NA - Not analyzed

TABLE 4-6

GROUNDWATER COMPARISON SUMMARY - MOBILE LAB DATA  
 SWMU 360  
 RCRA FACILITY INVESTIGATION - CTO-0143  
 MCB, CAMP LEJEUNE, NORTH CAROLINA

Site Sample I.D. Sample Date	USEPA Region IX PRGs	NC 2L Groundwater Protection Stds (ug/l)	SWMU360-gw20 07-08-2003	SWMU360-gw21 07-08-2003	SWMU360-gw21-1 07-08-2003	SWMU360-gw21-2 07-08-2003	SWMU360-gw22 07-08-2003	SWMU360-gw22-2 07-08-2003	SWMU360-gw22-3 07-08-2003	
<b>Volatiles (ug/l)</b>										
1,1-Dichloroethene	340	7	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2
1,2,3-Trichloropropane	0.0056	0.005	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2
Chloroform	6.2	0.19	2 U	2	2 U	2 U	4	1 J	2	
cis-1,2-Dichloroethene	61	70	23	2 U	26	29	11	27	27	
Tetrachloroethene	0.66	0.7	2 U	4	2 U	1 J	2 U	2 U	2	
Toluene	720	1000	2 U	3	2	2 U	2 U	2 U	2	
trans-1,2-Dichloroethene	120	70	2 U	2 U	2 U	2 U	2 U	2 U	2	
Trichloroethene	0.028	2.8	6	1 J	7	8	2	6	6	
Vinyl Chloride	0.02	0.015	2 U	2 U	1 J	2 J	2 U	2 U	2	

Notes:  
 Shaded - Exceeds USEPA Region IX PRGs  
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 NA - Not analyzed

TABLE 4-6

GROUNDWATER COMPARISON SUMMARY - MOBILE LAB DATA  
 SWMU 360  
 RCRA FACILITY INVESTIGATION - CTO-0143  
 MCB, CAMP LEJEUNE, NORTH CAROLINA

Site Sample I.D. Sample Date	USEPA Region IX PRGs TAP Water	NC 2L Groundwater Protection Std (ug/l)		SWMU360-gw23 07-08-2003	SWMU360-gw23-2 07-08-2003	SWMU360-gw23-3 07-08-2003	SWMU360-gw24 07-08-2003	SWMU360-gw24-2 07-08-2003	SWMU360-gw25 07-08-2003	SWMU360-gw26 07-09-2003
<b>Volatiles (ug/l)</b>										
1,1-Dichloroethene	340	7	U	2 U	2 U	2 U	2 U	2 U	2 U	2
1,2,3-Trichloropropane	0.0056	0.005	U	2 U	2 U	2 U	2 U	2 U	2 U	2
Chloroform	6.2	0.19	U	6	2	1 J	2 U	2 U	2 U	2
cis-1,2-Dichloroethene	61	70		2 U	14	2 U	2 U	2 U	47	2
Tetrachloroethene	0.66	0.7	U	2 U	1 J	2 U	2 U	2 U	17	2
Toluene	720	1000	U	2 U	2 U	2 U	2 U	2 U	2 U	2
trans-1,2-Dichloroethene	120	70	U	2 U	2 U	2 U	2 U	2 U	2 U	2
Trichloroethene	0.028	2.8		2 U	4	2 U	2 U	2 U	13	2
Vinyl Chloride	0.02	0.015	U	2 U	2 U	2 U	2 U	2 U	2 U	2

Notes:  
 Shaded - Exceeds USEPA Region IX PRGs  
 Bold - Exceeds NC DENR soil to groundwater comparison criteria  
 J - Analyte detected. Report value is estimated.  
 U - Not Detected  
 NA - Not analyzed

TABLE 4-6

**GROUNDWATER COMPARISON SUMMARY - MOBILE LAB DATA**  
**SWMU 360**  
**RCRA FACILITY INVESTIGATION - CTO-0143**  
**MCB, CAMP LEJEUNE, NORTH CAROLINA**

Site Sample I.D. Sample Date	USEPA Region IX PRGs TAP Water	NC 2L Groundwater Protection Std (ug/l)		SWMU360-gw27 07-09-2003	SWMU360-gw28 07-09-2003	SWMU360-gw28-1 07-09-2003	SWMU360-gw28-2 07-09-2003	SWMU360-gw29 07-10-2003	SWMU360-gw29-2 07-10-2003
<b>Volatiles (ug/l)</b>									
1,1-Dichloroethene	340	7	U	2 U	2 U	2 U	2 U	2 U	1 J
1,2,3-Trichloropropane	0.0056	0.005	U	2 U	2 U	2 U	2 U	2 U	2 U
Chloroform	6.2	0.19	U	2 U	1 J	2 U	2 U	2 U	2 U
cis-1,2-Dichloroethene	61	70	U	2 U	2 U	2 U	2 U	30	32
Tetrachloroethene	0.66	0.7	U	2 U	1 J	2 U	2 U	2 U	2 U
Toluene	720	1000	U	2 U	2 U	2 U	2 U	1 J	2 U
trans-1,2-Dichloroethene	120	70	U	2 U	2 U	2 U	2 U	2 U	2 U
Trichloroethene	0.028	2.8	U	2 U	2 U	2 U	2 U	5	6
Vinyl Chloride	0.02	0.015	U	2 U	2 U	2 U	2 U	2 U	1 J

Notes:

- Shaded - Exceeds USEPA Region IX PRGs
- Bold - Exceeds NC DENR soil to groundwater comparison criteria
- J - Analyte detected. Report value is estimated.
- U - Not Detected
- NA - Not analyzed

TABLE 4-6

GROUNDWATER COMPARISON SUMMARY - MOBILE LAB DATA  
 SWMU 360  
 RCRA FACILITY INVESTIGATION - CTO-0143  
 MCB, CAMP LEJEUNE, NORTH CAROLINA

Site Sample I.D. Sample Date	USEPA Region IX PRGs TAP Water	NC 2L Groundwater Protection Stds (ug/l)	SWMU360-gw29-3 07-10-2003	SWMU360-gw30 07-09-2003	SWMU360-gw30-1 07-09-2003	SWMU360-gw30-2 07-09-2003	SWMU360-gw31 07-10-2003	SWMU360-gw31-2 07-10-2003
<b>Volatiles (ug/l)</b>								
1,1-Dichloroethene	340	7	2 U	2 U	2 U	2 U	2 U	2 U
1,2,3-Trichloropropane	0.0056	0.005	2 U	2 U	2 U	2 U	2 U	2 U
Chloroform	6.2	0.19	2 U	2 U	2 U	2 U	2 J	2 U
cis-1,2-Dichloroethene	61	70	31	2 U	2 U	2 U	26	17
Tetrachloroethene	0.66	0.7	2 U	2 U	2 U	2 U	13	4
Toluene	720	1000	2 U	2 U	2 U	2 U	2 U	2 U
trans-1,2-Dichloroethene	120	70	2 U	2 U	2 U	2 U	2 U	2 U
Trichloroethene	0.028	2.8	5	2 U	2 U	2 U	6	2
Vinyl Chloride	0.02	0.015	1 J	2 U	2 U	2 U	2 U	2 U

Notes: Shaded - Exceeds USEPA Region IX PRGs  
 Bold - Exceeds NC DENR soil to groundwater  
 comparison criteria  
 J - Analyte detected. Report value is estimated.  
 U - Not Detected  
 NA - Not analyzed

TABLE 4-6

GROUNDWATER COMPARISON SUMMARY - MOBILE LAB DATA  
 SWMU 360  
 RCRA FACILITY INVESTIGATION - CTO-0143  
 MCB, CAMP LEJEUNE, NORTH CAROLINA

Site Sample I.D. Sample Date	USEPA Region IX PRGs TAP Water	NC 2L Groundwater Protection Stds (ug/l)	SWMU360-gw31-3 07-10-2003	SWMU360-gw32-02 07-12-2003	SWMU360-gw32-03 07-12-2003
<b>Volatiles (ug/l)</b>					
1,1-Dichloroethene	340	7	2 U	2 U	2 U
1,2,3-Trichloropropane	0.0056	0.005	2 U	2 U	2 U
Chloroform	6.2	0.19	2 U	2 U	2 U
cis-1,2-Dichloroethene	61	70	17	25	25
Tetrachloroethene	0.66	0.7	<b>8</b>	<b>14</b>	<b>10</b>
Toluene	720	1000	2 U	2 U	2 U
trans-1,2-Dichloroethene	120	70	2 U	2 U	2 U
Trichloroethene	0.028	2.8	<b>4</b>	<b>6</b>	<b>4</b>
Vinyl Chloride	0.02	0.015	2 U	2 U	2 U

Notes: Shaded - Exceeds USEPA Region IX PRGs  
 Bold - Exceeds NC DENR soil to groundwater  
 comparison criteria  
 J - Analyte detected. Report value is estimated.  
 U - Not Detected  
 NA - Not analyzed

TABLE 4-7

GROUNDWATER COMPARISON SUMMARY IN SHALLOW MONITORING WELLS  
 SWMU 360  
 RCRA FACILITY INVESTIGATION - CTO-0143  
 MCB, CAMP LEJEUNE, NORTH CAROLINA

Site Sample I.D. Sample Date	USEPA Region IX PRGs TAP Water	North Carolina 2L Groundwater Protection Stds <sup>(1)</sup>	Base Background Criteria Groundwater-Shallow	1817-MW01 07-24-2003	SWMU360-MW01 07-24-2003	SWMU360-MW02 07-24-2003	SWMU360-MW03 07-22-2003	SWMU360-MW04 07-22-2003
<b>VOLATILES (ug/L)</b>								
Chloroform	6.2	0.19	NE	10 U	10 U	10 U	10 U	10 U
cis-1,2-Dichloroethene	61	70	NE	750 J	42	31	10 U	32
Tetrachloroethene	0.66	0.7	NE	5100 J	160	10 U	10 U	17
trans-1,2-Dichloroethene	120	70	NE	3 J	10 U	10 U	10 U	10 U
Trichloroethene	0.028	2.8	NE	460 J	13	6.7 J	10 U	8.2 J
<b>METALS (ug/L)</b>								
Barium	2600	2000	37.31	60.8 J	28 J	30.8 J	38.2 J	34.7 J
Lead	NE	15	3.61	1.6 U	1.6 U	1.6 U	1.6 U	1.6 U
Selenium	180	50	NE	5.7	5.2	2.6 U	2.6 U	3.6 J

Notes:

- Shaded - Exceeds USEPA Region IX PRGs
- Bold - Exceeds NC DENR soil to groundwater comparison criteria
- Boxed - Exceeds base background concentrations
- D - Sample was diluted in the laboratory. The diluted value was used
- J - Analyte detected. Report value is estimated.
- U - Not Detected
- NE - Not established
- (1) - If NC 2L Standard was not available, Interim standards were used.

TABLE 4-7

GROUNDWATER COMPARISON SUMMARY IN SHALLOW MONITORING WELLS  
 SWMU 360  
 RCRA FACILITY INVESTIGATION - CTO-0143  
 MCB, CAMP LEJEUNE, NORTH CAROLINA

Site Sample I.D. Sample Date	USEPA Region IX PRGs TAP Water	North Carolina 2L Groundwater Protection Stds <sup>(1)</sup>	Base Background Criteria Groundwater-Shallow	SWMU360-MW05 07-22-2003	SWMU360-MW06 07-22-2003	SWMU360-MW07 07-22-2003	SWMU360-MW08 07-22-2003
<b>VOLATILES (ug/L)</b>							
Chloroform	6.2	0.19	NE	10 U	<b>6.9 J</b>	10 U	10 U
cis-1,2-Dichloroethene	61	70	NE	10 U	10 U	2.4 J	31
Tetrachloroethene	0.66	0.7	NE	10 U	10 U	10 U	10 U
trans-1,2-Dichloroethene	120	70	NE	10 U	10 U	10 U	10 U
Trichloroethene	0.028	2.8	NE	10 U	10 U	10 U	<b>5.5 J</b>
<b>METALS (ug/L)</b>							
Barium	2600	2000	37.31	<b>145 J</b>	27.9 J	32 J	35.8 J
Lead	NE	15	3.61	1.6 U	2.1 J	1.6 U	1.6 U
Selenium	180	50	NE	4.4 J	2.6 U	2.6 U	2.6 U

Notes:

- Shaded - Exceeds USEPA Region IX PRGs
- Bold - Exceeds NC DENR soil to groundwater comparison criteria
- Boxed - Exceeds base background concentrations
- D - Sample was diluted in the laboratory. The diluted value was used
- J - Analyte detected. Report value is estimated.
- U - Not Detected
- NE - Not established
- <sup>(1)</sup> - If NC 2L Standard was not available, Interim standards were used

TABLE 4-8

GROUNDWATER COMPARISON SUMMARY IN INTERMEDIATE MONITORING WELLS  
 SWMU 360  
 RCRA FACILITY INVESTIGATION - CTO-0143  
 MCB, CAMP LEJEUNE, NORTH CAROLINA

Site Sample I.D.	USEPA Region IX PRGs	North Carolina 2L Groundwater Protection Stds <sup>(1)</sup>	Base Background Criteria Groundwater-Deep	SWMU360-MW011W R3521-03 07-24-2003	SWMU360-MW021W R3521-07 07-24-2003	SWMU360-MW031W R3486-02 07-22-2003
Lab Sample I.D.	TAP Water					
Sample Date						
		ug/L				
<b>Volatiles (ug/L)</b>						
Chloroform	6.2	0.19	NE	10 U	10 U	1.1 J
cis-1,2-Dichloroethene	61	70	NE	10 U	37	10 U
Tetrachloroethene	0.66	0.7	NE	8.1 J	10 U	10 U
Trichloroethene	0.028	2.8	NE	10 U	8.5 J	10 U
<b>Metals (ug/L)</b>						
Barium	2600	2000	35.3	22.4 J	34.8 J	25.1 J
Lead	NE	15	30.9	2.5 J	1.6 U	1.6 U

Notes:

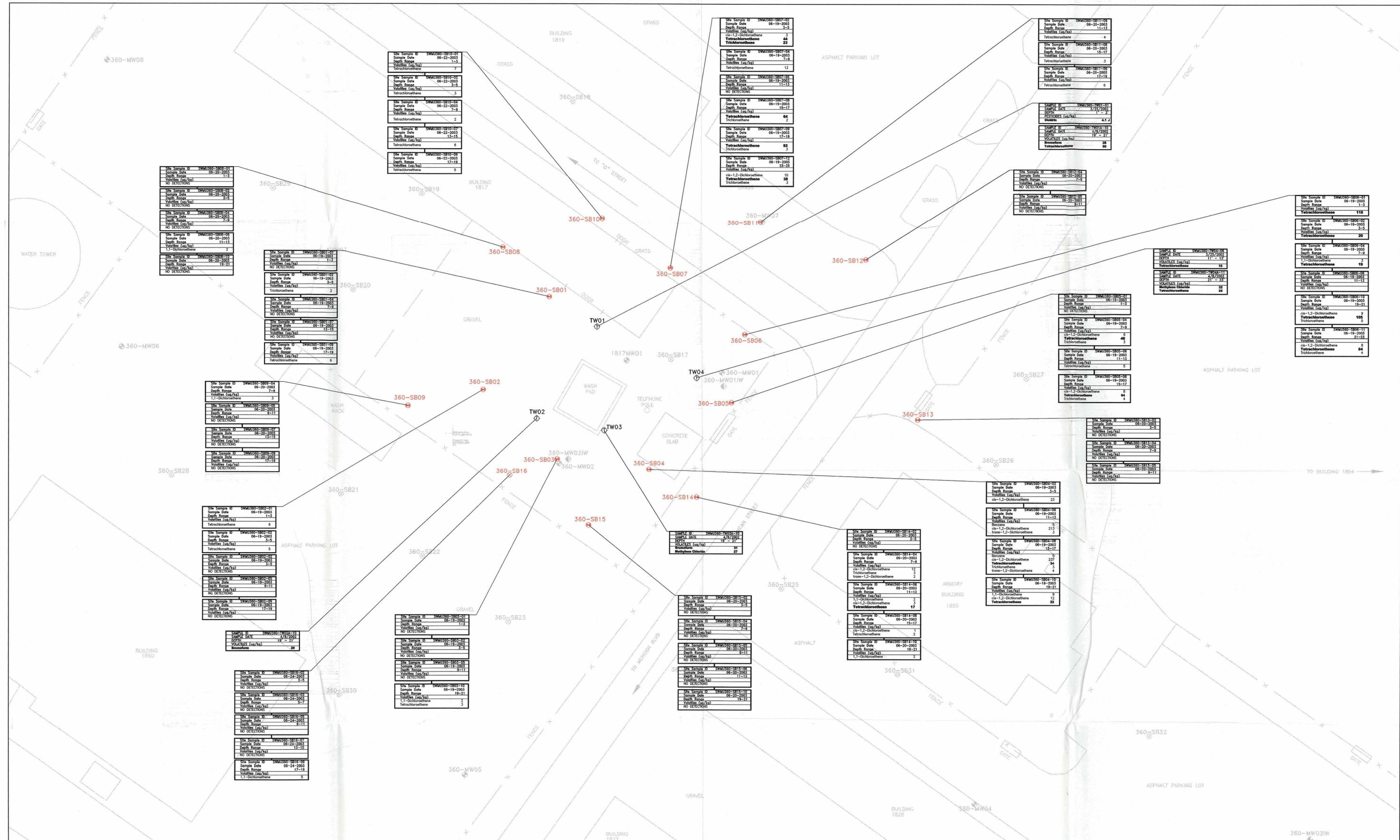
- Shaded - Exceeds USEPA Region IX PRGs
- Bold - Exceeds NC DENR soil to groundwater comparison criteria
- Boxed - Exceeds Base Background Criteria
- U - Not Detected
- J - Analyte detected. Report value is estimated.
- NE - Not established
- <sup>(1)</sup> - If NC 2L Standard was not available, Interim standards were used.

**Baker**

*Baker Environmental, Inc.*

**SECTION 4.0**

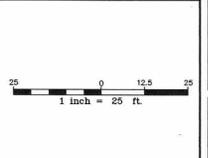
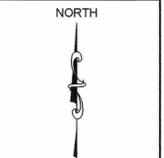
***FIGURES***



NOTE:  
**Bold** - Exceeds North Carolina soil to groundwater standards

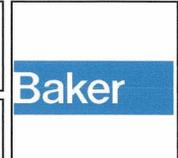
- LEGEND**
- ⊕ - PHASE II TEMPORARY WELL
  - ⊙ - EXISTING MONITORING WELL
  - ⊙ - MONITORING WELL LOCATION
  - ⊙ - INTERMEDIATE MONITORING WELL LOCATION
  - ⊙ - SOIL BORING AND GROUND WATER GRAB LOCATION
  - ⊙ - GROUND WATER GRAB LOCATION

DRAWN /RRR  
 REVIEWED RMS  
 S.O.# 26007-143-0000-06001  
 CADD# 3143360\_4\_1



MARINE CORPS BASE, CAMP LEJEUNE  
 NORTH CAROLINA

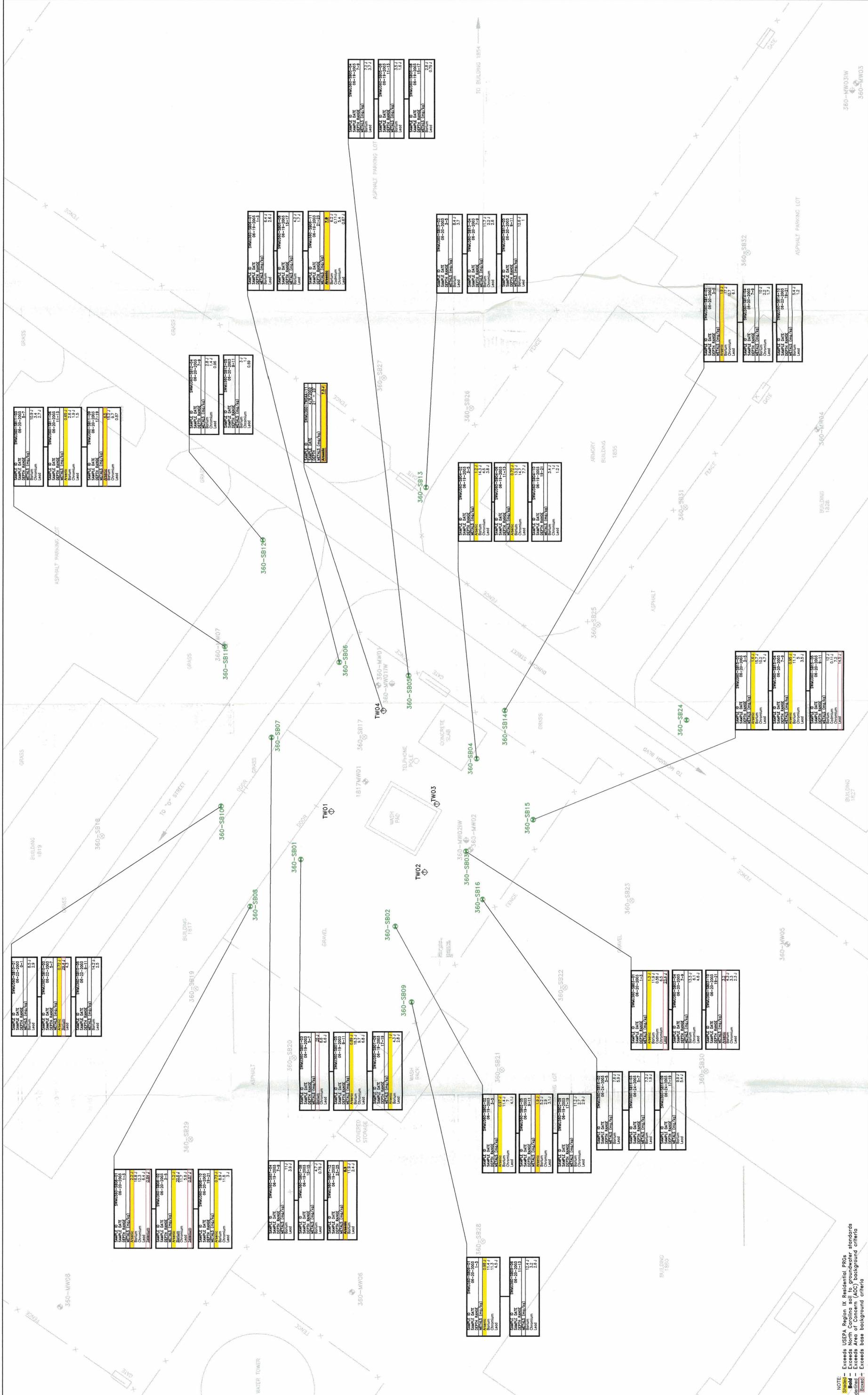
BAKER ENVIRONMENTAL, Inc.  
 Moon Township, Pennsylvania



VOCS AND PESTICIDES IN SUBSURFACE SOIL  
 SMMU 360, CTO-143

SCALE 1" = 25'  
 DATE JANUARY 2004

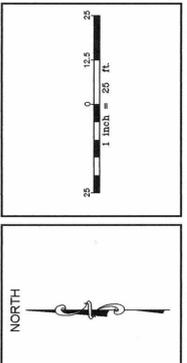
FIGURE  
**4-1**



NOTE:  
 - Exceeds USEPA Region IX Residential PRCs  
 - Exceeds North Carolina soil to groundwater standards  
 - Exceeds Area of Concern (AOC) background criteria  
 - Exceeds base background criteria

LEGEND  
 - PHASE II TEMPORARY WELL  
 - EXISTING MONITORING WELL  
 - MONITORING WELL LOCATION  
 - INTERMEDIATE MONITORING WELL LOCATION  
 - SOIL BORING AND GROUND WATER GRAB LOCATION  
 - GROUND WATER GRAB LOCATION

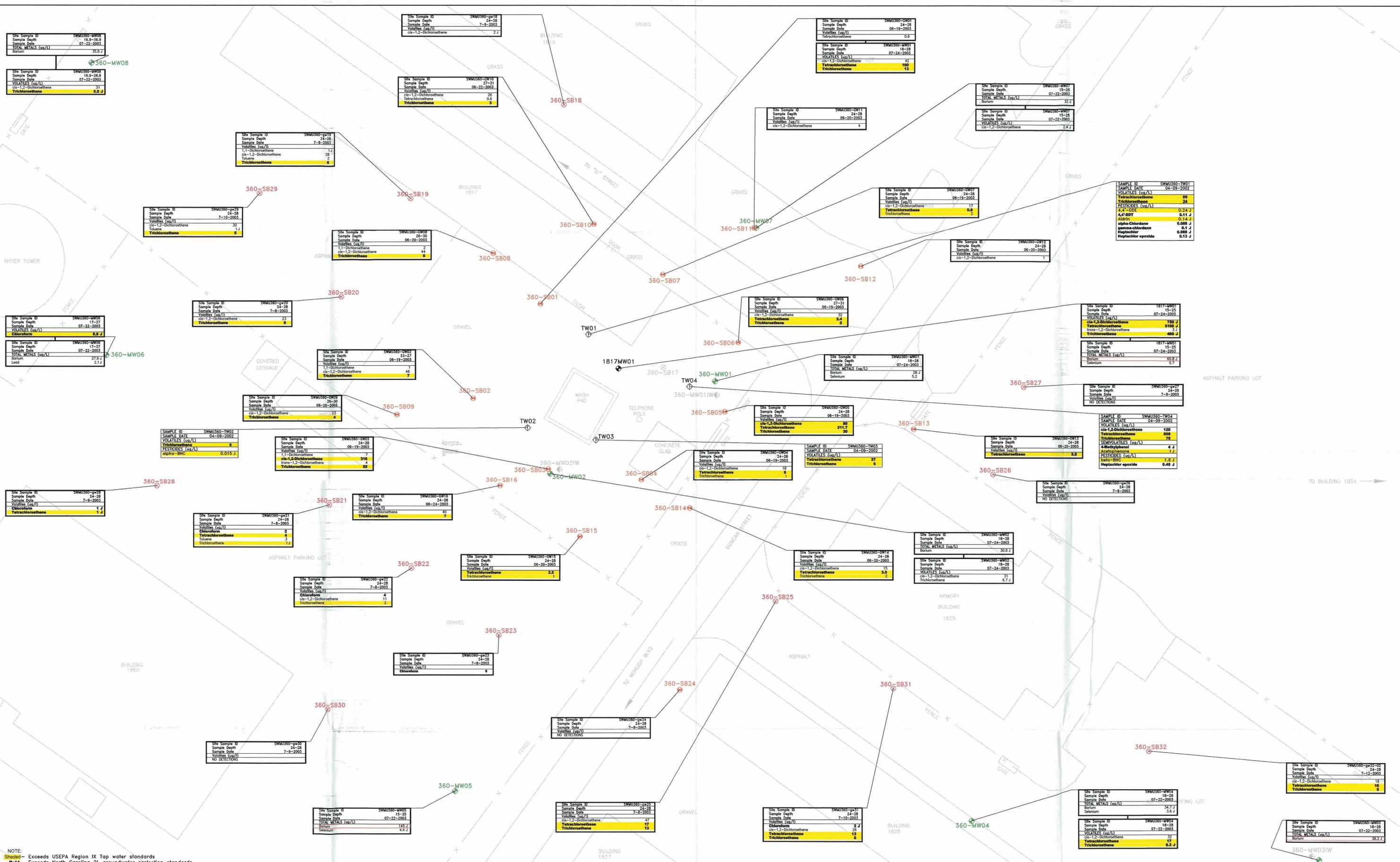
DRAWN /RRR  
 REVIEWED RWS  
 S.O.# 26007-143-0000-06001  
 CADD# 3143360\_4\_2



MARINE CORPS BASE, CAMP LEJEUNE  
 NORTH CAROLINA  
 BAKER ENVIRONMENTAL, Inc.  
 Moon Township, Pennsylvania

FIGURE  
**4-2**  
 METALS IN SUBSURFACE SOILS  
 SWMU 360, CTO-143  
 SCALE 1" = 25'  
 DATE JANUARY 2004

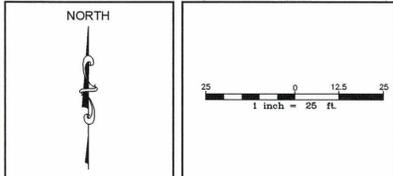




NOTE:  
 Shaded - Exceeds USEPA Region IX Tap water standards  
 Bold - Exceeds North Carolina 2L groundwater protection standards  
 Boxed - Exceeds base background criteria

LEGEND  
 ⊕ - PHASE II TEMPORARY WELL  
 ⊖ - EXISTING MONITORING WELL  
 ⊙ - MONITORING WELL LOCATION  
 ⊕ - INTERMEDIATE MONITORING WELL LOCATION  
 ⊙ - SOIL BORING AND GROUND WATER GRAB LOCATION  
 ⊙ - GROUND WATER GRAB LOCATION

DRAWN /RRR  
 REVIEWED RMS  
 S.O.# 26007-143-0000-06001  
 CADD# 3143360\_4\_3

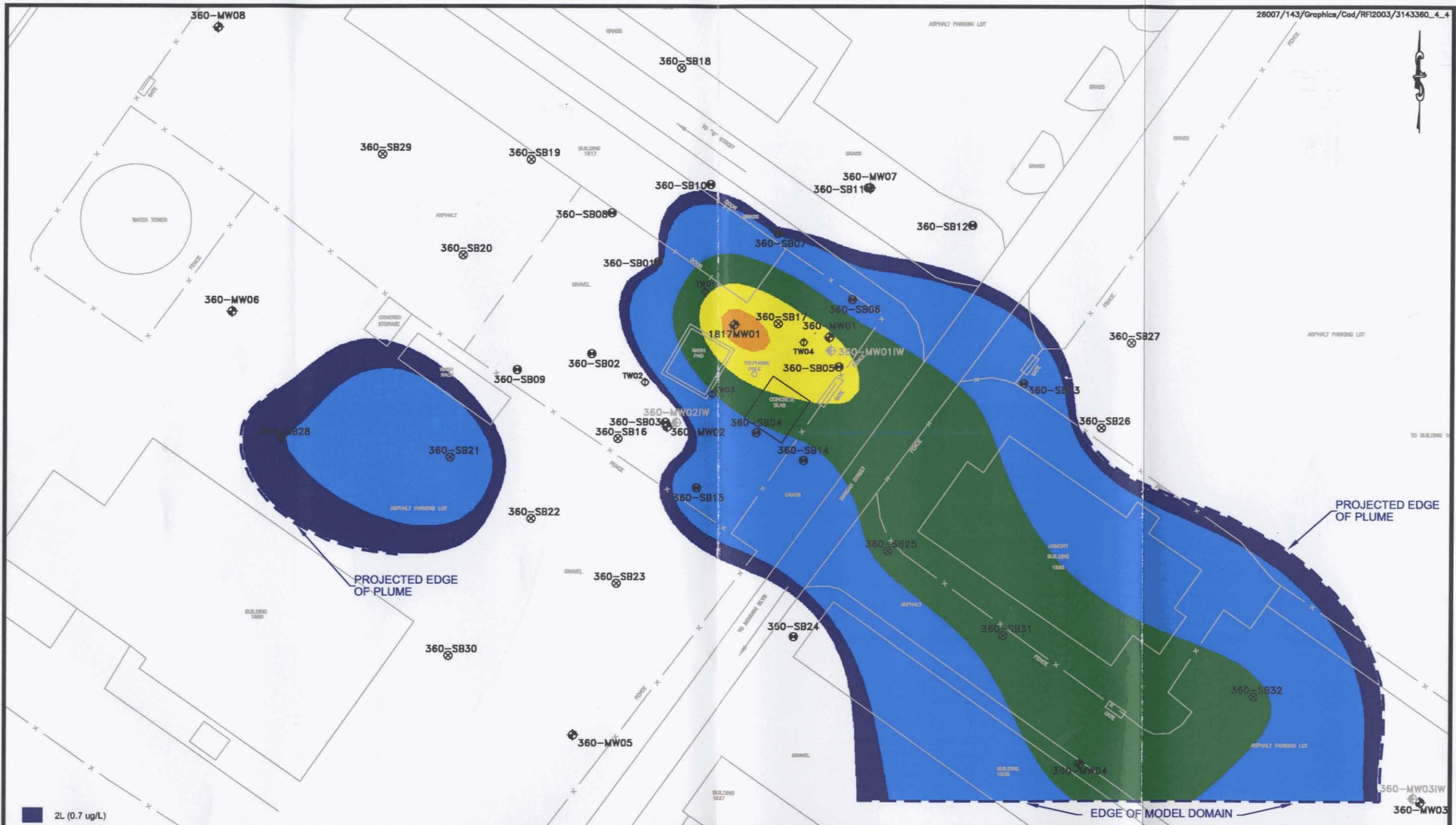


MARINE CORPS BASE, CAMP LEJEUNE  
 NORTH CAROLINA  
 BAKER ENVIRONMENTAL, Inc.  
 Moon Township, Pennsylvania



ANALYTICAL DETECTIONS IN SHALLOW GROUNDWATER  
 SWMU 360, CTO-143  
 SCALE 1" = 25'  
 DATE 12/17/03

FIGURE  
 4-3



- 2L (0.7 ug/L)
- 1 ug/L
- 10 ug/L
- 100 ug/L
- 1000 ug/L
- 10,000 ug/L

60 0 30 60  
1 inch = 60 ft.

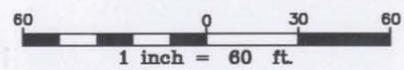
**Baker**

- LEGEND**
- ⊕ - PHASE II TEMPORARY WELL
  - ⊙ - MONITORING WELL LOCATION
  - ⊕ - INTERMEDIATE MONITORING WELL LOCATION
  - ⊙ - SOIL BORING AND GROUND WATER GRAB LOCATION
  - ⊗ - GROUND WATER GRAB LOCATION

SOURCE: MCB CAMP LEJEUNE MARCH 2000

**FIGURE 4-4**  
**TETRACHLOROETHENE (PCE) SHALLOW**  
**GROUNDWATER PLUME MAP**

SWMU 360, CTO-143  
MARINE CORPS BASE, CAMP LEJEUNE  
NORTH CAROLINA



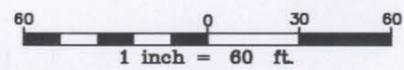
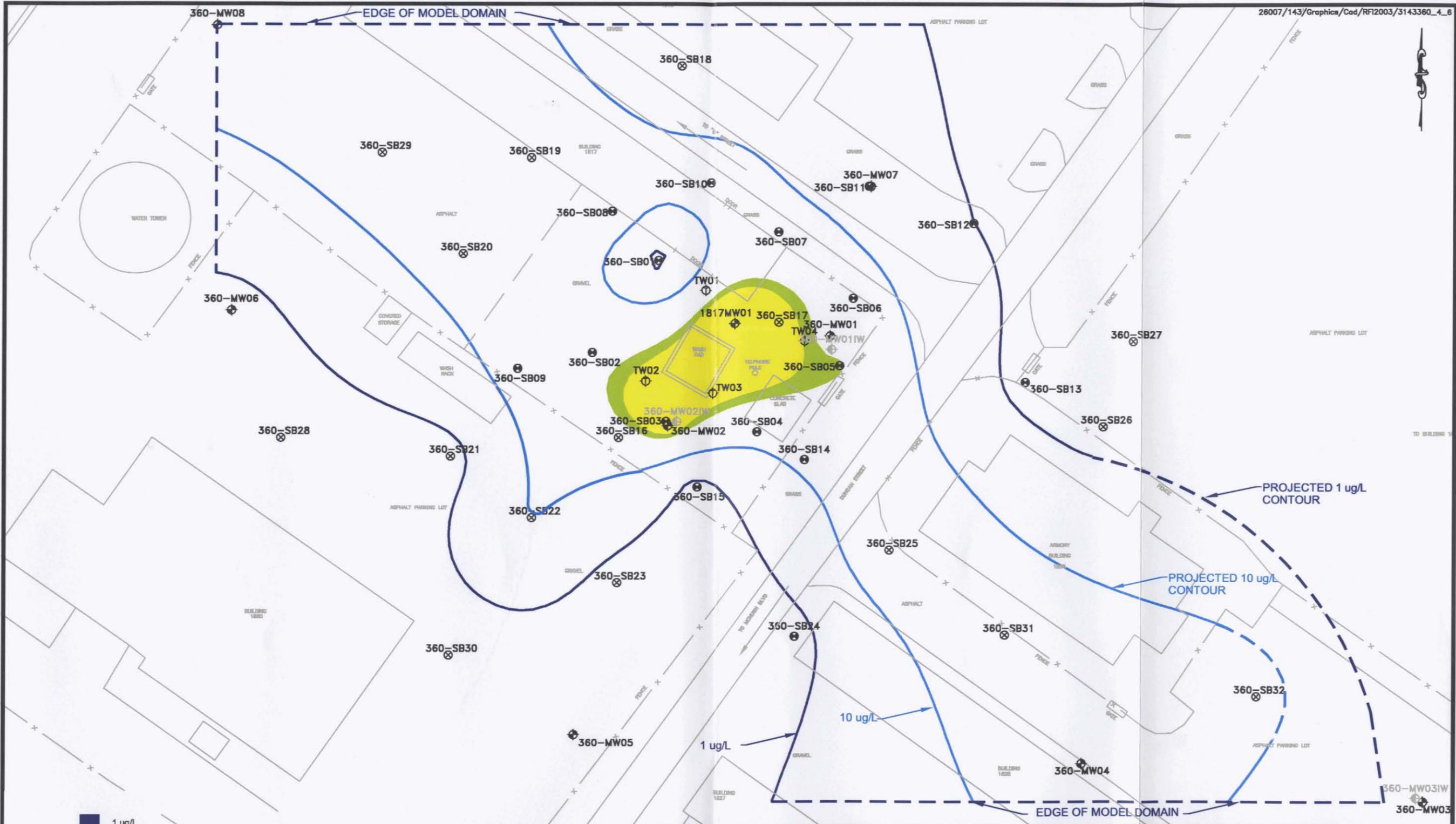
**Baker**

- LEGEND**
- ⊕ - PHASE II TEMPORARY WELL
  - ⊙ - MONITORING WELL LOCATION
  - ⊕ - INTERMEDIATE MONITORING WELL LOCATION
  - ⊙ - SOIL BORING AND GROUND WATER GRAB LOCATION
  - ⊗ - GROUND WATER GRAB LOCATION

SOURCE: MCB CAMP LEJEUNE MARCH 2000

**FIGURE 4-5**  
**TRICHLOROETHENE (TCE) SHALLOW**  
**GROUNDWATER PLUME MAP**

**SWMU 360, CTO-143**  
**MARINE CORPS BASE, CAMP LEJEUNE**  
**NORTH CAROLINA**



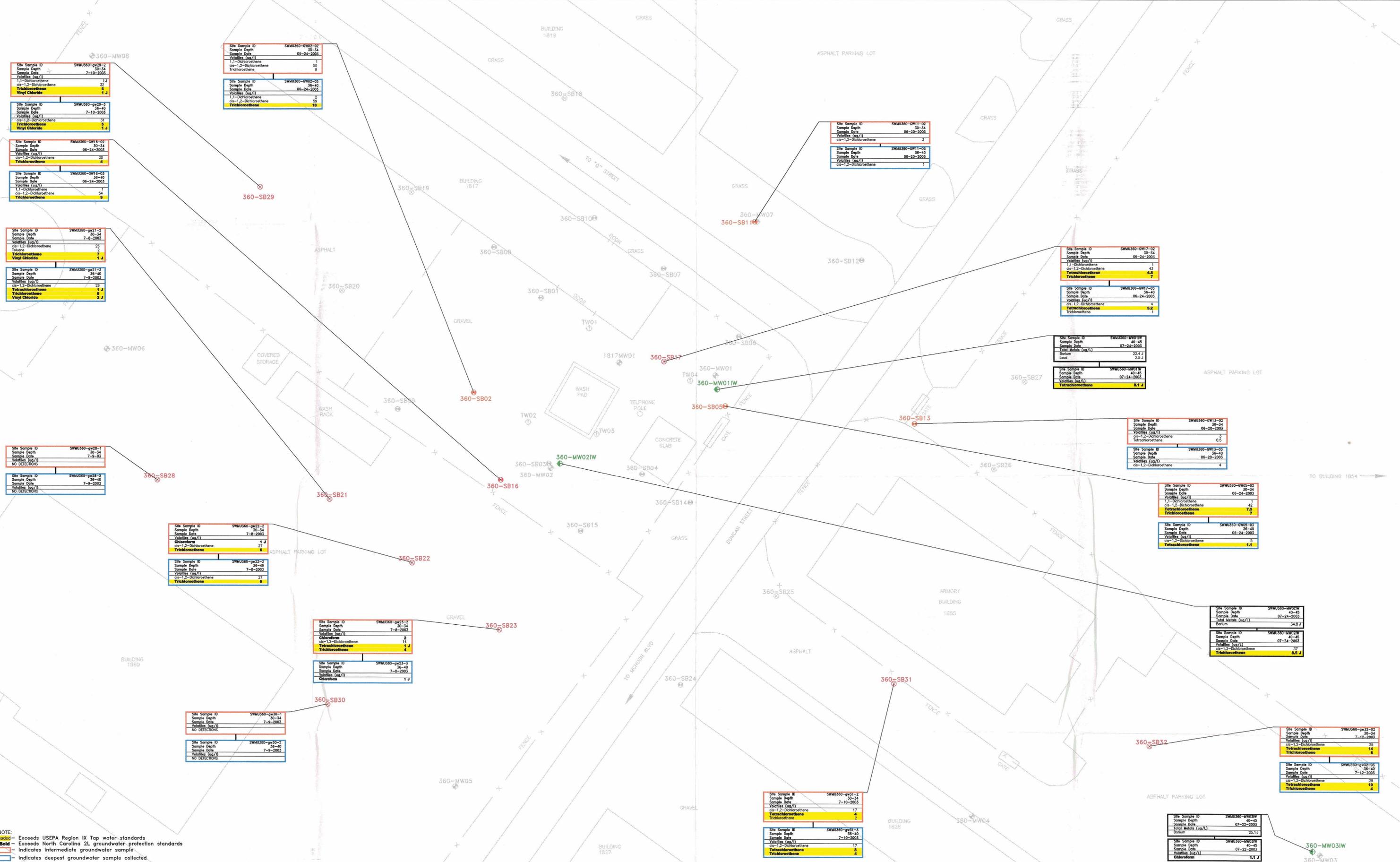
**Baker**

- LEGEND**
- ⊕ - PHASE II TEMPORARY WELL
  - ⊙ - MONITORING WELL LOCATION
  - ⊗ - INTERMEDIATE MONITORING WELL LOCATION
  - ⊘ - SOIL BORING AND GROUND WATER GRAB LOCATION
  - ⊙ - GROUND WATER GRAB LOCATION

SOURCE: MCB CAMP LEJEUNE MARCH 2000

**FIGURE 4-6**  
**CIS-1,2-DICHLOROETHENE SHALLOW**  
**GROUNDWATER PLUME MAP**

**SWMU 360, CTO-143**  
**MARINE CORPS BASE, CAMP LEJEUNE**  
**NORTH CAROLINA**



NOTE:  
 Shaded - Exceeds USEPA Region IX Tap water standards  
 Bold - Exceeds North Carolina 2L groundwater protection standards  
 - Indicates intermediate groundwater sample  
 - Indicates deepest groundwater sample collected

**LEGEND**

- - PHASE II TEMPORARY WELL
- - EXISTING MONITORING WELL
- ⊕ - MONITORING WELL LOCATION
- ⊕ - INTERMEDIATE MONITORING WELL LOCATION
- ⊕ - SOIL BORING AND GROUND WATER GRAB LOCATION
- ⊕ - GROUND WATER GRAB LOCATION

**DRAWN** /RRR  
**REVIEWED** RMS  
**S.O.#** 26007-143-0000-06001  
**CADD#** 3143360\_4\_7

**NORTH**

**SCALE**  
 1 inch = 25 ft

**MARINE CORPS BASE, CAMP LEJEUNE**  
 NORTH CAROLINA

**BAKER ENVIRONMENTAL, Inc.**  
 Moon Township, Pennsylvania

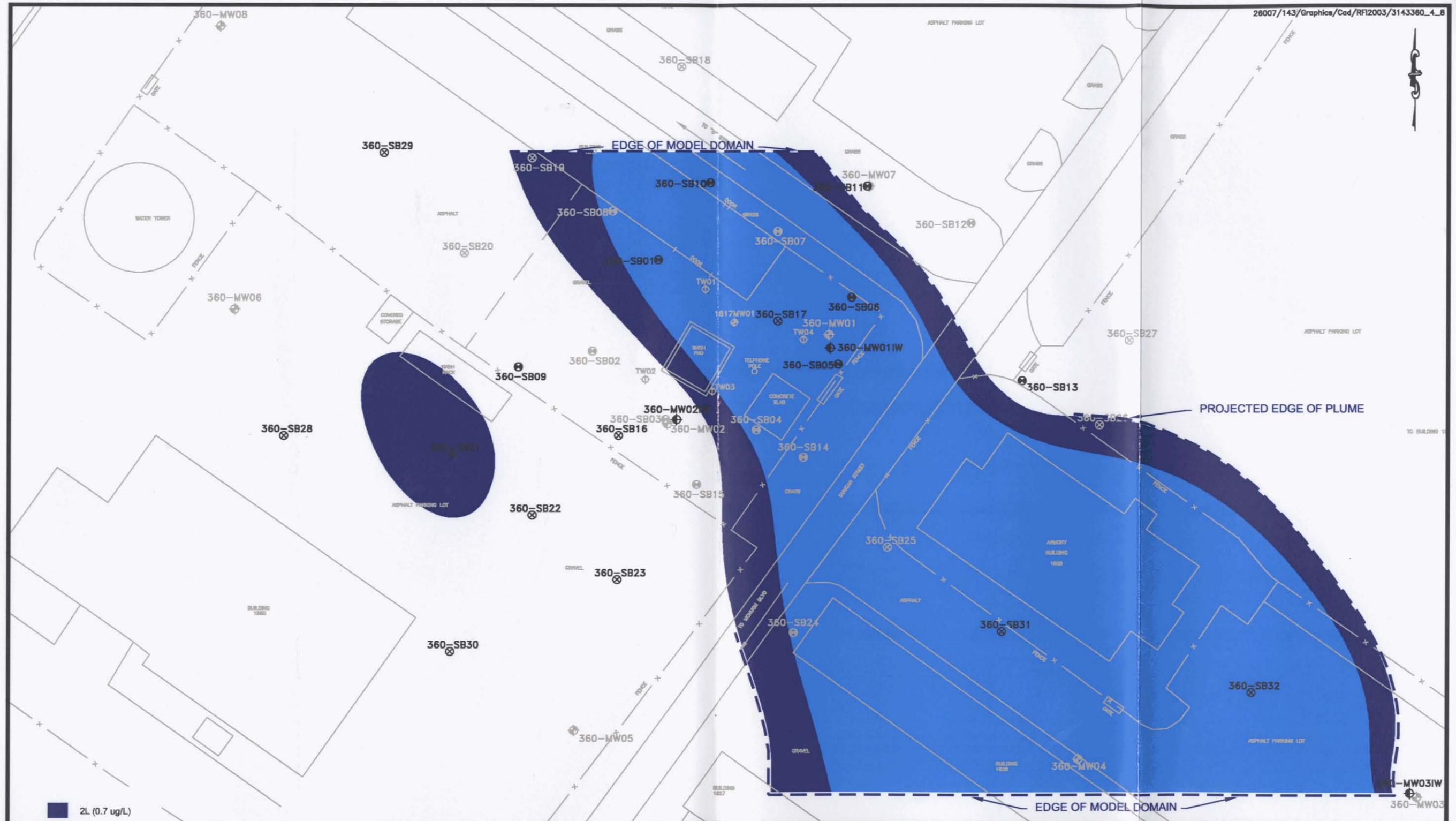


**ANALYTICAL DETECTIONS IN INTERMEDIATE GROUNDWATER**  
 SWMU 360, CTO-143

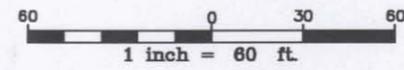
**SCALE** 1" = 25'  
**DATE** JANUARY 2004

**FIGURE**  
 4-7

SOURCE: MGB CAMP LEJEUNE MARCH 2000



- 2L (0.7 ug/L)
- 1 ug/L
- 10 ug/L
- 100 ug/L
- 1000 ug/L
- 10,000 ug/L

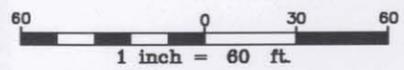


- LEGEND**
- ⊕ - PHASE II TEMPORARY WELL
  - ⊕ - MONITORING WELL LOCATION
  - ⊕ - INTERMEDIATE MONITORING WELL LOCATION
  - ⊕ - SOIL BORING AND GROUND WATER GRAB LOCATION
  - ⊕ - GROUND WATER GRAB LOCATION

SOURCE: MCB CAMP LEJEUNE MARCH 2000

**FIGURE 4-8**  
**TETRACHLOROETHENE (PCE) INTERMEDIATE**  
**GROUNDWATER PLUME MAP**

**SWMU 360, CTO-143**  
**MARINE CORPS BASE, CAMP LEJEUNE**  
**NORTH CAROLINA**

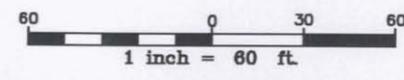
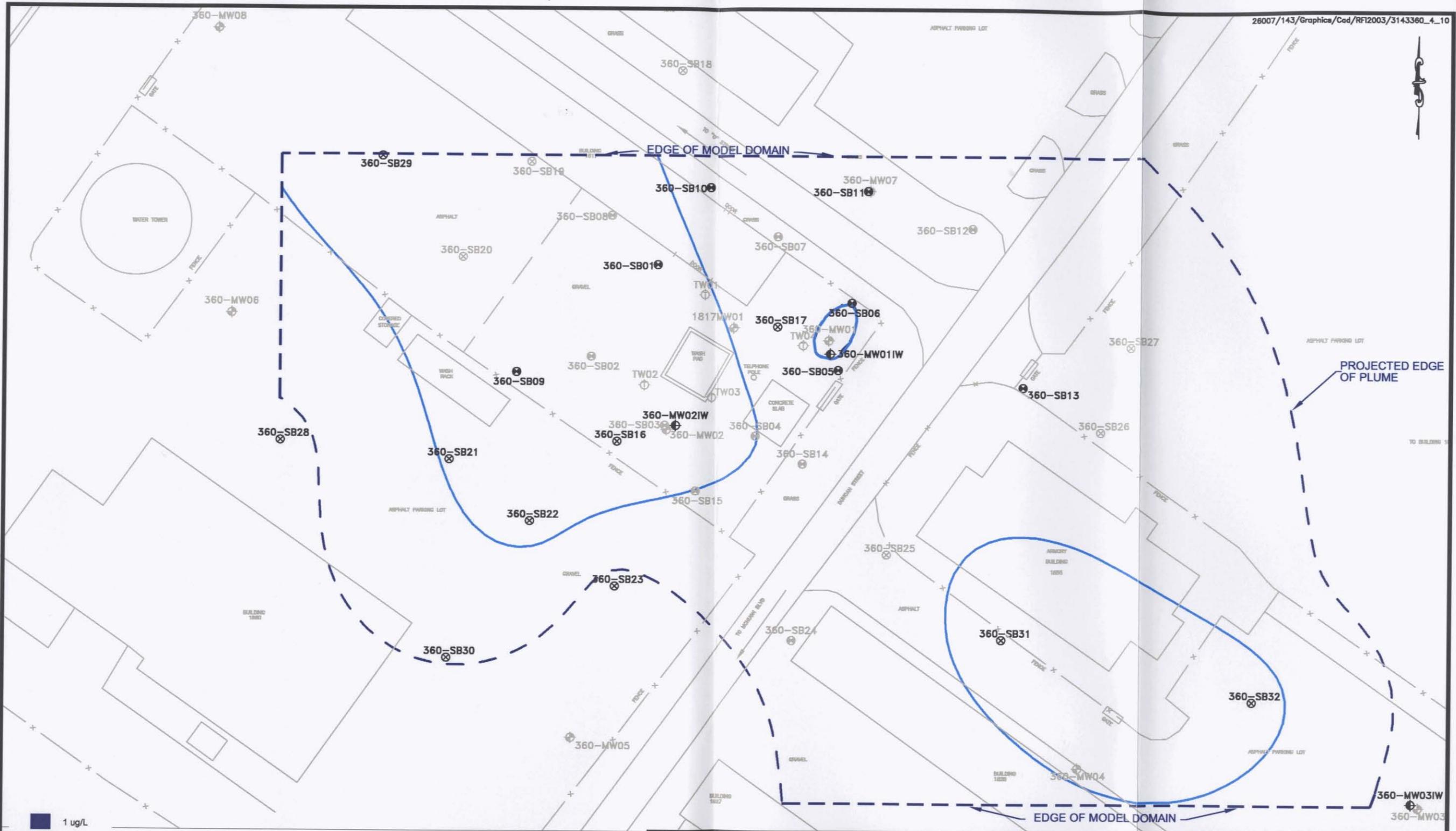


**Baker**

- LEGEND**
- ⊕ - PHASE II TEMPORARY WELL
  - ⊙ - MONITORING WELL LOCATION
  - ⊕ - INTERMEDIATE MONITORING WELL LOCATION
  - ⊙ - SOIL BORING AND GROUND WATER GRAB LOCATION
  - ⊗ - GROUND WATER GRAB LOCATION

SOURCE: MCB CAMP LEJEUNE MARCH 2000

**FIGURE 4-9**  
**TRICHLOROETHENE (TCE) INTERMEDIATE**  
**GROUNDWATER PLUME MAP**  
 SWMU 360, CTO-143  
 MARINE CORPS BASE, CAMP LEJEUNE  
 NORTH CAROLINA



**Baker**

- LEGEND**
- ⊕ - PHASE II TEMPORARY WELL
  - ⊗ - MONITORING WELL LOCATION
  - ⊙ - INTERMEDIATE MONITORING WELL LOCATION
  - ⊗ - SOIL BORING AND GROUND WATER GRAB LOCATION
  - ⊗ - GROUND WATER GRAB LOCATION

SOURCE: MCB CAMP LEJEUNE MARCH 2000

**FIGURE 4-10**  
**CIS-1,2-DICHLOROETHENE (cDCE)**  
**INTERMEDIATE**  
**GROUNDWATER PLUME MAP**  
**SWMU 360, CTO-143**  
**MARINE CORPS BASE, CAMP LEJEUNE**  
**NORTH CAROLINA**

## 5.0 FATE AND TRANSPORT

The potential for a contaminant to migrate and persist in an environmental medium is critical when evaluating the potential for a constituent to elicit an adverse human health or ecological effect. The environmental mobility of a constituent is influenced by several factors, including the following:

- Its physical and chemical properties
- The physical characteristics of the site
- The site chemistry

Because there is evidence that a release in and around SWMU 360 has impacted the surrounding soil and groundwater, a discussion of fate and transport is warranted. This section presents a discussion of the various physical and chemical properties of significant contaminants in SWMU 360 media discussed in Section 4.0 and their fate and transport in the environment.

### 5.1 Chemical and Physical Properties Impacting Fate and Transport

Table 5-1 presents the physical and chemical properties associated with the organic compounds detected during this investigation. These properties determine the inherent environmental mobility and fate of a contaminant. The properties of interest include the following:

- Vapor pressure
- Water solubility
- Octanol/water partition coefficient
- Organic carbon adsorption coefficient (sediment partition)
- Specific gravity
- Henry's Law constant

A discussion of the environmental significance of each of these properties follows.

Vapor pressure provides an indication of the rate at which a chemical may volatilize. It is of primary significance at environmental interfaces such as surface soil/air and surface water/air. Volatilization can be important when evaluating groundwater and subsurface soils, particularly when selecting remedial technologies. Vapor pressure for monocyclic aromatics is generally

higher than vapor pressures for poly-aromatic hydrocarbons (PAHs). Contaminants with higher vapor pressures (e.g., VOCs) will enter the atmosphere at a quicker rate than the contaminants with low vapor pressures (e.g., polychlorinated biphenyls).

The rate at which a contaminant is leached from soil by infiltrating precipitation is proportional to its water solubility. More soluble contaminants are usually more readily leached than less soluble contaminants. The water solubilities indicate that the volatile organic contaminants, including monocyclic aromatics, are usually several orders-of-magnitude more soluble than PAHs. Consequently, highly soluble compounds such as the chlorinated VOCs will go into solution faster and possibly in greater concentrations than less soluble compounds. The solubility of a specific compound is dependent on the chemistry of the groundwater and aquifer material. Factors such as groundwater pH, Eh (redox potential), temperature, and the presence of other compounds can greatly affect the solubility.

The octanol/water partition coefficient ( $K_{ow}$ ) is the ratio of the chemical concentration in octanol divided by the concentration in water. The octanol/water partition coefficient has been shown to correlate well with bioconcentration factors in aquatic organisms and adsorption to soil or sediment. Specifically, a linear relationship between octanol/water partition coefficients and the uptake of chemicals by fatty tissues of animal and human receptors (the bioconcentration factor - BCF) has been established (Lyman et al., 1982). The coefficient is also useful in characterizing the sorption of compounds by organic soils where experimental values are not available.

The organic carbon adsorption coefficient ( $K_{oc}$ ) indicates the tendency of a chemical to adhere to the organic carbon in soil particles. The solubility of a chemical in water is inversely proportional to the  $K_{oc}$ . Contaminants with high soil/sediment adsorption coefficients generally have low water solubilities. For example, contaminants such as PAHs are relatively immobile in the environment, are preferentially bound to the soil, and therefore have a higher  $K_{oc}$  value. These compounds are not subject to aqueous transport to the extent of compounds with higher water solubilities. Mechanical activities (e.g., erosion) and the physical characteristics of surface soils may, however, increase the mobility of these bound soil contaminants.

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

Vapor pressure and water solubility are of use in determining volatilization rates from surface water bodies and from groundwater. These two parameters can be used to estimate an equilibrium concentration of a contaminant in the water phase and in the air directly above the water. This relationship is expressed as Henry's Law Constant.

A quantitative assessment of mobility has been developed that uses water solubility (S), vapor pressure (VP), and organic carbon partition coefficient ( $K_{oc}$ ) (Laskowski, 1983). This value is referred to as the Mobility Index (MI). It is defined as:

$$MI = \log((S*VP)/K_{oc})$$

A scale to evaluate MI as presented by Ford and Gurba (1984) is:

<u>Relative MI</u>	<u>Mobility Description</u>
> 5	extremely mobile
0 to 5	very mobile
-5 to 0	slightly mobile
-10 to -5	immobile
< -10	very immobile

The mobility index of each organic analyte detected at SWMU 360 is presented on Table 5-1.

## **5.2 Contaminant Transport Pathways**

Based on the evaluation of existing conditions at SWMU 360, the following potential contaminant transport pathways have been identified:

- Volatilization from soil or groundwater to air
- Leaching of soil contaminants to groundwater
- Migration of groundwater contaminants, laterally and vertically

Contaminant concentrations may be affected by one or more mechanisms during transport. Contaminants may be physically transformed by volatilization or precipitation. Contaminants may be chemically transformed through photolysis, hydrolysis, or oxidation/reduction.

Contaminants may be biologically transformed by biodegradation. Additionally, contaminants may accumulate in one or more media. Since different transformation mechanisms are important for different contaminants, these mechanisms are discussed as necessary in Section 5.3.

The paragraphs that follow describe the potential transport pathways listed above with respect to significant compound concentrations. Significant compound concentrations refer to those compounds discussed in Section 4.0 frequently occurring above criteria comparisons. Specific fate and transport concerns are discussed in Section 5.3.

#### **5.2.1 Leaching of Soil Contaminants to Groundwater**

VOCs (mostly PCE and TCE) and metals (arsenic) were detected in subsurface soil samples at SWMU 360 (Figures 4-1 and 4-2). VOCs and metals in subsurface soils were limited to the northeast corner of the compound. PCE and TCE were detected frequently in groundwater samples (Figures 4-3 and 4-7). The detection of SVOCs and pesticides in groundwater was limited to the Phase II CSI and were not detected in any of the groundwater samples collected during this RFI.

Contaminants that adhere to soil particles or have accumulated in soil pore spaces can leach and migrate vertically to the groundwater as a result of infiltration of precipitation. The rate and extent of this leaching is influenced by several factors, including:

- The depth to the water table
- The amount of precipitation
- The rate of infiltration
- The physical and chemical properties of the soil
- The physical and chemical properties of the contaminant.

Based on the facts that VOCs are mobile compounds, the soil type is primarily fine sand, and that subsurface soil contamination exists just above the groundwater interface, constituent leaching to groundwater has likely occurred at SWMU 360. This is also rather evident due to the extent of groundwater contamination found at SWMU 360.

### 5.2.2 Migration of Groundwater Contaminants

Organic and inorganic contaminants leaching from soil to groundwater can migrate as dissolved constituents in groundwater in the direction of groundwater flow. Three general processes govern the migration of dissolved contaminants caused by groundwater flow: advection, dispersion, and retardation. Advection is a process by which solutes are carried by groundwater movement. Dispersion is the mixing of contaminated and uncontaminated water during advection. Retardation is the slowing of contaminant migration caused by the reaction of the solute with the aquifer matrix.

A contaminant that is present in water above its solubility concentration will form an immiscible, non-aqueous phase liquid (NAPL). Based on the specific gravity of the contaminant, NAPL will either float or sink in the water. Subsurface transport of the immiscible contaminants is governed by a set of factors different from those of dissolved contaminants. There is no evidence (e.g., concentration, distribution of constituents, and age of contamination) to suggest that NAPL is present at SWMU 360.

Advection is the process by which moving groundwater carries dissolved solutes (Fetter, 1988). Groundwater flow velocities at SWMU 360 were determined by using a variation of Darcy's equation (discussed in Section 2.5.4). Groundwater flow velocities in the surficial and Castle Hayne aquifers underlying SWMU 360 range from 0.05 to 0.27 ft/d, or 3.43 to 61.51 feet per year (Figure 5-3). The direction of the local groundwater flow regime is to the east to southeast (based on shallow wells) toward Codgel's Creek. The direction of the regional groundwater flow regime is assumed to the south (based on information from Site 78), and likely discharges to the New River. The Castle Hayne confining unit was not present in any of the borings at SWMU 360. Vertical hydraulic conductivity data obtained from laboratory measurements ranged from 0.003 feet per foot to 0.046 feet per foot (Table 2-4).

Dispersion results evolve from two basic processes molecular diffusion and mechanical mixing. The kinetic activity of dissolved solutes results in diffusion of solutes from a zone of high concentration to a zone of lower concentration. Dispersion can occur in three directions, longitudinal (in the direction of flow), transverse (horizontally perpendicular to longitudinal), and vertical. Dispersion is largely scale dependent (i.e., the greater the area over which it is measured, the larger the dispersion value). Furthermore, longitudinal dispersion is often observed to be markedly greater than dispersion in the transverse direction of flow. It is often assumed that

transverse dispersion is one-tenth longitudinal dispersion (Nichols, 1993). Lacking detailed site studies to determine dispersion, the parameter can be estimated to be one-tenth of the length of the flow path, in the same lithologies (Fetter, 1988).

Retardation is a process whereby a solute concentration is reduced through a chemical, biological, or radioactive change. Solutes can be categorized in two broad classes: conservative and reactive. Conservative solutes do not react with aquifer soil. Reactive solutes will interact with the soil encountered along the flow path through adsorption, partitioning, ion exchange, and other processes. The retardation factor (R) can be calculated by the following equation (Fetter, 1988):

$$R = 1 + (P_b/n)(K_d)$$

Where:

- $P_b$  = dry bulk density of the soil
- $n$  = porosity of the soil
- $k_d$  = distribution coefficient for the solute with the soil ( $K_{oc}$  of the solute times the TOC content of the soil)

Retardation factor calculations are presented in Table 5-3. The lower the retardation factor, the faster the migration rate. These factors are estimated because of the lack of site-specific data, including TOC analytical data and porosity. It is common however, to estimate retardation factors. The relative differences are useful for describing plume characteristics.

Based on a retardation factor, a constituent velocity can be estimated by the following equation (Fetter, 1988):

$V_{gw} / R$ , where:

$$V_{gw} = \text{Groundwater velocity}$$

Table 5-3 presents the estimated contaminant velocities for VOCs in groundwater. For the VOCs detected in groundwater, the velocity ranges from 3.43 feet per year to 61.51 feet per year. It is important to note that this contaminant velocity estimate is conservative because it does not account for biodegradation.

Transformation of chlorinated VOCs is an important fate process (USDHH&S, 1990). Tetrachloroethene will degrade to trichloroethene. Trichloroethene will in turn, degrade primarily to cis-DCE, and to a lesser extent, trans-1,2-dichloroethene. Cis-DCE will degrade to chloroethane and, to a lesser extent, vinyl chloride. 1,2-Dichloroethene (trans) will degrade to vinyl chloride.

Cis-DCE, trichloroethene, and tetrachloroethene have been detected in groundwater samples at SWMU 360. Both trichloroethene and tetrachloroethene are common solvents. Eighty percent of trichloroethene used in the United States is for metal parts cleaning (USDHH&S, 1991), while 50 percent of Tetrachloroethene is used for dry cleaning (USDHH&S, 1990). 1,2-Dichloroethene (cis & trans) is primarily used as a chemical intermediate in production of chlorinated solvents and compounds (USDHH&S, 1994). It is likely that trichloroethene and Tetrachloroethene were used at Camp Lejeune, rather than 1,2-dichloroethene. The presence of 1,2-dichloroethene in groundwater samples is likely a transformation product rather than a primary contaminant.

Metals are inherent to soil, sediment, and groundwater. For this reason, concentrations of metals must be discussed with respect to background or natural concentrations. Metal solutes behave differently than organic solutes. While the fate and transport of metal solutes generally occur by the same three processes described above, the fate of metals is significantly affected by groundwater and aquifer matrix chemistry. The concentration of metals and their movement are dependent on such things as ion exchange capacity, pH, and redox potential. Table 5-2 presents an assessment of relative environmental mobility of inorganics as a function of Eh and pH. Different metals will behave differently under the same conditions. Metal solutes therefore, need to be examined individually.

### **5.3 Fate and Transport Summary**

The paragraphs that follow discuss transport mechanisms and the fate for the significant contaminants discussed in Section 4.0.

### 5.3.1 Volatile Organic Compounds

VOCs tend to be mobile in environmental media as indicated by their presence in groundwater and their corresponding MI values/retardation factors. Their environmental mobility is a function of high water solubility's, high vapor pressures, low  $K_{ow}$  and  $K_{oc}$  values, and high mobility indices. Because VOCs are highly mobile in soil, they will readily leach to underlying groundwater. Detections of VOCs in subsurface soil in and around SWMU 360 indicate a potential source for the groundwater contamination at SWMU 360.

VOCs potentially related to the former UST were detected in monitoring wells located in and around the former UST area. Figure 4-3 and 4-7 shows the distribution of the organics and inorganics in groundwater. Based on each solute's MI value/retardation factor, each solute is expected to migrate at a different rate. Additionally, over time, transformation of the original solutes is expected.

The primary source area seems to be located in the vicinity of the former UST. This is based on two points. The first point is the presence of PCE, TCE and cis-DCE at the highest observed concentrations. Well 1817-MW01 exhibits the highest concentration of total VOCs as compared with other wells at the site. The second point is the high percentage of tetrachlorethene relative to transformation products of trichloroethene and cis 1,2-dichloroethene at well 1817-MW01. Additionally, note that the highest levels of VOCs detected during this investigation were also detected in well 1817-MW01.

It should be noted that subsurface soil concentrations found from the near surface all the way down to the groundwater interface in 360-SB06 and SB07 exhibit another potential source for VOC contamination in groundwater at SWMU 360.

### 5.3.2 Metals

According to Section 4.0, the presence of metals in soil and above criteria levels is limited. The dissolution of these metals from soils to groundwater has not resulted in concentrations exceeding NC 2L standards. Arsenic detected in subsurface soil samples 360-SB06-11 and 360-SB07-12 did exceed the NC STGCs. Arsenic is naturally occurring in soils, and has frequently been detected in soil samples above comparison criteria at Camp Lejeune. Even though arsenic is

present in subsurface soils exceeding NC STGCs, no arsenic was detected above NC 2L standards in groundwater samples collected during this RFI at SWMU 360.

Previous studies by Baker and others indicate that arsenic is ubiquitous in soils at MCB Camp Lejeune. These studies show that concentrations of arsenic are variable and can occur in surface soil, subsurface soil, sediments, surface water and groundwater at levels exceeding comparison criteria. It is possible that elevated levels of arsenic in a particular media may not be associated with contamination, but rather be representative of natural conditions.



**Baker**

*Baker Environmental, Inc.*

**SECTION 5.0**

*TABLES*

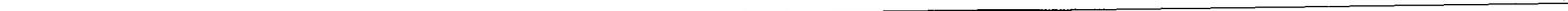


TABLE 5-1

**ORGANIC PHYSICAL AND CHEMICAL PROPERTIES**  
**SWMU-360**  
**RCRA FACILITY INVESTIGATION - CTO-0143**  
**MCB, CAMP LEJEUNE, NORTH CAROLINA**

Constituents of Potential Concern	log K <sub>ow</sub> (unitless)	Specific Gravity (unitless)	Henry's Law Constant (atm-m <sup>3</sup> /mol)	Mobility Index Input Parameters			Mobility Index	Comments
				Vapor Pressure (mm Hg)	Water Solubility (mg/L)	K <sub>oc</sub> (mL/g)		
cis 1,2-Dichloroethene	0.70	NA	7.58E-03	2.08E+02	3500	49	4.17	very mobile
Tetrachloroethene (PCE)	2.60	NA	2.59E-02	1.78E+01	150	364	0.87	very mobile
Trichloroethene (TCE)	2.38	NA	9.10E-03	5.79E+01	1100	126	2.70	very mobile
Vinyl chloride	1.38	NA	8.19E-02	2.66E+03	2670	57	5.10	extremely mobile
acetophenone	1.68	NA	1.07E-05	3.97E-01	5500	45	1.69	very mobile
4 - methylphenol	1.94	NA	6.53E-02	1.47E+01	19000	49	3.76	very mobile
aldrin	5.30	NA	1.60E-05	6.00E-06	180	96000	-7.95	very immobile
alpha - BHC	3.90	NA	5.87E-06	2.50E-05	1.63	3800	-7.97	very immobile
beta - BHC	3.90	NA	4.47E-07	2.80E-07	0.24	3800	-10.75	very immobile
Heptaclor	4.40	NA	8.19E-04	3.00E-04	0.18	12000	-8.35	very immobile
Heptaclor Epoxide	2.70	NA	4.39E-04	3.00E-04	0.35	220	-6.32	very immobile
4,4-DDE	7.00	NA	6.80E-05	6.50E-06	0.01	4400000	-13.83	very immobile
4,4-DDT	6.19	0.99	5.13E-04	5.50E-06	0.005	243000	-12.95	very immobile
alpha-chlordane	2.64	NA	2.41E-02	1.00E-05	0.56	140000	-10.40	very immobile
gamma-chlordane	2.64	1.6	2.41E-02	1.00E-05	0.56	140000	-10.40	very immobile
Dieldrin	3.50	1.75	4.58E-07	1.78E-07	0.195	1700	-10.69	very immobile

Notes:

Source - Superfund Public Health Evaluation Manual (EPA 540/1-86/060)

NA - Not available

TABLE 5-2

RELATIVE MOBILITIES OF METALS AS A FUNCTION OF ENVIRONMENTAL CONDITIONS (Eh, pH)  
 SWMU-360  
 RCRA FACILITY INVESTIGATION - CTO-0143  
 MCB, CAMP LEJEUNE, NORTH CAROLINA

Relative Mobility	Environmental Conditions			
	Oxidizing	Acidic	Neutral/Alkaline	Reducing
Very high			Se	
High	Se, Zn	Se, Zn, Cu, Ni, Hg, Ag		
Medium	Cu, Ni, Hg, Ag, As, Cd	As, Cd	As, Cd	
Low	Pb, Ba, Se	Pb, Ba, Be	Pb, Ba, Be	
Very Low	Fe, Cr	Cr	Cr, Zn, Cu, Ni, Hg, Ag	Cr, Se, Zn, Cu, Ni, Hg, Pb, Ba, Be, Ag

Notes:

Se = Selenium	Cd = Cadmium
Zn = Zinc	Ba = Barium
Cu = Copper	Pb = Lead
Ni = Nickel	Fe = Iron
Hg = Mercury	Cr = Chromium
Ag = Silver	Be = Beryllium
As = Arsenic	Zn = Zinc

Source:

Swartzbaugh, et al. "Remediating Sites Contaminated with Heavy Metals."  
 Hazardous Materials Control, November/December 1992.

TABLE 5-3

RETARDATION AND VELOCITY CALCULATIONS  
 SWMU-360  
 RCRA FACILITY INVESTIGATION - CTO-0143  
 MCB, CAMP LEJEUNE, NORTH CAROLINA

Surficial Aquifer								
Constituents of Potential Concern	$K_{oc}^{(1)}$ (mL/g)	$f_{oc}^{(2)}$ (%)	$K_d$ ( $K_{oc} \times f_{oc}$ )	Bulk Density <sup>(3)</sup> (g/cm <sup>3</sup> )	Soil Porosity <sup>(4)</sup> (%)	Retardation Factor	Groundwater Velocity <sup>(5)</sup> (feet/day)	Constituent Velocity <sup>(6)</sup> (feet/year)
cis 1,2-Dichloroethene	49	0.0024	1.18E-01	1.5	0.3	1.59	0.05	11.58
Tetrachloroethene (PCE)	364	0.0024	8.74E-01	1.5	0.3	5.37	0.05	3.43
Trichloroethene (TCE)	126	0.0024	3.02E-01	1.5	0.3	2.51	0.05	7.32
Vinyl chloride	57	0.0024	1.37E-01	1.5	0.3	1.68	0.05	10.92
Castle Hayne Aquifer								
cis 1,2-Dichloroethene	49	0.0024	1.18E-01	1.5	0.3	1.59	0.27	61.51
Tetrachloroethene (PCE)	364	0.0024	8.74E-01	1.5	0.3	5.37	0.27	18.20
Trichloroethene (TCE)	126	0.0024	3.02E-01	1.5	0.3	2.51	0.27	38.88
Vinyl chloride	57	0.0024	1.37E-01	1.5	0.3	1.68	0.27	58.00

Source:

(1) Superfund Public Health Evaluation Manual (EPA 540/1-86/060)

(2) Base-wide average compiled from various Baker projects

(3) Soil Survey of Onslow County, North Carolina

(4) Technical Protocol for Evaluating Natural Attenuation of Chlorinated Solvents in Groundwater (EPA/600/R-98/128)

(5) Groundwater velocity is determined by:

$$V = K/n_e \times i \text{ Where } K = \boxed{4.2} \text{ feet/day (Table 3-2, surficial)} \quad \boxed{22.3} \text{ feet/day (Table 3-2, Castle Hayne)}$$

$$n_e = \boxed{0.25} \text{ (effective porosity, see footnote \#4)}$$

$$i = \boxed{0.003} \text{ feet/foot (gradient, Figure 3-5)}$$

(6) Contaminant velocity is determined by:

$$V_c = V_{gw}/R, \text{ where } V_c = \text{Contaminant velocity}$$

$$V_{gw} = \text{Groundwater velocity}$$

$$R = \text{Retardation factor}$$

## **6.0 HUMAN HEALTH RISK ASSESSMENT**

A baseline HHRA was completed as part of the RFI for SWMU 360 to evaluate if unacceptable risks may be associated with potential exposure to existing conditions at the site. The baseline HHRA considers the most likely routes of potential human exposure for both current and future risk scenarios. The baseline HHRA was conducted in accordance with the Risk Assessment Guidance for Superfund (RAGS), Part A, Human Health Evaluation Manual (USEPA, 1989) and the most recent updates, including the reporting format as set forth in RAGS Part D (USEPA, 1998). USEPA Region IV Supplemental Risk Guidance (USEPA, 1996) was also utilized throughout the baseline HHRA process. Data available for the HHRA at SWMU 360 includes surface soil, subsurface soil, and groundwater data collected for the Phase II SWMU CSI (Baker, 2002) and the current RFI field investigation.

The baseline HHRA is comprised of seven sections; Section 6.1 presents the site location and characterization. Section 6.2 presents the hazard identification, which presents criteria for selecting COPCs. Sections 6.3 and 6.4 present the exposure assessment and toxicity assessment, respectively. The risk characterization, including a discussion of potential human health effects, is presented in Section 6.5. Section 6.6 outlines the potential sources of uncertainty encountered in the process of performing a risk assessment, and their potential effects on the estimation of human health risks. A summary of the baseline HHRA is provided in Section 6.7.

### **6.1 Site Location and Characterization**

The following information on SWMU 360 is provided to characterize the exposure setting. This background section provides an overview of the characteristics of SWMU 360 as well as site location, a general site description, and the site-specific chemicals as discussed in past reports. The physical characteristics of the site and the geographical areas of concern are also briefly discussed. For more detailed information on the previous investigations and the site characteristics of SWMU 360, a complete discussion is included in Sections 1.0 and 3.0 of this RFI report.

SWMU 360 was a former 300-gallon waste oil underground storage tank (UST) located near Building 1817. The UST was removed in July of 1997 and confirmatory samples were taken (Clean East Associates, Inc, 1997). These samples confirmed that a petroleum release had occurred at the SWMU. Additional sampling was completed in December 1997 (Catlin/Law

Engineers and Scientists, 1997). Building 1817 is located in the Hadnot Point Industrial Area between Duncan Street and "O" Street and one block northeast of McHugh Boulevard or the former Main Service Road (Figure 1-2). Two Marine Units currently use Building 1817. The actual SWMU is located in the eastern portion of the compound, which is occupied by a Hazardous Materials Unit and is being used as a temporary staging area for batteries, refrigeration units, and other used equipment prior to disposal and or reutilization. The entire compound is fenced and access is limited. A new wash pad has been built near the area of the UST excavation and is utilized by the Marine Units occupying the compound.

Refer to Section 1.3 for details on previous investigations conducted at SWMU 360 and to Section 2.0, Field Investigation, for details on the collection of the samples for the RFI field investigation activities conducted in June and July 2003.

The laboratory results from the Phase II (Baker, 2002) CSI and RFI (Baker, 2003a) sampling activities used in the human health risk assessment are discussed in Section 6.2, Hazard Identification.

## **6.2 Hazard Identification**

Data generated during the Phase II CSI (Baker, 2002) and the RFI field investigations at SWMU 360 were used to draw conclusions and to identify data gaps in the baseline HHRA. The data were evaluated to assess which data were of sufficient quality to include in the risk assessment. The objective when selecting data to include in the risk assessment was to provide accurate and precise data to characterize contamination and evaluate exposure pathways.

### **6.2.1 Data Evaluation**

The initial hazard identification step entailed the validation and evaluation of the site data to determine its usability in the risk assessment. This process identified a data set of useable data for human health risk assessment for the site. During this validation and evaluation, data that would result in inaccurate conclusions (e.g., data that were rejected or attributed to blank contamination, as qualified by the validator) were reduced within the data set. Data reduction entailed the removal of unreliable data from the original data set based on the guidelines established by USEPA. A summary of the data quality was presented in Section 4.0.

Duplicate sample data were averaged with corresponding environmental sample data and re-included into the data set for these risk evaluations. In instances where the original and duplicate sample result were either both detected or both non-detected, the values were averaged for the risk assessment. In instances when the original and duplicate sample result contained one positive detection and one non-detection, the detected value was averaged with one-half of the detection limit of the non-detected value and the averaged sample result was considered a positive detection.

### **6.2.2 Identification of Data Suitable for Use in a Quantitative Risk Assessment**

To provide for accurate conclusions to be drawn from sampling results, analytical data were reviewed and evaluated. This section summarizes the available analytical data for SWMU 360 and the subsequent reduction of these data to the data sets that were used in the HHRA.

Data available for the HHRA at SWMU 360 includes surface soil, subsurface soil, and groundwater data collected for the Phase II SWMU CSI (Baker, 2002) and the current RFI field investigation. These investigations were conducted in series with specific goals for each investigation. The Phase I investigation was conducted to evaluate if activities associated with the SWMU had affected the surrounding environment. Therefore, the samples collected as part of this investigation were located as close to the SWMU as physically possible or in areas where evidence of possible environmental impact had been observed. If a specific group of contaminants were not detected in the samples (e.g., VOCs), then they were eliminated as contaminants of concern for that particular SWMU. As such, subsequent investigations did not include any group of contaminants that had been eliminated as potential contaminants of concern. Likewise, if a particular group of contaminants were delineated during any investigation or combination of investigations, the extent of the contamination is assumed to be delineated and further investigation of these compounds would not be considered necessary.

As part of the Phase II CSI, surface (zero to one foot bgs) and subsurface (greater than one foot bgs) soil samples were collected from three soil borings and three temporary well borings, and groundwater was sampled from three temporary wells. Soil and groundwater samples were analyzed for VOCs and RCRA metals. SVOC analysis was not included in the Phase II study because none of the ten SVOCs detected during Phase I were detected at concentrations greater than NC DENR soil-to-groundwater screening criteria or USEPA Region IX residential PRGs (Baker, 2001a). Because these compounds did not exceed any of the

comparison criteria in the samples collected closest to the SWMU during the Phase I investigation, the COPC list was reduced to include only VOCs and RCRA metals. The RFI field investigation included the collection of six surface soil samples (zero to one foot bgs), 37 subsurface soil samples (greater than one foot bgs) from 10 soil borings, and 10 groundwater grab samples from soil borings (not including QC samples). Surface soil and groundwater samples collected for the RFI were analyzed for VOCs by a mobile laboratory (benzene, PCE, TCE, cis-DCE, trans-DCE, methylene chloride, and 1,1-DCE). Subsurface soil samples were analyzed for VOCs by a mobile laboratory and/or a fixed based laboratory and for RCRA metals by a fixed base laboratory (Table 2-1).

Of the data collected during the RFI field investigation, only analytical results from the fixed-base laboratory were included in this HHRA. Soil and groundwater samples collected for the RFI were analyzed for VOCs by two mobile laboratories using a gas chromatograph headspace method and a mass spectrometer method. Field decisions based on quick-turn mobile laboratory analysis of VOCs determined the direction and termination of the RFI field investigation. However, the mobile laboratory data were not validated and as such, were not included in the HHRA. It should be noted that soil and groundwater samples that were analyzed by the fixed based laboratory and validated were collected from locations distributed throughout the source area. Also, exclusion of the mobile laboratory data is not expected to affect the results of the HHRA. The uncertainty associated with the mobile laboratory data is discussed further in Section 6.6.1.

A subset of the available data was used for the SWMU 360 HHRA. All surface soil data collected from zero to one foot bgs (Phase II and RFI investigations) were used in the HHRA. Subsurface soil data from one to 13 feet bgs were used in the HHRA. These data are presented in full in Appendix H.

Shallow and deep groundwater is currently not utilized as a potable source at the site. Although the shallow aquifer is classified as GA (i.e., existing or potential source of drinking water for humans), it is not used as a potable water source at MCB Camp Lejeune because of its low yielding production rates. However, there remains the possibility that upon closure of this facility, residential housing or industrial/commercial buildings could be constructed, and groundwater at SWMU 360 could be used for potable purposes in the future. Therefore, in accordance with USEPA guidance, groundwater exposure was conservatively evaluated for future residential receptors.

For the current receptors (military Base personnel), potable water is supplied by the Base treatment facilities using water supply wells that are set in the lower reaches of the Castle Hayne aquifer (typically 200 to 300 feet bgs). Current operating wells are periodically sampled for control purposes. Hence, assessing current risks to contaminants detected in the groundwater for current receptors is unnecessary and, if estimated, may present an unlikely risk. Based on this, groundwater exposure to current receptors was not estimated for this investigation.

Information relating to the nature and extent of contamination at the site is provided in Section 4.0 of this report. The reduced data sets for all site media of concern used in this HHRA are provided in Appendix I of this report.

### **6.2.3 Criteria for Selecting Chemicals of Potential Concern**

As recommended in the USEPA Risk Assessment Guidance for Superfund (RAGS) (USEPA, 1989) and Region IV Bulletin (USEPA, 1996), the following criteria were used to select the COPCs:

- Comparison to USEPA Region IX PRGs
- Comparison to field and laboratory blank data
- Comparison to background or naturally occurring levels
- Essential Nutrients

Additional criteria used to assist in the evaluation of COPCs include the following:

- Historical information
- Persistence
- Mobility
- Comparison to anthropogenic levels
- Toxicity
- State and federal standards and criteria

A brief description of the selection criteria used in choosing final COPCs is presented below.

Tables 6-1 through 6-7 present the data and COPC selection summary for each media, grouped according to organic compounds and inorganics within each table.

**USEPA Region IX PRGs** - The screening values used in this baseline HHRA are PRGs for Region IX. PRGs are tools for evaluating and remediating contaminated sites. They are risk-based concentrations derived from standardized equations (representing ingestion, dermal contact, and inhalation exposure pathways), combining exposure information assumptions and EPA toxicity data. The PRGs contained in the Region IX PRG Table are generic; they are calculated without site-specific information. Region IX PRGs should be viewed as Agency guidelines, not legally enforceable standards. The PRGs for potentially carcinogenic chemicals are based on a target Incremental Lifetime Cancer Risk (ILCR) of  $1 \times 10^{-6}$ . The PRGs 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 PRGs based on a target hazard quotient of 0.1. Noncarcinogenic PRGs based on a target hazard quotient of 0.1 and the most recent toxicological criteria available, result in a set of values that can be used as screening criteria. In order to yield a hazard index of 0.1, the noncarcinogenic PRGs were divided by a factor of ten. For potential carcinogens, the toxicity criteria applicable to the derivation of PRG 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. The Region IX table is updated annually to reflect such changes. It should be noted that the most recent update was in the year 2002.

Tap water PRGs were used as screening values for groundwater based on the assumption that groundwater will be used as a potable supply in the future. Because of the potential for residential use of this site, residential soil PRGs were used as screening criteria for soil (USEPA, 2003a). USEPA Region IV guidance recommends industrial screening criteria be used for comparison to subsurface soil data only for construction worker scenarios. Therefore, in the event that constituents in subsurface soil exceeded residential soil PRGs, industrial PRGs were also used for comparison to the subsurface soil when considering the construction worker scenario.

**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, 1989). 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) was 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, eliminating an environmental sample result would directly correlate to a reduction in the prevalence of the contaminant in that media.

The aforementioned methodologies for evaluating blanks were implemented during third party analytical data validation prior to the selection of COPCs in the risk assessments. QA/QC data summaries are presented in Table 4-2 of this RFI Report.

**Background or Naturally Occurring Levels** - Generally, a comparison to naturally occurring levels applies only to inorganic analytes, because the majority of organic chemicals are not naturally occurring. Background samples are collected from areas that are not influenced by site contamination. Sample concentrations for surface soil, subsurface soil, and groundwater were compared to base-specific (i.e., two times the average concentration) background levels. If the maximum detected concentration of an inorganic was less than two times the average background concentration, it was not retained as a COPC.

Surface and subsurface soil background data were obtained from the Final Area of Concern Background Study (Baker, 2001b). SWMU-specific background concentrations were established using protocol outlined in Ohio Environmental Protection Agency's (OEPA's) Closure Plan Review Guidance for RCRA Facilities (March, 1999). NC DENR agreed that SWMUs could be grouped together into AOCs based on geographical location, geology and type of SWMU, and that background concentrations for metals could be established for each of these AOCs. These background data are to be evaluated in comparison to the levels of inorganic constituents detected at individual SWMUs to assess whether the presence of such constituents is naturally occurring or may be attributed to activities (past and/or present) within the AOCs. Surface and subsurface soil samples were collected from eleven AOCs. Surface soil samples were collected from 0 to 1 foot bgs, and subsurface soil samples were collected from just above the water table. All soil samples were analyzed for TAL metals, TOC, and pH. SWMU 360 is included within AOC 7. Therefore, surface and subsurface soil data from SWMU 360 are compared to the AOC 7 background data

set. The complete set of background data collected for each AOC is presented in the AOC Background Study (Baker, 2001b). Background soil data are presented in Tables 6-1 through 6-3.

Groundwater background data were obtained from the Draft Base Background Groundwater Investigation (Baker, 2002a). Background groundwater data were collected from locations throughout the Base away from identified sites in relatively undisturbed areas. In the Base Background Groundwater Investigation, groundwater data were divided into two categories, including upper (shallow) and lower (deep) portions of the surficial aquifer. Groundwater samples at SWMU 360 were collected from the shallow and deep portions of the surficial aquifer (less than 25 feet bgs); therefore, they were compared to the background data set for the upper and lower surficial aquifer. Background groundwater data, if applicable, are presented in Tables 6-4 and 6-7.

**Essential Nutrients** - Despite their inherent toxicity, certain inorganic constituents are essential nutrients. Essential nutrients need not be considered further in the baseline HHRA if they are present in relatively low concentrations (i.e., slightly elevated above naturally occurring levels), or if the constituent is toxic at doses much higher than those which could be assimilated through exposures at the site (USEPA, 1989). Elements evaluated as essential nutrients include calcium, magnesium, potassium, and sodium.

**Re-inclusion of Chemicals as COPCs** - Chemicals can be re-included as COPCs for quantitative evaluation in the baseline HHRA, despite having been eliminated as such from a comparison to PRGs (or other aforementioned criteria). Criteria for reinclusion of chemicals as COPCs are as follows: toxicity, mobility, persistence, and bioaccumulation; chemicals by class (i.e., carcinogenic PAHs); historical use; special exposure routes (i.e., daycares, nursing homes, hospitals); and ARARs (chemicals with Applicable or Relevant and Appropriate Requirements). Each criterion is discussed in the paragraphs that follow.

**Toxicity, Mobility, Persistence, and Bioaccumulation** - Certain aspects of toxicity of the chemicals must be considered before eliminating them as COPCs. For example, before eliminating potentially carcinogenic chemicals, the weight-of-evidence classification, which indicates the quality and quantity of data underlying a chemical's designation as a potential human carcinogen, should be considered in conjunction with the concentrations detected at the site. It may be practical and conservative to retain a chemical that was detected at low

concentrations if that chemical is a Group A carcinogen. Three additional factors that must be considered for a chemical's retention as a COPC are mobility, persistence, and bioaccumulation. For example, a highly volatile or mobile chemical such as benzene or a long-lived or persistent chemical such as dioxin, probably should remain in the risk assessment.

**Chemicals by Class** - Chemicals grouped by class, such as PAHs, may be included as COPCs despite the fact that some were detected at levels below the PRG screening criteria, or if toxicity information is not available. Carcinogenic PAHs are known to occur in groups and so their reinclusion can provide a more conservative evaluation for human health and the environment.

**Historical Information** - Chemicals reliably associated with site activities based on historical information generally should not be eliminated from the quantitative risk assessment, even if they do not exceed relevant criteria.

**Special Exposure Routes** - For some chemicals, certain exposure routes need to be considered carefully to determine if they should be reincluded. For example, some chemicals are highly volatile and may pose significant inhalation risk from residential use of contaminated water, particularly for showering. In addition, sensitive populations can present special exposure routes, such as the location of a daycare center, a nursing home, or a hospital near an area containing potentially harmful chemicals.

**ARARs** - Chemicals with Applicable or Relevant and Appropriate Requirements or ARARs (including those relevant to land ban compliance) usually are not appropriate for exclusion from the quantitative risk assessment. This may, however, depend, in part, on how the chemicals' site concentrations in specific media compare with their ARAR concentrations for these media. (USEPA, 1989).

Contaminant concentrations in aqueous media can be compared to contaminant-specific state and federal criteria. This risk assessment utilizes NCWQS for groundwater and federal Maximum Contaminant Levels (MCLs).

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

**North Carolina Water Quality Standards (NCWQSs) - Groundwater** - NCWQSs (15A NCAC 2L. 0202) 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 (NC DENR, 2002).

**Maximum Contaminant Levels (MCLs) - Federal Groundwater Standards** - 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 (USEPA, 1996a).

#### **6.2.4 Selection of COPCs**

As discussed previously, three environmental media (i.e., surface soil, subsurface soil, and groundwater) were sampled at SWMU 360 during one or two different field investigations. Data were combined for each medium for the human health risk assessment. The data sets used in the HHRA are presented in Appendix I. Tables 6-1 through 6-7 present the selection of COPCs for each environmental medium based on comparisons of maximum detected concentrations of constituents with corresponding USEPA Region IX PRGs, and other applicable criteria (see Section 6.2.1). Constituents retained as COPCs are indicated by shaded cells in the tables. Information is presented in these tables only for those constituents detected at least once in the medium of interest.

The following subsections present the rationale for selection of COPCs for SWMU 360. Sample locations, analytical results, and corresponding figures are presented in Sections 2.0 and 4.0 and in the appendices of this RFI report.

### *Surface Soil*

Surface soil samples (0–1 feet bgs) collected during the Phase II CSI and the RFI field investigation were analyzed for VOCs, SVOCs, pesticides, and RCRA metals. VOCs, SVOCs, pesticides, and RCRA metals were detected in the surface soil. There were no positively detected compounds that exceeded residential soil PRGs. Therefore, no compounds were retained as SWMU 360 surface soil COPCs. The SWMU 360 surface soil data summary and COPC selection results are presented in Table 6-1.

### *Subsurface Soil*

As part of the Phase II CSI and RFI field investigation, subsurface soil samples (>1 foot bgs) were collected and analyzed for VOCs, SVOCs, pesticides, and RCRA metals. COPCs were selected from a subsurface soil data set consisting of only those samples collected from 1-13 feet bgs. VOCs, SVOCs, pesticides, and RCRA metals were detected in the subsurface soil. A SWMU 360 subsurface soil data summary and COPC selection results are presented in Tables 6-2 and 6-3. Table 6-2 presents the comparison of subsurface soil data to residential PRGs, and Table 6-3 presents the comparison of subsurface soil data to industrial soil PRGs.

Subsurface soil samples were analyzed for VOCs, SVOCs, and pesticides. These compounds detected in the subsurface soil samples were present at concentrations below the residential and industrial PRGs. Therefore, none of these chemicals were retained as subsurface soil COPCs.

Subsurface soil samples were analyzed for RCRA metals. Arsenic was detected at a maximum concentration greater than its residential and industrial soil PRGs. Therefore, arsenic was retained as a subsurface soil COPC for the residential and industrial scenarios.

### *Groundwater*

As part of the Phase II CSI, groundwater was sampled from three temporary wells in the shallow aquifer and analyzed for VOCs, SVOCs, pesticides and RCRA metals. The RFI field investigation included the collection of two groundwater samples from groundwater monitoring wells in the deep aquifer. Samples were analyzed for VOCs, pesticides, and RCRA metals. The data and COPC selection summary for groundwater samples collected at SWMU 360 is presented in Tables 6-4 through 6-7. Table 6-4 presents the comparison of shallow groundwater data to tap

water PRGs. Table 6-5 presents the comparison of shallow groundwater data to NC 2L Standards. Table 6-6 presents the comparison of deep groundwater data to tap water PRGs. Table 6-7 presents the comparison of deep groundwater data to NC 2L Standards. Note that COPCs were not selected based on the comparison with NC 2L Standards. Tables 6-5 and 6-7 are for presentation purposes only.

From the shallow aquifer, four groundwater samples were analyzed for VOCs. Three VOCs cis-DCE, PCE and TCE were detected in the groundwater samples at concentrations exceeding tap water PRGs. Therefore, these VOCs were retained as shallow groundwater COPCs. These three VOCs also exceeded corresponding NC 2L Standards.

Four shallow groundwater samples were analyzed for SVOCs. One SVOC (acetophenone) was retained because no tap water PRGs are available for comparison. Therefore, acetophenone was retained as shallow groundwater COPC.

Four shallow groundwater samples were analyzed for pesticides. Eight pesticides exceeded their corresponding tap water PRGs: 4,4'-DDE, alpha-BHC, beta-BHC, delta-BHC, gamma-BHC, aldrin, heptachlor, and heptachlor epoxide. Therefore, these compounds were retained as shallow groundwater COPCs. In addition to the pesticides mentioned above, 4,4'-DDT, alpha-chlordane and gamma-chlordane also exceeded corresponding NC 2L Standards, while gamma-BHC was below its corresponding NC 2L Standard.

Four shallow groundwater samples were analyzed for RCRA metals. Arsenic was detected in the groundwater samples at concentrations that exceeded its respective tap water PRGs. Therefore, arsenic was retained as a shallow groundwater COPC. Also, arsenic did not exceed its respective NC 2L Standard.

From the deep aquifer, two groundwater samples were analyzed for VOCs. Three VOCs cis-DCE, PCE, and TCE) were detected in the groundwater samples at concentrations exceeding tap water PRGs. Therefore, these VOCs were retained as deep groundwater COPCs. PCE and TCE also exceeded their corresponding NC 2L Standards.

Two deep groundwater samples were analyzed for pesticides. Pesticides were not detected in the deep aquifer, and therefore, were not retained as deep groundwater COPCs.

Two deep groundwater samples were analyzed for RCRA metals. None of the metals were detected in the groundwater samples at concentrations that exceeded their respective tap water PRGs or NC 2L Standards. Therefore, RCRA metals were not retained as deep groundwater COPCs.

#### **6.2.5 Summary of COPCs**

The following chemicals exceeded the residential PRG values in the environmental media obtained from SWMU 360 during the Phase II CSI and RFI field investigations, and were therefore, retained as COPCs for further analysis.

Surface Soil: none

Subsurface Soil (residential and industrial): arsenic

Shallow Groundwater: cis-DCE, PCE, TCE, acetophenone, 4,4'-DDE, alpha-BHC, beta-BHC, delta-BHC, gamma-BHC, aldrin, heptachlor, heptachlor epoxide, and arsenic

Deep Groundwater: cis-DCE, PCE, TCE

#### **6.3 Exposure Assessment**

The exposure assessment estimates the magnitude of actual and/or potential human exposure, the frequency and duration of those exposures, and the pathways (i.e., inhalation, ingestion, and dermal contact) by which people are potentially exposed. To determine whether human exposure could occur at SWMU 360 in the absence of remedial action, an exposure assessment, which identifies potential exposure pathways and receptors, was conducted. The following four elements were considered to determine whether a complete exposure pathway was present (USEPA, 1989a):

- A source and potential mechanism of chemical release
- An environmental retention or transport medium
- A point of potential human contact with the contaminated medium
- A human exposure route (e.g., ingestion) at the contact point

The exposure scenarios discussed in this HHRA represent USEPA's Reasonable Maximum Exposure (RME). Relevant equations for assessing intakes and exposure factors were obtained from RAGS (USEPA, 1989), Region IV Bulletin (USEPA, 1996), Exposure Factors Handbook (USEPA, 1997), Dermal Exposure Assessment: Principles and Applications, Interim Report (USEPA, 1992), RAGS Part E, Supplemental Guidance for Dermal Risk Assessment Interim (USEPA, 2001), Superfund's Standard Default Exposure Factors for the Central Tendency and Reasonable Maximum Exposure (USEPA, 1993), and Standard Default Exposure Factors, Interim Final (USEPA, 1991a). The Central Tendency (CT) risk descriptor was also used for exposure scenarios when the RME scenarios indicated a potential risk to human health. This approach more completely presents the range of possible risks. The CT exposure calculations use less conservative exposure factors (as appropriate) to calculate chemical intakes for the CT-case scenarios. In this baseline HHRA, the CT exposure scenario was calculated only for those RME exposure scenarios that resulted in unacceptable risks or hazard levels. The inclusion of the CT exposure scenario provides a range of potential carcinogenic risks and noncarcinogenic health hazards with which to make informed risk management decisions when determining remedial action.

### **6.3.1 Potential Human Receptors**

MCB Camp Lejeune operates as a Marine Corps base. It is assumed that long-term plans for the facility are the same as the present plan, with land use also generally the same as at present. Based on information available regarding the physical features, site setting, site historical activities, and current and expected land uses, four potential human receptors have been selected for evaluation. These include:

- Current Military Base Personnel
- Future Resident Adults and Children (1-6 years)
- Future Construction Workers

Building 1817 is located in the Hadnot Point Industrial Area between Duncan Street and "O" Street and one block northeast of McHugh Boulevard or the former Main Service Road (Figure 1-2). Two Marine Units use Building 1817. SWMU 360 is located in the eastern portion of the compound, which is occupied by a Hazardous Materials Unit and is used as a temporary staging area for batteries, refrigeration units, and other used equipment prior to disposal and or reutilization. The entire compound is fenced and access is limited.

Surface soil samples were collected from within the fenced compound. Therefore, no exposure pathway for the current trespasser receptor exists. Also, mobile lab data indicates that no compounds were detected in any surface soil samples. It should be noted that the potential exists for the fence to be breached or removed in the future, making the exposure pathway complete for a future trespasser. However, since there were no COPCs were retained for surface soil, the risks posed by the potentially complete future exposure pathway were determined to be acceptable. Therefore, trespassers were not evaluated in this HHRA.

Consequently, current receptors will only include military base personnel who work at Building 1817. Military base personnel would be exposed to surface soil at the SWMU; however, no COPCs were retained for surface soil. Therefore, the surface soil exposure pathway is incomplete for military base personnel, and exposure to surface soil was not assessed in the HHRA for SWMU 360. At present, groundwater is not used for potable purposes. For the current receptors (military base personnel), public water is supplied. As a result, current groundwater exposure was not assessed. Exposure to subsurface soil in the current scenario is unlikely for the receptor population. Consequently, subsurface soil exposure was not considered to be applicable.

Although residential development by the military or general public is unlikely in the industrialized area of SWMU 360, future hypothetical residential exposure to children and adults was evaluated. The future adult and child residential receptors could potentially be exposed to COPCs in surface soil by ingestion and dermal contact, and inhalation of dusts from surface soil. However, no COPCs were retained for surface soil. Therefore, the surface soil exposure pathway is incomplete for residential receptors, and exposure to surface soil was not assessed in the HHRA for SWMU 360. Residential receptors could also potentially be exposed to COPCs in subsurface soil via ingestion, dermal contact, and inhalation of dusts should that soil be excavated. The depths of soil samples used in the risk evaluation for future residents were zero to 13 feet bgs. Groundwater at SWMU 360 is currently not used as a potable source. However, it is possible that the groundwater could be used for potable purposes in the future. Therefore, in accordance with USEPA guidance, groundwater exposure via ingestion and dermal contact was conservatively evaluated for future residential receptors. Total inorganic results in groundwater were evaluated according to USEPA Region IV guidance. Inhalation of volatiles in groundwater was evaluated only for the future adult receptors according to USEPA Region IV guidance (i.e., assuming shower exposure is equivalent to exposure from ingestion of two liters of

contaminated water per day). Young children are not expected to shower, and therefore, were not evaluated for exposure to inhalation of VOCs in groundwater. However, dermal contact while bathing is evaluated for the future young child receptor.

Future construction workers who may perform excavation and construction at the site were also evaluated for incidental ingestion and dermal contact exposures to excavated soils, as well as the inhalation of fugitive dusts emanating from soil during excavation/construction activities. The depths of soil samples used in the risk evaluation for construction workers were zero to 13 feet bgs. For the future construction worker, surface soil and subsurface soil were evaluated as separate data sets segregated by depth. Surface soil depth was zero to one foot, and subsurface soil depth was one to 13 feet. However, no COPCs were retained for surface soil. Therefore, the surface soil exposure pathway is incomplete for construction workers, and exposure to surface soil was not assessed in the HHRA for SWMU 360. Only subsurface soil exposure was assessed for the construction workers.

In summary, the following potential human receptors and exposure pathways were retained for quantitative evaluation in this baseline HHRA.

#### Future Adult and Child (Ages 1-6 Years) Residents

- Incidental Ingestion of Subsurface Soil
- Dermal Contact with Subsurface Soil
- Inhalation of Fugitive Dusts Emanating from Subsurface Soil
- Ingestion of Groundwater
- Dermal Contact with Groundwater
- Inhalation of Volatiles in Groundwater while Showering (Adults only)

#### Future Construction Workers

- Incidental Ingestion of Subsurface Soil
- Dermal Contact with Subsurface Soil
- Inhalation of Fugitive Dusts from Subsurface Soil

### **6.3.2 Conceptual Site Model**

Development of a conceptual site model of potential exposure is critical in evaluating exposures for the human receptors. The conceptual site model considers all reasonable current and future potential exposures and media of concern under a no-action scenario. Current and potential future exposure scenarios for SWMU 360 are summarized in the conceptual site model in Figure 6-1 of this HHRA. Exposure pathways are incomplete for current receptors at SWMU 360; therefore, only future exposures were evaluated at this site for residents and construction workers.

Potential contaminant release mechanisms from affected media include stormwater runoff, leaching to underlying groundwater, and advective transport in the direction of groundwater flow. Potentially affected media at SWMU 360 may include surface and subsurface soil and groundwater.

The current/potential future land use scenarios considered adult exposures. In addition, a residential child, 1-6 years old was also considered. Exposure routes (i.e., ingestion, dermal contact, and inhalation) for each exposure scenario are summarized in Figure 6-1.

### **6.3.3 Quantification of Exposure**

Exposure to contaminants is quantified using data from the site (i.e., concentrations of contaminants) and determining human exposure to the environmental media. The chemical concentrations used in the estimation of chronic daily intakes (CDIs) and dermally-absorbed doses (DADs) for each medium are considered to be representative of the types of potential exposures encountered by each receptor throughout the time of exposure. The equations used to calculate the CDIs and DADs for each receptor and exposure pathway are presented in Section 6.3.5 and on Tables 6-8 through 6-12. Groundwater is in motion: thus, chemical concentrations detected in these media change frequently over time. Soil generally moves more slowly through erosion and deposition. Therefore, groundwater contaminant concentrations may be best represented by the most recently collected data, while soil concentrations can include some older data, as appropriate. The manner in which environmental data are represented also depends on the number of samples and sampling locations available for a given area and a given medium. For example, exposure can occur on a portion of the site (i.e., a "hotspot") or the entire site, depending on the type of scenario considered for a given receptor.

#### 6.3.4 Data Analysis

An individual moving randomly across the study area of SWMU 360 is assumed to have an equal probability of potential exposure to environmental media such as soil. Therefore, for soil, the exposure point concentration for a constituent in the intake equation can be reasonably estimated as the arithmetic average concentration of site sampling data. USEPA supplemental risk assessment guidance (USEPA, 1992a) states that the average concentration is an appropriate estimator of the exposure concentration for two reasons: 1) carcinogenic and chronic noncarcinogenic toxicity criteria are based on lifetime average exposures, and 2) the average concentration is most representative of the concentration that would be contacted over time. However, uncertainty is inherent in the estimation of the true average constituent concentration at the site.

USEPA Region IV risk assessment guidance makes an exception to the use of the average concentration of site sampling data as the exposure point concentration for groundwater. Region IV guidance states that groundwater exposure point concentrations should be the arithmetic average of the wells in the highly concentrated area of the plume. However, there was no plume defined at SWMU 360. Therefore, the maximum detected concentrations of the COPCs retained in groundwater were used as the exposure concentrations.

A conservative estimate of the arithmetic average concentration recommended by the USEPA (1992a) is the 95 percent upper confidence limit of the arithmetic mean concentration (95% upper confidence limit [UCL]). A statistical test to determine the distribution of the data set was used. The Shapiro-Wilkes distribution test was used for data sets of less than 50 samples. If the data were determined to be normally distributed (this includes those results that indicate "yes" to both normal and lognormal distributions), the 95% UCL of the arithmetic mean of the data was used (USEPA, 1992a). If the data were lognormally distributed, the 95% UCL of the arithmetic mean of the log-transformed data was used (USEPA, 1992a). In those instances where the distribution tests were unable to definitively determine the type of distribution (i.e., the results indicated "no" to both normal and lognormal distributions), the data set was assumed to be lognormally distributed, as per USEPA Region IV risk assessment guidance (USEPA, 1996). If the 95% UCL of the arithmetic mean exceeds the maximum detected concentration in a given data set, the maximum detected concentration will be used to represent the concentration term for that COPC.

The 95% UCL for a normal distribution was calculated using the following equation (USEPA, 1992c):

$$95\%UCL = \bar{x} + t(s / \sqrt{n})$$

Where:

$\bar{x}$	=	mean
s	=	standard deviation
t	=	Student t statistic (Gilbert, 1987)
n	=	number of samples

The 95% UCL of the lognormal distribution was calculated using the following equation (USEPA, 1992c):

$$\text{Lognormal } 95\% \text{ UCL} = e^{(\bar{x} + 0.5s^2 + sH/\sqrt{n-1})}$$

where:

UCL	=	upper confidence limit
e	=	constant (base of the natural log, equal to 2.718)
$\bar{x}$	=	mean of the transformed data
s	=	standard deviation of the transformed data
H	=	H-statistic (Gilbert, 1987)
n	=	number of samples

Frequencies of detection, as well as maximum detected values, are presented in Tables 6-1 through 6-7. The 95% UCL values, mean values, and results of the W-test derived for COPCs in all media at SWMU 360 are presented on Tables 6-13 through 6-15 and in Appendix J. The equations for estimating intakes due to direct exposures to site-related chemicals for the various identified pathways are presented in Section 6.3.5 and on the risk calculation spreadsheets found in Appendix K.

For results reported as "nondetect" (i.e., results flagged with the following validation qualifiers: U and UJ), a value of one half of the sample-specific detection limit was used to calculate the 95% UCL; the actual value could be between zero and a value just below the detection limit.

95% UCLs were calculated only for the constituents detected in at least one sample collected from the environmental medium of interest.

Estimated concentrations also were used to calculate the 95% UCL, such as "J" qualified (estimated) data. Reported concentrations qualified with an "R" (rejected) were not used in the statistical evaluation.

As previously mentioned, duplicate sample data were averaged with corresponding environmental sample data and re-included into the data set for these risk evaluations. In instances where the original and duplicate sample result were either both detected or both non-detected, the values were averaged for the risk assessment. In instances when the original and duplicate sample result contained one detection and one non-detection, the detected value was averaged with one-half of the detection limit of the non-detected value and the averaged sample result was considered a detection.

Statistical data summary tables for COPCs in each medium sampled (i.e. surface soil, subsurface soil, and groundwater) are found in the Statistical Summaries presented in Appendix J. These tables provide the arithmetic mean, the standard deviation, and the 95% UCL value for both normally and lognormally distributed data (as determined by Shapiro-Wilkes distribution test).

### **6.3.5 Calculation of Chronic Daily Intakes**

In order to numerically estimate the risks for current and future human receptors at SWMU 360, a CDI must be estimated for each COPC in every retained exposure pathway. These equations were obtained from USEPA guidance (USEPA, 1989).

The following paragraphs present the general equations used in the calculation of CDIs for each potential exposure pathway. The exposure input parameters used in the calculation of CDIs are presented in Section 6.3.6. Input parameters were taken from USEPA's default exposure factors guidelines where available and applicable. All inputs not defined by USEPA were derived from USEPA documents concerning exposure or from best professional judgment. All exposure assessments incorporate the representative contaminant concentrations in the estimation of intakes. Therefore, only one exposure scenario was developed for each exposure route/receptor combination.

CDIs for carcinogenic effects incorporate terms to represent the exposure duration (years) over the course of a lifetime (70 years or 25,550 days) (USEPA, 1989). Noncarcinogenic CDIs, on the other hand, were estimated using the concept of an average annual exposure. The intake incorporates terms describing the exposure time and/or frequency representing the number of hours per day and the number of days per year that exposure occurs. In general, noncarcinogenic CDIs for many exposure routes (e.g., soil ingestion) are greater for children than adults because of the differences in body weights, similar exposure frequencies, and higher ingestion rates.

#### 6.3.5.1 Shallow Subsurface Soil

##### *Incidental Ingestion of Shallow Subsurface Soil*

The following equation is used in the calculation of a CDI (mg/kg/day) for a human receptor who accidentally ingests soils at the site:

$$CDI = \frac{Cs \times IR \times FI \times CF \times EF \times ED}{BW \times AT_c \text{ or } AT_{nc}}$$

Where:

Cs	=	chemical concentration in soil (mg/kg)
IR	=	ingestion rate (mg/day)
FI	=	fraction of soil ingested from the source (unitless)
CF	=	conversion factor ( $10^{-06}$ kg/mg)
EF	=	exposure frequency (days/yr)
ED	=	exposure duration (yrs)
BW	=	adult body weight (kg)
AT <sub>c</sub>	=	averaging time, carcinogens (days)
AT <sub>nc</sub>	=	averaging time, noncarcinogens (days)

Relevant equations and factors required for estimating the daily intake were calculated and are presented in Appendix K.

### *Dermal Contact with Shallow Subsurface Soil*

The absorbed dose associated with the potential dermal contact of COPCs in soil was calculated using the following equation (USEPA, 1989):

$$DAD = \frac{Cs \times SA \times AF \times ABS \times EF \times ED \times CF}{BW \times AT}$$

Where:

DAD	=	Dermally Absorbed Dose, mg/kg-day
Cs	=	Chemical concentration in the soil, mg/kg
AF	=	Adherence Factor, milligram per square centimeter day (mg/cm <sup>2</sup> -d)
ABS	=	Absorbed fraction, unitless
CF	=	Conversion Factor, 10 <sup>-06</sup> mg/kg
SA	=	Surface Area of exposed skin, cm <sup>2</sup>
EF	=	Exposure Frequency, days/year
ED	=	Exposure Duration, years
BW	=	Average Body Weight, kg
AT	=	Averaging Time, days

Relevant equations and factors required for estimating the absorbed dose were calculated and are presented in Appendix K.

### *Inhalation of Fugitive Dust from Shallow Subsurface Soil*

The daily intake resulting from the inhalation of COPCs adsorbed onto fugitive dust particles was estimated using the following equation (USEPA, 1989):

$$CDI = \frac{Ca \times RR \times ET \times EF \times ED}{BW \times AT}$$

Where:

CDI	=	Chronic Daily Intake, mg/kg-day
Ca	=	Chemical concentration in air as fugitive dust, milligrams per cubic meter (mg/m <sup>3</sup> )
RR	=	Respiration Rate, m <sup>3</sup> /hour
ET	=	Exposure Time, hours/day
EF	=	Exposure Frequency, days/year
ED	=	Exposure Duration, years
BW	=	Average Body Weight, kg
AT	=	Averaging Time, days

The air concentration (Ca) of a chemical in fugitive dust emissions was estimated from the following equation, as determined by Cowherd (1985).

$$Ca = Cs \times 1/PEF$$

Where:

Ca	=	Chemical concentration in air as fugitive dust, mg/m <sup>3</sup>
Cs	=	Concentration of chemical in the soil, mg/kg
PEF	=	Particulate Emission Factor, m <sup>3</sup> /kg

Relevant equations and factors required for estimating the absorbed dose were calculated and are presented in Appendix K.

#### 6.3.5.2 Groundwater

##### *Ingestion of Groundwater*

The daily intake associated with the direct potential ingestion of the COPCs in groundwater under a drinking water scenario were calculated using the following equation (USEPA, 1989):

$$CDI = \frac{Cw \times IR \times EF \times ED}{BW \times AT}$$

Where:

CDI	=	Chronic Daily Intake, mg/kg-day
Cw	=	Chemical concentration in water, mg/L
IR	=	Ingestion Rate, L/day
EF	=	Exposure Frequency, days/year
ED	=	Exposure Duration, years
BW	=	Average Body Weight, kg
AT	=	Averaging Time, days

Relevant equations and factors required for estimating the absorbed dose were calculated and are presented in Appendix K.

*Dermal Contact with Groundwater*

The absorbed dose associated with potential dermal contact with COPCs in groundwater was calculated using the following equation (USEPA, 1989 and 2001):

$$CDI = \frac{DA_{event} * EF * ED * CF * SA}{BW * AT}$$

Where:

CDI	=	Chronic Daily Intake, mg/kg-day
DA <sub>event</sub>	=	Absorbed dose per event (mg/cm <sup>2</sup> -event) (assume 1 event/day)
EF	=	Exposure Frequency, days/year
ED	=	Exposure Duration, years
CF	=	Conversion Factor, 1 L/1000 cm <sup>3</sup>
SA	=	Surface Area of exposed skin, cm <sup>2</sup>
BW	=	average Body Weight, kg
AT	=	Averaging Time, days

The following equations are used to calculate DA<sub>event</sub> for organic compounds:

If  $t_{event} \leq t^*$ , then

$$DA_{event} = 2FA * K_p * C_w * \sqrt{\frac{6\tau_{event} * t_{event}}{\pi}}$$

If  $t_{event} > t^*$ , then

$$DA_{event} = FA * K_p * C_w \left[ \frac{t_{event}}{1+B} + 2\tau_{event} \left( \frac{1+3B+3B^2}{(1+B)^2} \right) \right]$$

Where:

$DA_{event}$	=	Absorbed dose per event (mg/cm <sup>2</sup> -event)
FA	=	Fraction absorbed (dimensionless)
$K_p$	=	Dermal permeability coefficient of compound in water (cm/hour)
$C_w$	=	Chemical concentration in water (mg/cm <sup>3</sup> )
$\tau_{event}$	=	Lag time per event (hour /event)
$t_{event}$	=	Event duration (hour /event) (assume 1 event/day)
$t^*$	=	Time to reach steady-state (hour) = $2.4\tau_{event}$
B	=	Dimensionless ratio of the permeability coefficient of a compound through the stratum corneum relative to its permeability coefficient across the viable epidermis (ve) (dimensionless).

The following equation is used to calculate  $DA_{event}$  for inorganic and highly ionized organic chemicals:

$$DA_{event} = K_p * C_w * t_{event}$$

Where:

$DA_{event}$	=	Absorbed dose per event (mg/cm <sup>2</sup> -event)
$K_p$	=	Dermal permeability coefficient of compound in water (cm/ hour)
$C_w$	=	Chemical concentration in water (mg/cm <sup>3</sup> )
$t_{event}$	=	Event duration (hours/event) (assume 1 event/day)

Relevant equations and factors required for estimating the absorbed dose were calculated and are presented in Appendix K.

#### *Inhalation of Volatiles in Groundwater*

Inhalation of volatiles in groundwater was calculated according to guidance put forth in the USEPA Region IV Bulletin. Therefore, it was assumed that inhalation of volatiles in groundwater was equivalent to ingesting two liters of water per day. In order to express this quantitatively, the carcinogenic risks and noncarcinogenic health hazards for the ingestion of volatile organic COPCs only were summed and incorporated into the total site risk. This was applied to the adult resident receptors only, as young children typically do not shower.

Relevant equations and factors required for estimating the absorbed dose were calculated and are presented in Appendix K.

### **6.3.6 Exposure Input Parameters**

Tables 6-8 through 6-12 present the exposure factors used in the estimation of potential CDIs for COPCs retained for each receptor identified below. USEPA promulgated exposure factors are used in conjunction with USEPA standard default exposure factors. When USEPA exposure factors are not available, best professional judgment and site-specific information are used to derive a conservative and defensible value. The following paragraphs present the rationale for the selection of exposure factors for each receptor group evaluated in the baseline HHRA.

#### **6.3.6.1 Future Adult and Young Child Residents**

This scenario assumes that future adult and young child (1-6 years) residents could come into contact with surface soil and subsurface soil at SWMU 360. However, the exposure pathway for surface soil is incomplete and will not be evaluated in this HHRA. It is also conservatively assumed that the groundwater will be potable. Therefore, these receptors could come into contact with contaminants detected in the groundwater under a drinking water scenario in the future, in addition to coming into contact with subsurface soil. These receptors were evaluated for potential exposure to subsurface soil via accidental ingestion, dermal contact, and inhalation of fugitive dust and to groundwater via ingestion, dermal contact and inhalation of VOCs while showering (adult only). A summary of the exposure parameters is discussed in the following paragraphs and

presented on Tables 6-8 through 6-12. Unless otherwise noted, the CT exposure parameters are the same as for Reasonable Maximum Exposure (RME).

Future adult and young child residents could contact subsurface soil during outdoor recreational activities such as playing, walking, or running, in the area immediately surrounding their homes or while gardening. A 70 kg adult and a 15 kg child (USEPA, 1997) were assumed for exposure durations of 24 years and 6 years, respectively (USEPA, 1993). Exposure durations of 7 years for the adult and 2 years for the child were used for CT exposure (USEPA, 1993). Exposure times were estimated to be 1.5 hours per day for adults and 5.57 hours per day for the child (USEPA, 1997). The ingestion rate was assumed to be 100 mg/day for the adult and 200 mg/day for the young child (USEPA, 1993), with a 100 percent fraction ingested from source, over 350 days per year (USEPA, 2001). Ingestion rates of 50 mg/day for the adult and 100 mg/day for the young child were used for CT exposure (USEPA, 1993). Respiration rates of 0.55 m<sup>3</sup>/hr for the adult and 0.308 m<sup>3</sup>/hr for the child (USEPA, 1997) were also used. The respiration rate used for the young child represents the average for an individual aged 0 to 8 years old. Averaging times for noncarcinogens are 8,760 days for adults and 2,190 days for children. CT exposure averaging times of 2,555 days for adults and 730 days for children for noncarcinogens are used. An averaging time of 25,550 days for carcinogens are also used (USEPA, 1989). The USEPA recommended weighted skin adherence factor (SAF) of 0.07 mg/cm<sup>2</sup> was used for the residential adult, with a CT exposure SAF of 0.01 mg/cm<sup>2</sup> (USEPA, 2001). This is based on the 50<sup>th</sup> percentile weighted SAF for gardeners, which is the activity determined to represent a reasonable, high-end contact activity. The USEPA recommended weighted 0.2 mg/cm<sup>2</sup> SAF for the young child, with a CT exposure SAF of 0.04 mg/cm<sup>2</sup>. This is based on the 95<sup>th</sup> percentile weighted SAF for children playing at a day care center or in wet soil (USEPA, 2001). Dermal absorption values provided in USEPA RAGS Part E (USEPA, 2001) or Region IV default dermal absorption values of 0.01 for organics, and 0.001 for inorganics (USEPA, 1996) were also used to estimate soil exposures. Skin surface areas of 5,700 cm<sup>2</sup> for the adult and 2,800 cm<sup>2</sup> for the young child (USEPA, 2001) were assumed for the surface soil scenario. These are the surface area values currently recommended by the USEPA for exposure to contaminated soil and are the averages of the 50<sup>th</sup> percentiles for males and females greater than 18 years of age (adults) and from <1 to <6 years old (young children). As recommended in RAGS Part E, the SA values used for the RME scenario were also assumed for the CT exposure scenario.

Potential exposures to groundwater COPCs may occur under a groundwater drinking water scenario. Exposure to total concentrations of inorganic COPCs in groundwater was evaluated as

per USEPA Region IV guidance. Exposure pathways evaluated for future residents include accidental ingestion and dermal contact. Inhalation of VOCs while showering was evaluated for adult residents only. As per USEPA Region IV guidance, inhalation of VOCs in groundwater was evaluated as the equivalent of ingesting two liters of water per day. It is assumed in this risk assessment that young children typically do not shower. Groundwater ingestion rates of 2 L/day and 1 L/day, respectively, were also assumed for the adult and young child residents assuming an exposure frequency of 350 days per year (USEPA, 1993). Groundwater ingestion rates of 1.4 L/day and 1 L/day (adult and child, respectively) over 234 days per year were used for CT exposure (USEPA, 1993). Exposure times were estimated to be 0.58 hours per day for adults and one hour per day for the child, with CT exposure times estimated to be 0.25 hours per day for adults and 0.33 hours per day for the child (USEPA, 2001). Total body surface areas of 18,000 cm<sup>2</sup> and 6,600 cm<sup>2</sup> (50<sup>th</sup> percentile values for male and female young children or adults) (USEPA, 2001) were assumed for the groundwater scenario for the adult and young child, respectively. All other exposure parameters were the same as the soil exposure parameters.

#### 6.3.6.2 Future Adult Construction Workers

Potential exposures to soil COPCs may occur to construction workers during soil excavation and construction activities at SWMU 360. This scenario assumes that future construction workers could come into contact with surface soil and subsurface soil at SWMU 360. However, the exposure pathway for surface soil is incomplete and will not be evaluated in this HHRA. Therefore, exposure pathways evaluated include accidental ingestion, dermal contact, and inhalation of fugitive dust of shallow subsurface soil. A summary of the exposure parameters is discussed in the following paragraphs and presented on Table 6-12. Exposure was assumed to occur for 8 hours per day (USEPA, 1991a), 250 days per year (USEPA, 2001), for a construction period of one year (professional judgement). A USEPA default value for the soil ingestion rate of 480 mg/day (USEPA, 1993), a 100 percent fraction ingested from source and a respiration rate of 3.3 m<sup>3</sup>/hour (USEPA, 1997) were also assumed for a 70 kg construction worker (USEPA, 1997). A skin surface area of 3,300 cm<sup>2</sup> for an adult (USEPA, 2001) assumed to wear a short-sleeved shirt, long pants, and shoes, was used to evaluate dermal contact with soil. The soil-to-skin adherence factor of 0.2 mg/cm<sup>2</sup> (USEPA, 2001) was used. Dermal absorption values provided in USEPA RAGS Part E (USEPA, 2001) or Region IV default dermal absorption values of 0.01 for organics, and 0.001 for inorganics (USEPA, 1996) were also used to estimate soil exposures. The averaging time of 365 for noncarcinogens and 25,550 days for carcinogens, respectively, were also used (USEPA, 1989).

USEPA believes construction workers are likely to experience substantial exposures to soils during excavation and other work activities. The equation to calculate PEF for a construction scenario has been revised to focus exclusively on emissions from truck traffic on unpaved roads, which typically contribute the majority of dust emissions during construction. A site-specific PEF has been derived for the construction worker scenario for this risk assessment. As shown on Figure 1-2, the "study area" surrounding SWMU 360 is approximately 7.3 acres in size. The methodologies used to calculate the new PEF are taken from USEPA's Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites (Peer Review Draft) (USEPA, 2001b). The following equation was used to calculate the construction scenario PEF:

$$PEF_{sc} = Q/C_{sr} * 1/F_D * \left[ \frac{(T * A_R)}{(556 * (W/3)^{0.4} * (365-p)/365 * VKT)} \right]$$

Where:

- PEF<sub>sc</sub> = subchronic road particulate emission factor (m<sup>3</sup>/kg)
- Q/C<sub>sr</sub> = Inverse of 1-h average air concentration along a straight road segment bisecting a 7.3 acre square site (g/m<sup>2</sup>-s per kg/m<sup>3</sup>)
- F<sub>D</sub> = dispersion correction factor (unitless) (0.185)
- T = total time over which construction occurs (s) (250 days or 7,200,000 seconds)
- A<sub>R</sub> = surface area of contaminated road segment (m<sup>2</sup>) (2,619 m<sup>2</sup>)
- W = mean vehicle weight (11 tons)
- p = number of days with at least 0.01 inches of precipitation (days/year) (120 days for the area of Jacksonville, NC)
- VKT = sum of fleet vehicle kilometers traveled during the exposure duration (km) (670.8 km assuming a site area of 7.3 acres)

The following assumptions were incorporated into the above-referenced parameters used to calculate the site-specific construction worker scenario. SWMU 360 is in an industrialized area of MCB Camp Lejeune. The site is surrounded on three sides by streets and asphalt parking lots, and the necessity to construct a dirt road across the site is considered unlikely. Therefore, it was assumed that daily unpaved road traffic would consist of at most 20 cars (2 tons) and 10 trucks (20 tons). A<sub>R</sub> is based on a road length of 172 m and assumes a road width of 15.24 m. VKT is

based on 30 vehicles traveling a road length of 172 m (or 0.172 km) for 5 days per week for 26 weeks (considering an EF of 250 days per year). Thus, a construction worker scenario PEF of  $4.33 \times 10^6 \text{ m}^3/\text{kg}$  was calculated. This calculation is also presented in Appendix H.

#### **6.4 Toxicity Assessment**

Section 6.4 presents potential exposure pathways and receptors for this baseline HHRA. This section will review the available toxicological information for COPCs retained for quantitative evaluation.

An important component of the HHRA process is the relationship between the dose of a compound (amount to which an individual or population is potentially exposed) and the potential for adverse health effects resulting from exposure to that dose. Dose-response relationships provide a means by which potential public health impacts may be evaluated. Standard RfDs and/or CSFs have been developed for many of the COPCs. This section provides a brief description of these parameters.

##### **6.4.1 Reference Doses**

The RfDs and Reference Concentrations (RfCs for inhalation) are developed for chronic and/or subchronic human exposure to chemicals, and are based solely on the noncarcinogenic effects of chemical substances. These values are defined as an estimate of a daily exposure level for the human population, including sensitive subpopulations, that is likely to be without an appreciable risk of adverse effects during a lifetime. The RfD is expressed as dose (mg) per unit body weight (kg) per unit time (day). The RfC is expressed as dose (mg) per cubic meter of air ( $\text{m}^3$ ).

##### **6.4.2 Carcinogenic Slope Factors**

CSFs are used to estimate an upper bound lifetime probability of an individual developing cancer as a result of exposure to a particular level of a potential carcinogen (USEPA, 1989a). This factor is reported in units of proportion (of a population) affected per mg/kg/day and is derived through an assumed low-dosage, linear multistage model and an extrapolation from high to low dose-responses determined from animal studies. The slope factor represents the upper 95<sup>th</sup> percent confidence limit on the increased cancer risk from a lifetime exposure to an agent. CSFs also can be derived from USEPA promulgated unit risk values for air and/or water. CSFs derived from

unit risks cannot, however, be applied to environmental media other than the medium considered in the unit risk estimate.

Slope factors are also accompanied by weight-of-evidence classifications, which designate the strength of the evidence that the COPC is a potential human carcinogen.

Quantitative indices of toxicity and USEPA weight-of-evidence classifications are presented in Tables 6-16 through 6-19 for the identified COPCs. The hierarchy (USEPA, 1989a) for choosing these values was:

- Integrated Risk Information System (IRIS)
- Health Effects Assessment Summary Table (HEAST)
- National Center for Environmental Assessment (NCEA)

The IRIS database is updated a few times each year and contains verified RfDs, RfCs, and CSFs. The USEPA has formed an RfD work group to review existing data used to derive RfDs and RfCs. Once this task has been completed, the verified RfD appears in IRIS. Like the RfD Work Group, the USEPA has also formed the Carcinogen Risk Assessment Verification Endeavor (CRAVE) Work Group to review and validate toxicity values used in developing CSFs. Once the slope factors have been verified via extensive peer review, they also appear in the IRIS database. HEAST and NCEA, on the other hand, provide provisional (unverified) RfDs, RfCs and CSFs.

#### **6.4.3 Dermal Absorption Efficiency**

Many of the RfDs and CSFs are derived from oral toxicological studies based on administered dose, and do not account for the amount of a substance that can penetrate exchange boundaries after contact (e.g., absorbed dose). As a result, there is very little information available regarding dermal toxicity criteria. Therefore, in order to account for a difference in toxicity between an administered dose and an absorbed dose, the RfDs and CSFs (that were based on an administered dose) were adjusted, as described by Appendix A of RAGS A (USEPA, 1989), using oral absorption efficiencies obtained from RAGS Part E (USEPA, 2001). For those chemicals that were not adjusted according to RAGS E, experimentally-derived oral absorption efficiencies obtained from information compiled by Oak Ridge National Laboratory (as recommended by North Carolina Department of Environment and Natural Resources) were used. The adjustment for the oral RfD that would correspond to a dermally absorbed dose is represented by multiplying

the RfD by an oral-to-dermal extrapolation value. The adjustment for the oral CSF that would correspond to the dermally-absorbed dose is represented by dividing the CSF by an oral-to-dermal extrapolation value. The oral-to-dermal extrapolation values were obtained from sources such as the NCEA, IRIS, Agency for Toxic Substance and Disease Registry (ATSDR) toxicological profiles, toxicology publications, toxicology references, and USEPA Regional Offices. The oral-to-dermal extrapolation values used in this baseline HHRA for SWMU 360 are presented in Tables 6-16 and 6-18. The table of oral absorption efficiencies compiled by Oak Ridge National Laboratory, which includes detailed references, is provided as a subsection of Appendix K.

## **6.5 Risk Characterization**

The risk characterization combines the selected COPCs, the exposure assessment, and the toxicity assessment to produce a quantitative estimate of current and future potential human health risks associated with SWMU 360. Sections 6.5.1 and 6.5.2 discuss the USEPA methodologies used for quantifying and characterizing carcinogenic and noncarcinogenic human health risks. ILCRs and Hazard Indices (HIs) are calculated to characterize potential human health effects. These terms are defined in the sections that follow. ILCRs and HIs are estimated for current and future receptors exposure scenarios that were identified for SWMU 360 in Section 6.3, and are discussed in Section 6.5.3.

### **6.5.1 Quantification and Characterization of Carcinogenic Risks**

Quantitative risk calculations for potentially carcinogenic compounds estimate inferentially (versus probabilistically) the potential ILCR for an individual in a specified population. This unit of risk refers to a potential cancer risk that is above the background cancer risk in unexposed individuals. For example, an ILCR of  $1 \times 10^{-6}$  indicates that an exposed individual has an increased probability of one in one million of developing cancer subsequent to exposure, over the course of their lifetime.

The potential lifetime ILCR for an individual was estimated from the following relationship:

$$ILCR = \sum_{i=1}^n (CDI_{i,orDAD_i}) \times CSF_i$$

where the CSF<sub>i</sub> is expressed as (mg/kg/day)<sup>-1</sup> for compound i, and the CDIs and DAD<sub>i</sub> is expressed as mg/kg/day for compound i. Since the units of CSF are (mg chemical/kg body weight-day)<sup>-1</sup> and the units of intake or dose are mg chemical/kg body weight-day, the ILCR value is dimensionless. The aforementioned equation was derived assuming that cancer is a nonthreshold process and that the potential excess risk level is proportional to the cumulative intake over a lifetime.

For quantitative estimation of risk, it is assumed that cancer risks from various exposure routes are additive. Estimated ILCR values will be compared to 1 x 10<sup>-6</sup> to 1 x 10<sup>-4</sup>, which represents the target risk range of ILCR values considered by the USEPA to represent an acceptable (i.e., de minimis) risk (USEPA, 1990).

#### 6.5.2 Quantification and Characterization of Noncarcinogenic Risks

Noncarcinogenic compounds assume that a threshold toxicological effect exists. Therefore, the potential for noncarcinogenic effects is calculated by comparing (i.e., dividing) CDI<sub>i</sub> and DAD<sub>i</sub> levels with RfDs for each COPC.

Noncarcinogenic effects are estimated by calculating the HQ for individual chemicals and the hazard index (HI) for overall chemicals and pathways by the following equation:

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

$$\text{where: } HQ_i = \frac{(CDI_i \text{ or } DAD_i)}{RfD_i \text{ or } RfC_i}$$

An HQ is the ratio of the daily intake or absorbed dose to the reference dose (or reference concentration for inhalation exposure). CDI<sub>i</sub> is the chronic daily intake (mg/kg/day) of contaminant i; DAD<sub>i</sub> is the dermally absorbed dose (mg/kg/day) of contaminant i, and RfD<sub>i</sub> is the reference dose (mg/kg/day) of the contaminant i over a prolonged period of exposure. RfC<sub>i</sub> is the reference concentration used when determining exposure due to inhalation. Since the units of RfD are mg/kg-day and the units of CDI/DAD are mg/kg-day, the HQ and HI are dimensionless. To account for the additivity of noncarcinogenic risk following exposure to numerous chemicals, the HI, which is the sum of all the HQs, will be calculated. A ratio of 1.0 is used for comparison

to the HQ and HI (USEPA, 1990). Ratios less than 1.0 indicate that adverse noncarcinogenic health effects are unlikely. Ratios greater than 1.0 indicate that adverse noncarcinogenic health effects may occur at that exposure level. However, this does not mean that adverse effects will definitely occur, since the RfD incorporates safety and modifying factors to ensure that it is well below that dose for which adverse effects have been observed. This procedure assumes that the risks from exposure to multiple chemicals are additive, an assumption that is probably valid for compounds that have the same target organ or cause the same toxic effect.

### **6.5.3 Potential Human Health Effects**

Both pathway-specific risks and total site risks have been estimated for future residents and future construction workers at SWMU 360. All scenarios evaluated in this baseline HHRA were previously discussed in detail in Section 6.3. All calculation spreadsheets used for estimating potential carcinogenic and noncarcinogenic risks for receptors at SWMU 360 are presented in Appendix K. Please note that the full set of RAGS Part D tables is presented in Appendix L.

The total site carcinogenic and noncarcinogenic risks estimated for all current and future receptors evaluated in this baseline HHRA are presented in Tables 6-20 through 6-25. The pathway risks contributing to the potentially unacceptable total site risks are also presented in these tables.

#### **6.5.3.1 Current Military Base Personnel**

There were no COPCs selected for surface soil in the vicinity of SWMU 360. Therefore, a complete surface soil exposure pathway does not exist for the current military base personnel. Consequently, there are no carcinogenic risks or adverse health effects resulting from exposure to surface soil.

#### **6.5.3.2 Future Adult and Child Residents**

Tables 6-20 and 6-22 (RME) and 6-21 and 6-23 (CT) present all potential pathway-specific and total site risks estimated for future adult and child residents evaluated for ingestion and dermal exposures to site COPCs in subsurface soil and groundwater, inhalation of fugitive dusts from subsurface soil and inhalation of volatiles in groundwater (adults only). The total ILCRs ( $1.2 \times 10^{-3}$  and  $5.1 \times 10^{-4}$ ) exceed the USEPA recommended range of  $1 \times 10^{-6}$  to  $1 \times 10^{-4}$

for the future adult and child residents. This is primarily caused by accidental ingestion and dermal contact with TCE in the shallow groundwater, which contributes approximately 73 percent to the total ILCR for the adult and 67 percent to the total ILCR for the young child. Exposure to PCE (7 percent contribution to adult, 8 percent contribution to child), heptachlor epoxide (9 percent contribution to adult, 8 percent contribution to child), and arsenic (4 percent contribution to adult and child) in the shallow groundwater, as well as TCE in the deep groundwater (8 percent contribution to adult and child) also contributed to the total ILCR exceedence. In the CT scenario, the total ILCRs for the adult and child fell within the USEPA's acceptable range of  $1 \times 10^{-6}$  to  $1 \times 10^{-4}$  for the child ( $9.3 \times 10^{-5}$ ) and exceeded for the adult ( $1.7 \times 10^{-4}$ ). The total lifetime ILCR also exceeded this range with a value of  $1.7 \times 10^{-3}$ .

The total HI for the adult and child also exceeded the USEPA's acceptable hazard level of 1.0 (27 and 43, respectively). This is due to shallow groundwater exposure to TCE (78 percent contribution to adult, 77 percent contribution to the child) and heptachlor epoxide (4 percent contribution to the adult and child). Deep groundwater exposure to TCE also contributed to the total HI (9 percent to the adult and child).

#### 6.5.3.3 Future Construction Workers

Table 6-24 presents all potential pathway-specific and total site risks estimated for future construction workers evaluated for ingestion and dermal exposures to site COPCs in subsurface soil, and inhalation of fugitive dusts from subsurface soil.

There were no carcinogenic risks or adverse noncarcinogenic health hazards calculated that exceeded USEPA's acceptable criteria for the future construction worker.

### 6.6 Sources of Uncertainty

Uncertainties are encountered throughout the risk assessment process. This section discusses the sources of uncertainty inherent in the following elements of the human health evaluation performed for SWMU 360:

- Sampling and analysis
- Selection of COPCs
- Exposure assessment

- Toxicological assessment
- Human risk characterization

Uncertainties associated with this risk assessment are discussed in the following paragraphs. Table 6-25 summarizes the potential effects of certain uncertainties on the estimation of human health risks.

#### **6.6.1 Sampling and Analysis**

The development of a risk assessment depends on the reliability of, and uncertainties associated with the analytical data available to the risk assessor. These, in turn, are dependent on the operating procedures and techniques applied to the collection of environmental samples in the field and their subsequent analyses in the laboratory. To minimize the uncertainties associated with sampling and analysis at SWMU 360, USEPA-approved sampling and analytical methods were employed. Data was generated following USEPA's Statement of Work for Contract Laboratory Program (CLP). Samples were analyzed for TCL organics and RCRA metals. Samples were taken from locations specified in the approved Work Plan along with the necessary QA/QC samples.

Analytical data are limited by the precision and accuracy of the methods of analysis, which are reflected by the Relative Percent Difference (RPD) of duplicate analyses and the percent recovery of spikes, respectively. In addition, the statistical methods used to compile and analyze the data (mean concentrations, detection frequencies) are subject to the overall uncertainty in data measurement. Furthermore, chemical concentrations in environmental media fluctuate over time and with respect to sampling location. Analytical data must be sufficient to consider the temporal and spatial characteristics of contamination at the site with respect to exposure.

Uncertainty exists also in the fact that contamination may or may not be fully delineated. And so, having a complete data set impacts the representativeness of exposure concentrations derived from the data.

There is some uncertainty associated with the exclusion of the mobile laboratory data from this HHRA. Upon evaluation of the mobile laboratory data, there were no organic compounds detected in surface soil (refer to Table 4-3), similar compounds as the fixed-base laboratory data in subsurface soil (refer to Table 4-4), and several more compounds as the fixed-base laboratory

data in groundwater (refer to Table 4-6). It should be noted that for both fixed-base and mobile laboratory groundwater data, TCE and PCE represented the primary compounds exceeding screening criteria. Also, the vinyl chloride detections from the mobile laboratory data did not exceed screening criteria in any of the wells located at SWMU 360. These locations are up gradient of the SWMU. Therefore, it can be concluded that the exclusion of the mobile laboratory data would not likely change the results of the HHRA. Also, the inclusion of the mobile laboratory data introduces uncertainty in that those data were not validated. However, fixed-base laboratory data were validated using procedures established by the National Functional Guidelines for Organic and Inorganic Analyses (USEPA, 1994).

#### **6.6.2 Selection of COPCs**

Soil and groundwater water COPCs were selected based on comparisons of the maximum detected concentration with USEPA Region IX PRGs for residential soil (soil) and tap water (groundwater).

PRGs were derived using conservative, USEPA-promulgated default values, and the most recent toxicological criteria available. All non-carcinogenic PRGs were divided by 10 to account for potential additive effects. This adjustment corresponds to assuming an HQ of 0.1, rather than 1.0. This adds additional conservatism to the COPC selection process.

RfDs and CSFs have been combined with "standard" exposure scenarios to calculate the PRGs. Actual exposure scenarios and parameters may differ from those used to calculate the PRG.

Guidance contained within RAGS Volume I, Part A discusses the evaluation of quantitation limits in relation to whether or not chemicals should be eliminated from a baseline HHRA because they were not detected. In other words, just because a chemical was not detected does not mean it should be deleted from consideration. In the baseline HHRA performed for SWMU 360, only those chemicals that were positively detected were retained for quantitative evaluation in the risk assessment. There is some uncertainty associated with chemicals that may not have been detected, whose sample quantitation limits were greater than corresponding standards and/or criteria. This situation could result in undetected risk. However, given the other conservative aspects of this baseline HHRA, it is anticipated that the uncertainty of this risk assessment is low. Furthermore, for chemicals detected just once in a given medium, one half of all detection limits of that chemical (considered as non-detects) are used as proxy calculations in

calculating the concentration term. Only those chemicals in a medium that are not positively detected in each sample collected and analyzed are eliminated from further consideration.

Currently, no base closures are planned for MCB Camp Lejeune; therefore, future residential development is unlikely. The application of the residential PRG values to soil and groundwater COPC selections would, therefore, tend to result in a list of COPCs that could be considered conservative for a military base. Conservative COPC selections in the baseline HHRA protect public health because the results of the baseline HHRA determine remedial alternatives and remedial action objectives.

### **6.6.3 Exposure Assessment**

In performing exposure assessments, uncertainties arise from two main sources. First, uncertainties arise in estimating the fate of a compound in the environment, including estimating release and transport in a particular environmental medium. Second, uncertainties arise in the estimation of chemical intakes resulting from contact by a receptor with a particular medium.

To estimate an intake, certain assumptions must be made about exposure events, exposure durations, and the corresponding assimilation of constituents by the receptor. Exposure factors have been generated by the scientific community and have been reviewed by the USEPA. The USEPA has published an Exposure Factors Handbook (USEPA, 1997), which contains the best and latest values. These exposure factors have been derived from a range of values generated by studies of limited numbers of individuals. It is assumed that all potential receptors remain on or near the site throughout the exposure periods and that their exposures to chemicals from the site are all uniform. In all instances, values used in this risk assessment, scientific judgments, and conservative assumptions agree with those of the USEPA.

The RME approach, designed to avoid underestimating daily intakes, was used throughout this risk assessment. The 95% UCL estimates of the arithmetic mean versus maximum values as the concentration terms in estimating the CDI or DAD for the soil exposure scenarios and the maximum values as the concentration terms for groundwater exposure scenarios reduce the potential for underestimating exposure at SWMU 360.

#### 6.6.4 Toxicological Assessment

In making quantitative estimates of the toxicity of varying dosages of compounds to human receptors, uncertainties arise from two sources. First, data on human exposure and the subsequent effects are usually insufficient, if they are available. Human exposure data usually lack adequate concentration estimations and suffer from inherent temporal variability. Therefore, animal studies are often used and new uncertainties arise from the process of extrapolating animal results to humans. Second, to obtain observable effects with a manageable number of experimental subjects, high doses of a compound are often used. In this situation, a high dose means that high exposures are used in the experiment with respect to most environmental exposures. Therefore, when applying the results of the animal experiment to human exposures, the effects at the high doses must be extrapolated to approximate effects at lower doses.

In extrapolating effects from high doses in animals to low doses in humans, scientific judgment and conservative assumptions are employed. In selecting animal studies for use in dose-response calculations, the following factors are considered:

- Studies are preferred where the animal closely mimics human pharmacokinetics.
- Studies are preferred where dose intake most closely mimics the intake route and duration for humans.
- Studies are preferred which demonstrate the most sensitive response to the compound in question.

For compounds believed to cause threshold effects (i.e., noncarcinogens), safety factors are employed in the extrapolation of effects from animals to humans and from high doses to low doses. In deriving carcinogenic potency factors, the 95% UCL value is promulgated by the USEPA to prevent underestimation of potential risk.

All potential toxic endpoints for human receptors have been addressed to the extent allowed by the data evaluated from the most recent toxicological/epidemiological studies used to derive the cancer slope factors and reference doses. Therefore, any uncertainties associated with toxic endpoints are directly correlated to the information obtained from, and reliability of those studies.

Further conservatism in the baseline HHRA is also introduced by using experimentally-derived oral absorption efficiencies to account for a difference in the degree of toxicity between an administered dose and an absorbed dose. Equating the absorption efficiency of the dermal bi-phasic barrier to the absorption efficiency of the gastrointestinal lining is a very conservative approach that tends to overestimate the potential risk to human health.

#### **6.6.5 Human Risk Characterization**

The risk characterization bridges the gap between potential exposure and the possibility of systemic or carcinogenic human health effects, ultimately providing impetus for the remediation of the site or providing a basis for no remedial action.

Uncertainties associated with risk characterization include the assumption of chemical additivity and the inability to predict synergistic or antagonistic interactions between COPCs. These uncertainties are inherent in any inferential risk assessment. USEPA promulgated inputs to the quantitative risk assessment and toxicological indices are calculated to protect the human receptor and to err conservatively, so as to not underestimate the potential human health risks.

#### **6.7 Summary of the Baseline HHRA**

Current land use scenarios that were evaluated in this baseline HHRA for SWMU 360 include military base personnel. Future land use scenarios that were evaluated include the adult and child residents and construction worker.

There were no surface soil COPCs selected. Therefore, a quantitative risk evaluation for the military base personnel was not necessary. Consequently, there is no unacceptable risks or hazard levels for the military base personnel.

There were no carcinogenic risks or adverse noncarcinogenic health hazards calculated that exceeded USEPA's acceptable criteria for the future construction worker.

The total ILCRs exceed the USEPA recommended range of  $1 \times 10^{-6}$  to  $1 \times 10^{-4}$  for the future adult and child residents. This is due to accidental contact with TCE, PCE, heptachlor epoxide, and arsenic in the shallow groundwater, as well as to TCE in the deep groundwater. The total lifetime ILCR still exceeds the acceptable range.

The total HI for the future adult and child residents also exceeded the USEPA's acceptable hazard level of 1.0. This is due to shallow groundwater exposure to TCE and heptachlor epoxide and deep groundwater exposure to TCE.

**Baker**

*Baker Environmental, Inc.*

**SECTION 6.0**

***TABLES***

TABLE 6-1  
 OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN  
 SWMU 360  
 RCRA FACILITY INVESTIGATION  
 MCB, CAMP LEJEUNE, NORTH CAROLINA

Scenario Timeframe: Current, Future  
 Medium: Surface Soil  
 Exposure Medium: Surface Soil  
 Exposure Point: Surface Soil

CAS Number	Chemical	Minimum Concentration	Minimum Qualifier	Maximum Concentration	Maximum Qualifier	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening	Background Value <sup>(1)</sup>	Screening <sup>(2)</sup> Toxicity Value	Potential ARAR/TBC Value	Potential ARAR/TBC Source	COPC Flag	Rationale for <sup>(3)</sup> Contaminant Deletion or Selection
<b>VOLATILES (ug/kg)</b>																
120-82-1	1,2,4-Trichlorobenzene	3	J	3	J	µg/kg	SWMU360-TW01-00	1/4	6U - 7U	3	NA	6.50E+04 N	N/A	N/A	NO	BSL
156-59-2	1,2-Dichloroethene (cis)	22	J	22	J	µg/kg	SWMU360-TW03-00	1/4	6U - 10U	22	NA	4.29E+03 N	N/A	N/A	NO	BSL
71-43-2	Benzene	1	J	1	J	µg/kg	SWMU360-TW02-00	1/4	7U - 10U	1	NA	6.01E+02 C	N/A	N/A	NO	BSL
75-15-0	Carbon Disulfide	6	J	6	J	µg/kg	SWMU360-TW03-00	1/4	6U - 10UJ	6	NA	3.55E+04 N	N/A	N/A	NO	BSL
100-41-4	Ethylbenzene	3	J	3	J	µg/kg	SWMU360-TW02-00	1/4	7U - 10U	3	NA	8.92E+03 C	N/A	N/A	NO	BSL
75-09-2	Methylene Chloride	1	J	6	J	µg/kg	SWMU360-TW02-00	2/4	7U - 10U	6	NA	9.11E+03 C	N/A	N/A	NO	BSL
79-01-6	Trichloroethene (TCE)	2	J	2	J	µg/kg	SWMU360-TW03-00	1/4	6U - 10U	2	NA	5.30E+01 C	N/A	N/A	NO	BSL
<b>SEMIVOLATILES (ug/kg)</b>																
88-74-4	2-Nitroaniline	40	J	40	J	µg/kg	SWMU360-TW01-00	1/4	720U - 780U	40	NA	1.75E+02 N	N/A	N/A	NO	BSL
117-81-7	Bis(2-ethylhexyl) Phthalate (DEHP)	90	J	410	J	µg/kg	SWMU360-TW03-00	4/4	(4)	410	NA	3.47E+04 C	N/A	N/A	NO	BSL
117-84-0	Di-n-octyl Phthalate	69	J	69	J	µg/kg	SWMU360-TW01-00	1/4	360U - 390U	69	NA	2.44E+05 N	N/A	N/A	NO	BSL
<b>PESTICIDES (ug/kg)</b>																
72-54-8	4,4'-DDD	1.2	J	3.3	J	µg/kg	SWMU360-TW03-00	2/4	3.6UJ - 3.9U	3.3	NA	2.44E+03 C	N/A	N/A	NO	BSL
72-55-9	4,4'-DDE	0.58	J	2.3	J	µg/kg	SWMU360-TW01-00	2/4	1.9U - 2U	2.3	NA	1.72E+03 C	N/A	N/A	NO	BSL
50-29-3	4,4'-DDT	1	J	6.1	J	µg/kg	SWMU360-TW01-00	4/4	(4)	6.1	NA	1.72E+03 C	N/A	N/A	NO	BSL
319-84-6	BHC, alpha-	6.7	J	6.7	J	µg/kg	SWMU360-TW03-00	1/4	0.91U - 1U	6.7	NA	9.02E+01 C	N/A	N/A	NO	BSL
319-85-7	BHC, beta-	6.4	J	6.4	J	µg/kg	SWMU360-TW03-00	1/4	1.9U - 2.1U	6.4	NA	3.16E+02 C	N/A	N/A	NO	BSL
319-86-8	BHC, delta-	0.31	J	0.31	J	µg/kg	SWMU360-TW03-00	1/4	0.91U - 1U	0.31	NA	3.16E+02 C <sup>(5)</sup>	N/A	N/A	NO	BSL
58-89-9	BHC, gamma- (Lindane)	0.62	J	0.62	J	µg/kg	SWMU360-TW03-00	1/4	0.34U - 1U	0.62	NA	4.37E+02 C	N/A	N/A	NO	BSL
5103-71-9	Chlordane, alpha-	0.42	J	0.42	J	µg/kg	SWMU360-TW03-00	1/4	1.9U - 2.1U	0.42	NA	1.62E+03 C <sup>(6)</sup>	N/A	N/A	NO	BSL
5103-74-2	Chlordane, gamma-	0.63	J	0.63	J	µg/kg	SWMU360-TW03-00	1/4	0.91U - 1U	0.63	NA	1.62E+03 C <sup>(6)</sup>	N/A	N/A	NO	BSL
33213-65-9	Endosulfan II	3.9	J	3.9	J	µg/kg	SWMU360-TW04-00	1/4	3.6U - 4.1UJ	3.9	NA	3.67E+04 N <sup>(7)</sup>	N/A	N/A	NO	BSL
1031-07-8	Endosulfan Sulfate	4.2	J	4.2	J	µg/kg	SWMU360-TW01-00	1/4	3.6U - 3.9U	4.2	NA	3.67E+04 N <sup>(7)</sup>	N/A	N/A	NO	BSL
7421-93-4	Endrin Aldehyde	1.2	J	1.2	J	µg/kg	SWMU360-TW01-00	1/4	3.6UJ - 3.9U	1.2	NA	1.83E+03 N <sup>(8)</sup>	N/A	N/A	NO	BSL
<b>METALS (mg/kg)</b>																
7440-38-2	Arsenic	0.35	J	0.54	J	mg/kg	SWMU360-TW04-00	3/4	0.26U - 0.26U	0.54	1.196	3.90E-01 C	N/A	N/A	NO	BKG
7440-39-3	Barium	10.1	J	13.1	J	mg/kg	SWMU360-TW04-00	3/4	5.4U - 5.4U	13.1	27.7	5.37E+02 N	N/A	N/A	NO	BSL
7440-43-9	Cadmium	0.54	J	0.56	J	mg/kg	SWMU360-TW01-00	2/4	0.03U - 0.04U	0.56	0.0966	3.70E+00 N	N/A	N/A	NO	BSL
7440-47-3	Chromium	2.1	J	10.2	J	mg/kg	SWMU360-TW01-00	4/4	(4)	10.2	14.5	3.01E+01 C <sup>(9)</sup>	N/A	N/A	NO	BSL
7439-92-1	Lead	2.8	J	28	J	mg/kg	SWMU360-TW03-00	4/4	(4)	28	21.1	4.00E+01 N	N/A	N/A	NO	BSL
7439-97-6	Mercury	0.02	J	0.02	J	mg/kg	SWMU360-TW04-00	1/4	0.02UJ - 0.02UJ	0.02	0.0640	2.30E+00 N <sup>(10)</sup>	N/A	N/A	NO	BSL
7782-49-2	Selenium	0.52	J	0.52	J	mg/kg	SWMU360-TW04-00	1/4	0.48U - 0.53U	0.52	0.693	3.91E+01 N	N/A	N/A	NO	BSL

- (1) MCB Camp Lejeune Base Background Study, Final (Baker, 2001): 2 \* Mean (1/2 nondetects) - AOC 7  
 (2) All non-carcinogenic criteria were divided by 10 to account for potential additive effects of chemicals  
 USEPA Region IX COC Screening Value (derived from USEPA Region IX PRO Table - October, 2002)  
 (3) Rationale Codes Deletion Reason: Background Levels (BKG)  
 Below Screening Level (BSL)

Definitions: NA = Not Analyzed  
 COPC = Chemical of Potential Concern  
 ARAR/TBC = Applicable or Relevant and Appropriate Requirement/To Be Considered

J - Analyte present - Reported value is estimated  
 U - Not detected  
 UJ - Reported quantitation limit is qualified as estimated

C = Carcinogenic mg/kg = milligrams per kilogram  
 N = Non-Carcinogenic ug/kg = micrograms per kilogram

- (4) No detection limits given; analyte detected in every sample  
 (5) Screening values for technical-BHC used as a surrogate.  
 (6) Screening value for chlordane used as a surrogate.  
 (7) Screening value for endosulfan used as a surrogate.  
 (8) Screening value for endrin used as a surrogate.  
 (9) Screening value for chromium VI used.  
 (10) Screening values for mercuric chloride used as a surrogate.

TABLE 6-2  
 OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN  
 SWMU 360  
 RCRA FACILITY INVESTIGATION  
 MCB, CAMP LEJEUNE, NORTH CAROLINA

Scenario Timeframe: Future  
 Medium: Subsurface Soil  
 Exposure Medium: Subsurface Soil  
 Exposure Point: Subsurface Soil

CAS Number	Chemical	Minimum Concentration	Minimum Qualifier	Maximum Concentration	Maximum Qualifier	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening	Background Value <sup>(1)</sup>	Screening <sup>(2)</sup> Toxicity Value	Potential ARAR/TBC Value	Potential ARAR/TBC Source	COPC Flag	Rationale for <sup>(3)</sup> Contaminant Deletion or Selection
<b>VOLATILES (ug/kg)</b>																
156-59-2	1,2-Dichloroethene (cis)	3	J	20	J	µg/kg	SWMU360-TW03-02	3/13	6U - 11U	20	NA	4.29E+03 N	N/A	N/A	NO	BSL
156-60-5	1,2-Dichloroethene (trans)	0.92	J	0.92	J	µg/kg	SWMU360-SB04-02	1/13	6U - 11U	0.92	NA	6.95E+03 N	N/A	N/A	NO	BSL
78-93-3	2-Butanone (MEK)	3.8	J	3.8	J	µg/kg	SWMU360-SB04-02	1/13	11U - 28UJ	3.8	NA	7.33E+05 N	N/A	N/A	NO	BSL
71-43-2	Benzene	1.5	J	1.5	J	µg/kg	SWMU360-SB04-02	1/13	6U - 11U	1.5	NA	6.01E+02 C	N/A	N/A	NO	BSL
75-15-0	Carbon Disulfide	3	J	5	J	µg/kg	SWMU360-TW02-02	2/13	7U - 11U	5	NA	3.55E+04 N	N/A	N/A	NO	BSL
100-41-4	Ethylbenzene	63	J	63	J	µg/kg	SWMU360-SB04-02	1/13	6U - 11U	63	NA	8.92E+03 C	N/A	N/A	NO	BSL
98-82-8	Isopropylbenzene (Cumene)	6.1	J	6.1	J	µg/kg	SWMU360-SB04-02	1/13	6U - 11U	6.1	NA	5.72E+04 N	N/A	N/A	NO	BSL
108-87-2	Methyl Cyclohexane	1.3	J	1.3	J	µg/kg	SWMU360-SB04-02	1/13	6U - 11U	1.3	NA	2.59E+05 N	N/A	N/A	NO	BSL
75-09-2	Methylene Chloride	2	J	6	J	µg/kg	SWMU360-TW01-01	3/13	7U - 11U	6	NA	9.11E+03 C	N/A	N/A	NO	BSL
127-18-4	Tetrachloroethene (PCE)	3.55	J	10	J	µg/kg	SWMU360-TW04-06	3/13	6U - 11U	10	NA	1.51E+03 C	N/A	N/A	NO	BSL
108-88-3	Toluene	9.7	J	9.7	J	µg/kg	SWMU360-SB04-02	1/13	6U - 11U	9.7	NA	6.60E+04 N	N/A	N/A	NO	BSL
79-01-6	Trichloroethene (TCE)	2	J	2	J	µg/kg	SWMU360-TW03-02	1/13	6U - 11U	2	NA	5.30E+01 C	N/A	N/A	NO	BSL
000000-01-4	Xylene, m/p-	230	J	230	J	µg/kg	SWMU360-SB04-02	1/9	11U - 11U	230	NA	2.75E+04 N <sup>(3)</sup>	N/A	N/A	NO	BSL
95-47-6	Xylene, o-	100	J	100	J	µg/kg	SWMU360-SB04-02	1/9	11U - 11U	100	NA	2.75E+04 N <sup>(3)</sup>	N/A	N/A	NO	BSL
<b>SEMIVOLATILES (ug/kg)</b>																
1912-24-9	Atrazine	11	J	11	J	µg/kg	SWMU360-TW02-02	1/4	360U - 380U	11	NA	2.19E+03 C	N/A	N/A	NO	BSL
117-81-7	Bis(2-ethylhexyl) Phthalate (DEHP)	66	J	180	J	µg/kg	SWMU360-TW01-01	4/4	(4)	180	NA	3.47E+04 C	N/A	N/A	NO	BSL
117-84-0	Di-n-octyl Phthalate	23	J	27	J	µg/kg	SWMU360-TW01-01	2/4	370U - 380U	27	NA	2.44E+05 N	N/A	N/A	NO	BSL
206-44-0	Fluoranthene	25	J	25	J	µg/kg	SWMU360-TW01-01	1/4	370U - 380U	25	NA	2.29E+05 N	N/A	N/A	NO	BSL
<b>PESTICIDES (ug/kg)</b>																
72-54-8	4,4'-DDD	0.76	J	4.9	J	µg/kg	SWMU360-TW01-01	2/37	3.5U - 4U	4.9	NA	2.44E+03 C	N/A	N/A	NO	BSL
72-55-9	4,4'-DDE	0.5	J	6.4	J	µg/kg	SWMU360-TW01-01	2/37	1.9U - 4U	6.4	NA	1.72E+03 C	N/A	N/A	NO	BSL
50-29-3	4,4'-DDT	1.6	J	3.3	J	µg/kg	SWMU360-TW01-01	2/37	3.5U - 5.7UJ	3.3	NA	1.72E+03 C	N/A	N/A	NO	BSL
319-85-7	BHC, beta-	1.4	J	1.4	J	µg/kg	SWMU360-TW04-06	1/37	1.8U - 9.2U	1.4	NA	3.16E+02 C	N/A	N/A	NO	BSL
5103-71-9	Chlordane, alpha-	0.29	J	0.29	J	µg/kg	SWMU360-TW02-02	1/37	1.8U - 9.2U	0.29	NA	1.62E+03 C <sup>(4)</sup>	N/A	N/A	NO	BSL
60-57-1	Dieldrin	4.1	J	4.1	J	µg/kg	SWMU360-TW01-01	1/37	1.9U - 4U	4.1	NA	3.04E+01 C	N/A	N/A	NO	BSL
<b>METALS (mg/kg)</b>																
7440-38-2	Arsenic	0.39	J	2.2	J	mg/kg	SWMU360-SB08-01	16/37	0.25U - 0.68U	2.2	1.682	3.90E-01 C	N/A	N/A	YES	ASL
7440-39-3	Barium	2.6	J	29.4	J	mg/kg	SWMU360-SB10-03	36/37	4.7U - 4.7U	29.4	19.4	5.37E+02 N	N/A	N/A	NO	BSL
7440-43-9	Cadmium	0.11	J	0.58	J	mg/kg	SWMU360-SB03-01	2/37	0.03U - 0.28U	0.58	0.0588	3.70E+00 N	N/A	N/A	NO	BSL
7440-47-3	Chromium	1	J	14.7	J	mg/kg	SWMU360-SB04-06	27/37	0.13U - 4.5U	14.7	15.9	3.01E+01 C <sup>(7)</sup>	N/A	N/A	NO	BSL
7439-92-1	Lead	0.69	J	30.9	J	mg/kg	SWMU360-TW01-01	36/37	2.7U - 2.7U	30.9	10.59	4.00E+01 N	N/A	N/A	NO	BSL
7439-97-6	Mercury	0.03	J	0.07	J	mg/kg	SWMU360-TW01-01	2/37	0.02UJ - 0.12U	0.07	0.0392	2.30E+00 N <sup>(8)</sup>	N/A	N/A	NO	BSL
7782-49-2	Selenium	0.84	J	0.87	J	mg/kg	SWMU360-SB08-02	2/37	0.47U - 0.73UJ	0.87	0.492	3.91E+01 N	N/A	N/A	NO	BSL

- (1) MCB Camp Lejeune Base Background Study, Final (Baker, 2001): 2 \* Mean (1/2 nondetects) - AOC 7  
 (2) All non-carcinogenic criteria were divided by 10 to account for potential additive effects of chemicals USEPA Region IX COC Screening Value (derived from USEPA Region IX PRG Table - October, 2002)  
 (3) Rationale Codes  
 Selection Reason: Above Screening Levels (ASL)  
 Deletion Reason: Below Screening Level (BSL)  
 (4) No detection limits given; analyte detected in every sample.  
 (5) Screening value for xylenes (total).  
 (6) Screening value for chlordane used as a surrogate.  
 (7) Screening value for chromium VI used.  
 (8) Screening values for mercuric chloride used as a surrogate.

Definitions: NA = Not Analyzed  
 ND = Not Detected  
 COPC = Chemical of Potential Concern  
 ARAR/TBC = Applicable or Relevant and Appropriate Requirement/To Be Considered

J - Analyte present - Reported value is estimated  
 U - Not detected  
 UJ - Reported quantitation limit is qualified as estimated  
 C = Carcinogenic  
 N = Non-Carcinogenic  
 S = Soil Saturation  
 mg/kg = milligrams per kilogram  
 ug/kg = microgram per kilogram

TABLE 6-3  
 OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN  
 SWMU 360  
 RCRA FACILITY INVESTIGATION  
 MCB, CAMP LEJEUNE, NORTH CAROLINA

Scenario Timeframe: Future  
 Medium: Subsurface Soil  
 Exposure Medium: Subsurface Soil  
 Exposure Point: Subsurface Soil

CAS Number	Chemical	Minimum Concentration	Minimum Qualifier	Maximum Concentration	Maximum Qualifier	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening	Background Value <sup>(1)</sup>	Screening <sup>(2)</sup> Toxicity Value	Potential ARAR/TBC Value	Potential ARAR/TBC Source	COPC Flag	Rationale for <sup>(3)</sup> Contaminant Deletion or Selection
	<b>VOLATILES (ug/kg)</b>															
156-59-2	1,2-Dichloroethene (cis)	3	J	20	J	µg/kg	SWMU360-TW03-02	3/13	6U - 11U	20	NA	1.46E+04 N	N/A	N/A	NO	BSL
156-60-5	1,2-Dichloroethene (trans)	0.92	J	0.92	J	µg/kg	SWMU360-SB04-02	1/13	6U - 11U	0.92	NA	2.35E+04 N	N/A	N/A	NO	BSL
78-93-3	2-Butanone (MEK)	3.8	J	3.8	J	µg/kg	SWMU360-SB04-02	1/13	11U - 28UJ	3.8	NA	2.71E+06 N	N/A	N/A	NO	BSL
71-43-2	Benzene	1.5	J	1.5	J	µg/kg	SWMU360-SB04-02	1/13	6U - 11U	1.5	NA	1.31E+03 C	N/A	N/A	NO	BSL
75-15-0	Carbon Disulfide	3	J	5	J	µg/kg	SWMU360-TW02-02	2/13	7U - 11U	5	NA	1.20E+05 N	N/A	N/A	NO	BSL
100-41-4	Ethylbenzene	63	J	63	J	µg/kg	SWMU360-SB04-02	1/13	6U - 11U	63	NA	1.95E+04 C	N/A	N/A	NO	BSL
98-82-8	Isopropylbenzene (Cumene)	6.1	J	6.1	J	µg/kg	SWMU360-SB04-02	1/13	6U - 11U	6.1	NA	1.98E+05 N	N/A	N/A	NO	BSL
108-87-2	Methyl Cyclohexane	1.3	J	1.3	J	µg/kg	SWMU360-SB04-02	1/13	6U - 11U	1.3	NA	8.72E+05 N	N/A	N/A	NO	BSL
75-09-2	Methylene Chloride	2	J	6	J	µg/kg	SWMU360-TW01-01	3/13	7U - 11U	6	NA	2.05E+04 C	N/A	N/A	NO	BSL
127-18-4	Tetrachloroethene (PCE)	3.55	J	10	J	µg/kg	SWMU360-TW04-06	3/13	6U - 11U	10	NA	3.42E+03 C	N/A	N/A	NO	BSL
108-88-3	Toluene	9.7	J	9.7	J	µg/kg	SWMU360-SB04-02	1/13	6U - 11U	9.7	NA	2.20E+05 N	N/A	N/A	NO	BSL
79-01-6	Trichloroethene (TCE)	2	J	2	J	µg/kg	SWMU360-TW03-02	1/13	6U - 11U	2	NA	1.15E+02 C	N/A	N/A	NO	BSL
000000-01-4	Xylene, m/p-	230	J	230	J	µg/kg	SWMU360-SB04-02	1/9	11U - 11U	230	NA	9.00E+04 N <sup>(3)</sup>	N/A	N/A	NO	BSL
95-47-6	Xylene, o-	100	J	100	J	µg/kg	SWMU360-SB04-02	1/9	11U - 11U	100	NA	9.00E+04 N <sup>(3)</sup>	N/A	N/A	NO	BSL
	<b>SEMIVOLATILES (ug/kg)</b>															
1912-24-9	Atrazine	11	J	11	J	µg/kg	SWMU360-TW02-02	1/4	360U - 380U	11	NA	7.76E+03 C	N/A	N/A	NO	BSL
117-81-7	Bis(2-ethylhexyl) Phthalate (DEHP)	66	J	180	J	µg/kg	SWMU360-TW01-01	4/4	(4)	180	NA	1.23E+05 C	N/A	N/A	NO	BSL
117-84-0	Di-n-octyl Phthalate	23	J	27	J	µg/kg	SWMU360-TW01-01	2/4	370U - 380U	27	NA	2.46E+06 N	N/A	N/A	NO	BSL
206-44-0	Fluoranthene	25	J	25	J	µg/kg	SWMU360-TW01-01	1/4	370U - 380U	25	NA	2.20E+06 N	N/A	N/A	NO	BSL
	<b>PESTICIDES (ug/kg)</b>															
72-54-8	4,4'-DDD	0.76	J	49	J	µg/kg	SWMU360-TW01-01	2/37	3.5U - 4U	49	NA	9.95E+03 C	N/A	N/A	NO	BSL
72-55-9	4,4'-DDE	0.5	J	6.4	J	µg/kg	SWMU360-TW01-01	2/37	1.9U - 4U	6.4	NA	7.02E+03 C	N/A	N/A	NO	BSL
50-29-3	4,4'-DDT	1.6	J	3.3	J	µg/kg	SWMU360-TW01-01	2/37	3.5U - 5.7UJ	3.3	NA	7.02E+03 C	N/A	N/A	NO	BSL
319-85-7	BHC, beta-	1.4	J	1.4	J	µg/kg	SWMU360-TW04-06	1/37	1.8U - 9.2U	1.4	NA	1.26E+03 C	N/A	N/A	NO	BSL
5103-71-9	Chlordane, alpha-	0.29	J	0.29	J	µg/kg	SWMU360-TW02-02	1/37	1.8U - 9.2U	0.29	NA	6.47E+03 C <sup>(6)</sup>	N/A	N/A	NO	BSL
60-57-1	Dieldrin	4.1	J	4.1	J	µg/kg	SWMU360-TW01-01	1/37	1.9U - 4U	4.1	NA	1.08E+02 C	N/A	N/A	NO	BSL
	<b>METALS (mg/kg)</b>															
7440-38-2	Arsenic	0.39	J	2.2	J	mg/kg	SWMU360-SB08-01	16/37	0.25U - 0.68U	2.2	1.682	1.59E+00 C	N/A	N/A	YES	ASL
7440-39-3	Barium	2.6	J	29.4	J	mg/kg	SWMU360-SB10-03	36/37	4.7U - 4.7U	29.4	19.4	6.66E+03 N	N/A	N/A	NO	BSL
7440-43-9	Cadmium	0.11	J	0.58	J	mg/kg	SWMU360-SB03-01	2/37	0.03U - 0.28U	0.58	0.0588	4.51E+01 N	N/A	N/A	NO	BSL
7440-47-3	Chromium	1	J	14.7	J	mg/kg	SWMU360-SB04-06	27/37	0.13U - 4.5U	14.7	15.9	6.40E+01 C <sup>(7)</sup>	N/A	N/A	NO	BSL
7439-92-1	Lead	0.69	J	30.9	J	mg/kg	SWMU360-TW01-01	36/37	2.7U - 2.7U	30.9	10.59	7.50E+01 N	N/A	N/A	NO	BSL
7439-97-6	Mercury	0.03	J	0.07	J	mg/kg	SWMU360-TW01-01	2/37	0.02UJ - 0.12U	0.07	0.0392	3.10E+01 N <sup>(8)</sup>	N/A	N/A	NO	BSL
7782-49-2	Selenium	0.84	J	0.87	J	mg/kg	SWMU360-SB08-02	2/37	0.47U - 0.73UJ	0.87	0.492	5.11E+02 N	N/A	N/A	NO	BSL

- (1) MCB Camp Lejeune Base Background Study, Final (Baker, 2001): 2 \* Mean (1/2 nondetects) - AOC 7  
 (2) All non-carcinogenic criteria were divided by 10 to account for potential additive effects of chemicals  
 USEPA Region IX COC Screening Value (derived from USEPA Region IX PRG Table - October, 2002)  
 (3) Rationale Codes  
 Selection Reason: Above Screening Levels (ASL)  
 Deletion Reason: Below Screening Level (BSL)

Definitions: NA = Not Analyzed  
 ND = Not Detected  
 COPC = Chemical of Potential Concern  
 ARAR/TBC = Applicable or Relevant and Appropriate Requirement/To Be Considered

- (4) No detection limits given; analyte detected in every sample.  
 (5) Screening value for xylenes (total).  
 (6) Screening value for chlordane used as a surrogate.  
 (7) Screening value for chromium VI used.  
 (8) Screening values for mercuric chloride used as a surrogate.

J - Analyte present - Reported value is estimated  
 U - Not detected  
 C = Carcinogenic  
 N = Non-Carcinogenic  
 S = Soil Saturation  
 mg/kg = milligrams per kilogram  
 ug/kg = microgram per kilogram

TABLE 6-4  
 OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN  
 SWMU 360  
 RCRA FACILITY INVESTIGATION  
 MCB, CAMP LEJEUNE, NORTH CAROLINA

Scenario Timeframe: Future  
 Medium: Groundwater  
 Exposure Medium: Groundwater  
 Exposure Point: Groundwater

CAS Number	Chemical	Minimum Concentration	Minimum Qualifier	Maximum Concentration	Maximum Qualifier	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening	Background Value	Screening <sup>(1)</sup> Toxicity Value	Potential ARAR/TBC Value	Potential ARAR/TBC Source	COPC Flag	Rationale for <sup>(2)</sup> Contaminant Deletion or Selection
	<b>VOLATILES (ug/L)</b>															
120-82-1	1,2,4-Trichlorobenzene	2	J	2	J	µg/L	SWMU360-GW03	1/4	5U - 5U	2	NA	1.94E+01 N	70	MCL	NO	BSL
156-59-2	1,2-Dichloroethene (cis)	23		120		µg/L	SWMU360-GW04	4/4	(3)	120	NA	6.08E+00 N	70	MCL	YES	ASL
127-18-4	Tetrachloroethene (PCE)	27		89		µg/L	SWMU360-GW01	2/3	5U - 5U	89	NA	6.59E-01 C	5	MCL	YES	ASL
79-01-6	Trichloroethene (TCE)	5		75		µg/L	SWMU360-GW04	4/4	(3)	75	NA	2.80E-02 C	5	MCL	YES	ASL
	<b>SEMIVOLATILES (ug/L)</b>															
95-48-7	2-Methylphenol (o-Cresol)	1	J	1	J	µg/L	SWMU360-GW04	1/4	10U - 11U	1	NA	1.82E+02 N	35	NC DENR	NO	BSL
106-44-5	4-Methylphenol (p-Cresol)	2	J	4	J	µg/L	SWMU360-GW04	2/4	10U - 11U	4	NA	1.82E+01 N	3.5	NC DENR	NO	BSL
98-86-2	Acetophenone	1	J	1	J	µg/L	SWMU360-GW04	1/4	10U - 11U	1	NA	N/A	N/A	N/A	YES	NSC
86-73-7	Fluorene	0.9	J	0.9	J	µg/L	SWMU360-GW04	1/4	10U - 11U	0.9	NA	2.43E+01 N	280	NC DENR	NO	BSL
85-01-8	Phenanthrene	0.9	J	4	J	µg/L	SWMU360-GW04	2/4	10U - 11U	4	NA	1.83E+01 N <sup>(4)</sup>	210	NC DENR	NO	BSL
	<b>PESTICIDES (ug/L)</b>															
72-55-9	4,4'-DDE	0.24	J	0.24	J	µg/L	SWMU360-GW01	1/4	0.1U - 0.5UJ	0.24	NA	1.98E-01 C	N/A	N/A	YES	ASL
50-29-3	4,4'-DDT	0.11	J	0.11	J	µg/L	SWMU360-GW01	1/4	0.3U - 1.5U	0.11	NA	1.98E-01 C	0.1	NC DENR	NO	BSL
319-84-6	BHC, alpha-	0.015	J	0.015	J	µg/L	SWMU360-GW02	1/4	0.05UJ - 0.25U	0.015	NA	1.07E-02 C	0.019	NC DENR	YES	ASL
319-85-7	BHC, beta-	1.6	J	1.6	J	µg/L	SWMU360-GW04	1/4	0.1UJ - 0.1UJ	1.6	NA	3.74E-02 C	0.019	NC DENR	YES	ASL
319-86-8	BHC, delta-	0.18	J	0.19	J	µg/L	SWMU360-GW01	2/4	0.05UJ - 0.05UJ	0.19	NA	3.74E-02 C <sup>(5)</sup>	0.019	NC DENR	YES	ASL
58-89-9	BHC, gamma- (Lindane)	0.1	J	0.1	J	µg/L	SWMU360-GW01	1/4	0.05U - 0.25U	0.1	NA	5.17E-02 C	0.2	MCL <sup>(6)</sup>	YES	ASL
5103-71-9	Chlordane, alpha-	0.088	J	0.088	J	µg/L	SWMU360-GW01	1/4	0.1U - 0.5U	0.088	NA	1.92E-01 C <sup>(6)</sup>	2	MCL <sup>(6)</sup>	NO	BSL
5103-74-2	Chlordane, gamma-	0.1	J	0.1	J	µg/L	SWMU360-GW01	1/4	0.05U - 0.25U	0.1	NA	1.92E-01 C <sup>(6)</sup>	2	MCL <sup>(6)</sup>	NO	BSL
309-00-2	Aldrin	0.14	J	0.14	J	µg/L	SWMU360-GW01	1/4	0.05U - 0.25U	0.14	NA	3.95E-03 C	N/A	N/A	YES	ASL
76-44-8	Heptachlor	0.088	J	0.088	J	µg/L	SWMU360-GW01	1/4	0.05U - 0.25U	0.088	NA	1.49E-02 C	0.4	MCL	YES	ASL
1024-57-3	Heptachlor Epoxide	0.13	J	0.45	J	µg/L	SWMU360-GW04	2/4	0.05U - 0.05U	0.45	NA	7.39E-03 C	0.2	MCL	YES	ASL
	<b>METALS (ug/L)</b>															
7440-38-2	Arsenic	2.6	J	2.6	J	µg/L	SWMU360-GW02	1/4	2U - 2U	2.6	NA	4.48E-02 C	10	MCL	YES	ASL
7440-39-3	Barium	42.1		60.8		µg/L	SWMU360-GW01	4/4	(3)	60.8	NA	2.55E+02 N	2000	MCL	NO	BSL
7440-47-3	Chromium	1.3	J	7.6	J	µg/L	SWMU360-GW02	2/4	0.5UJ - 0.5UJ	7.6	NA	1.09E+01 N <sup>(7)</sup>	100	MCL	NO	BSL

(1) All non-carcinogenic RBCs were divided by 10 to account for potential additive effects of chemicals  
 USEPA Region IX COC Screening Value (derived from USEPA Region IX PRG Table - October, 2002)

(2) Rationale Codes Selection Reason: No Screening Criteria (NSC)  
 Above Screening Levels (ASL)  
 Deletion Reason: Below Screening Level (BSL)

(3) No detection limits given; analyte detected in every sample.  
 (4) Screening value for pyrene used as a surrogate.  
 (5) Screening values for technical-BHC used as a surrogate.  
 (6) Screening value for chlordane used as a surrogate.  
 (7) Screening value for chromium VI used.

Definitions: N/A = Not Applicable  
 NA = Not Analyzed  
 COPC = Chemical of Potential Concern  
 ARAR/TBC = Applicable or Relevant and Appropriate Requirement/To Be Considered

J - Analyte present - Reported value is estimated  
 U - Not detected  
 UJ - Reported quantitation limit is qualified as estimated

C = Carcinogenic ug/L = microgram per liter  
 N = Non-Carcinogenic

MCL = Maximum Contaminant Level  
 NC DENR = North Carolina Department of Environment and Natural Resources

TABLE 6-5  
 OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN  
 SWMU 360  
 RCRA FACILITY INVESTIGATION  
 MCB, CAMP LEJEUNE, NORTH CAROLINA

Scenario Timeframe: Future  
 Medium: Groundwater  
 Exposure Medium: Groundwater  
 Exposure Point: Groundwater

CAS Number	Chemical	Minimum Concentration	Minimum Qualifier	Maximum Concentration	Maximum Qualifier	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening	Background Value	Screening (1) Toxicity Value	Potential ARAR/TBC Value	Potential ARAR/TBC Source	COPC Flag	Rationale for (2) Contaminant Deletion or Selection
	<b>VOLATILES (ug/L)</b>															
120-82-1	1,2,4-Trichlorobenzene	2	J	2	J	µg/L	SWMU360-GW03	1/4	5U - 5U	2	NA	7.00E+01	70	MCL	NO	BSL
156-59-2	1,2-Dichloroethene (cis)	23		120		µg/L	SWMU360-GW04	4/4	(3)	120	NA	7.00E+01	70	MCL	YES	ASL
127-18-4	Tetrachloroethene (PCE)	27		89		µg/L	SWMU360-GW01	2/3	5U - 5U	89	NA	7.00E-01	5	MCL	YES	ASL
79-01-6	Trichloroethene (TCE)	5		75		µg/L	SWMU360-GW04	4/4	(3)	75	NA	2.80E+00	5	MCL	YES	ASL
	<b>SEMIVOLATILES (ug/L)</b>															
95-48-7	2-Methylphenol (o-Cresol)	1	J	1	J	µg/L	SWMU360-GW04	1/4	10U - 11U	1	NA	3.50E+01	35	NC DENR	NO	BSL
106-44-5	4-Methylphenol (p-Cresol)	2	J	4	J	µg/L	SWMU360-GW04	2/4	10U - 11U	4	NA	3.50E+00	3.5	NC DENR	YES	ASL
98-86-2	Acetophenone	1	J	1	J	µg/L	SWMU360-GW04	1/4	10U - 11U	1	NA	N/A	N/A	N/A	YES	NSC
86-73-7	Fluorene	0.9	J	0.9	J	µg/L	SWMU360-GW04	1/4	10U - 11U	0.9	NA	2.80E+02	280	NC DENR	NO	BSL
85-01-8	Phenanthrene	0.9	J	4	J	µg/L	SWMU360-GW04	2/4	10U - 11U	4	NA	2.10E+02	210	NC DENR	NO	BSL
	<b>PESTICIDES (ug/L)</b>															
72-55-9	4,4'-DDE	0.24	J	0.24	J	µg/L	SWMU360-GW01	1/4	0.1U - 0.5UJ	0.24	NA	N/A	N/A	N/A	YES	NSC
50-29-3	4,4'-DDT	0.11	J	0.11	J	µg/L	SWMU360-GW01	1/4	0.3U - 1.5U	0.11	NA	1.00E-01	0.1	NC DENR	YES	ASL
319-84-6	BHC, alpha	0.015	J	0.015	J	µg/L	SWMU360-GW02	1/4	0.05UJ - 0.25U	0.015	NA	1.90E-02	0.019	NC DENR	NO	BSL
319-85-7	BHC, beta	1.6	J	1.6	J	µg/L	SWMU360-GW04	1/4	0.1UJ - 0.1UJ	1.6	NA	1.90E-02	0.019	NC DENR	YES	ASL
319-86-8	BHC, delta	0.18	J	0.19	J	µg/L	SWMU360-GW01	2/4	0.05UJ - 0.05UJ	0.19	NA	1.90E-02	0.019	NC DENR	YES	ASL
58-89-9	BHC, gamma (Lindane)	0.1	J	0.1	J	µg/L	SWMU360-GW01	1/4	0.05U - 0.25U	0.1	NA	2.00E-01	0.2	MCL	NO	BSL
5103-71-9	Chlordane, alpha	0.088	J	0.088	J	µg/L	SWMU360-GW01	1/4	0.1U - 0.5U	0.088	NA	2.70E-02	2	MCL (5)	YES	ASL
5103-74-2	Chlordane, gamma	0.1	J	0.1	J	µg/L	SWMU360-GW01	1/4	0.05U - 0.25U	0.1	NA	2.70E-02	2	MCL (5)	YES	ASL
309-00-2	Aldrin	0.14	J	0.14	J	µg/L	SWMU360-GW01	1/4	0.05U - 0.25U	0.14	NA	N/A	N/A	N/A	YES	NSC
76-44-8	Heptachlor	0.088	J	0.088	J	µg/L	SWMU360-GW01	1/4	0.05U - 0.25U	0.088	NA	8.00E-03	0.4	MCL	YES	ASL
1024-57-3	Heptachlor Epoxide	0.13	J	0.45	J	µg/L	SWMU360-GW04	2/4	0.05U - 0.05U	0.45	NA	4.00E-03	0.2	MCL	YES	ASL
	<b>METALS (ug/L)</b>															
7440-38-2	Arsenic	2.6	J	2.6	J	µg/L	SWMU360-GW02	1/4	2U - 2U	2.6	NA	1.00E+01	10	MCL	NO	BSL
7440-39-3	Barium	42.1		60.8		µg/L	SWMU360-GW01	4/4	(3)	60.8	NA	2.00E+03	2000	MCL	NO	BSL
7440-47-3	Chromium	1.3	J	7.6		µg/L	SWMU360-GW02	2/4	0.5UJ - 0.5UJ	7.6	NA	5.00E+01	100	MCL	NO	BSL

(1) North Carolina Department of Environment and Natural Resources (NC DENR) Target Groundwater Concentration

(2) Rationale Codes Selection Reason: No Screening Criteria (NSC) Above Screening Levels (ASL) Deletion Reason: Below Screening Level (BSL)

(3) No detection limits given; analyte detected in every sample.

Definitions: N/A = Not Applicable  
 NA = Not Analyzed  
 COPC = Chemical of Potential Concern  
 ARAR/TBC = Applicable or Relevant and Appropriate Requirement/To Be Considered

MCL = Maximum Contaminant Level  
 NC DENR = North Carolina Department of Environment and Natural Resource

J - Analyte present - Reported value is estimated  
 U - Not detected  
 UJ - Reported quantitation limit is qualified as estimated

µg/L = microgram per liter





TABLE 6-8  
VALUES USED FOR DAILY INTAKE CALCULATIONS  
SWMU 360  
RCRA FACILITY INVESTIGATION  
MCB, CAMP LEJEUNE, NORTH CAROLINA

Scenario Timeframe: Future
Medium: Subsurface Soil
Exposure Medium: Subsurface Soil
Exposure Point: Subsurface Soil
Receptor Population: Residents
Receptor Age: Adult

Exposure Route	Parameter Code	Parameter Definition	Units	RME Value	RME Rationale/Reference	CT Value	CT Rationale/Reference	Intake Equation/Model Name
Ingestion	C	Contaminant Concentration in Soil	mg/kg	Chemical Specific	Chemical Specific	Chemical Specific	Chemical Specific	Chronic Daily Intake (CDI) (mg/kg-day) = $C \times IR \times CF \times Fi \times EF \times ED \times 1/BW \times 1/AT$
	IR-S	Ingestion Rate of Soil	mg/day	100	USEPA, 1993	50	USEPA, 1993	
	CF	Conversion Factor	kg/mg	1.00E-06	USEPA, 1989	1.00E-06	USEPA, 1989	
	FI	Fraction Ingested from Source	NA	1	Prof Judge	1	Prof Judge	
	EF	Exposure Frequency	days/year	350	USEPA, 2001	234	USEPA, 1993	
	ED	Exposure Duration	years	24	USEPA, 1993	7	USEPA, 1993	
	BW	Body Weight	kg	70	USEPA, 1997	70	USEPA, 1997	
	AT-C	Averaging Time (Cancer)	days	25,550	USEPA, 1989	25,550	USEPA, 1989	
	AT-N	Averaging Time (Non-Cancer)	days	8,760	USEPA, 1989	2,555	USEPA, 1989	
Dermal	C	Contaminant Concentration in Soil	mg/kg	Chemical Specific	Chemical Specific	Chemical Specific	Chemical Specific	CDI (mg/kg-day) = $C \times CF \times SA \times AF \times ABS \times EF \times ED \times 1/BW \times 1/AT$
	CF	Conversion Factor	kg/mg	1.00E-06	USEPA, 1989	1.00E-06	USEPA, 1989	
	SA	Surface Area Available for Contact	cm <sup>2</sup> /day	5,700	USEPA, 2001	5,700	USEPA, 2001	
	AF	Soil to Skin Adherence Factor	mg/cm <sup>2</sup>	0.07	USEPA, 2001	0.01	USEPA, 2001	
	ABS	Absorption Factor	NA	(1)	USEPA, 2001	(1)	USEPA, 2001	
	EF	Exposure Frequency	days/year	350	USEPA, 2001	234	USEPA, 1993	
	ED	Exposure Duration	years	24	USEPA, 1993	7	USEPA, 1993	
	BW	Body Weight	kg	70	USEPA, 1997	70	USEPA, 1997	
	AT-C	Averaging Time (Cancer)	days	25,550	USEPA, 1989	25,550	USEPA, 1989	
	AT-N	Averaging Time (Non-Cancer)	days	8,760	USEPA, 1989	2,555	USEPA, 1989	

Notes

(1) In the absence of USEPA RAGS Part E ABS values, USEPA Region IV default values of 0.01% organics and 0.001% for inorganics were used.

Prof Judge - Professional Judgment

Sources:

USEPA, 1989: Risk Assessment Guidance for Superfund Vol 1, Human Health Evaluation Manual, Part A. OERR. EPA/540/1-89/002.

USEPA, 1993: "Superfund's Standard Default Exposure Factors for the Central Tendency and Reasonable Maximum Exposure." November, 1993.

USEPA, 1997: Exposure Factors Handbook. Vol. 1: General Factors. ORD. EPA/600/P-95/002Fa.

USEPA, 2001: Risk Assessment Guidance for Superfund Vol 1, Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment). EPA/540/R-99/005.

TABLE 6-8s  
VALUES USED FOR DAILY INTAKE CALCULATIONS  
SWMU 360  
RCRA FACILITY INVESTIGATION  
MCB, CAMP LEJEUNE, NORTH CAROLINA

Scenario Timeframe: Future
Medium: Subsurface Soil
Exposure Medium: Air
Exposure Point: Fugative dust
Receptor Population: Residents
Receptor Age: Adult

Exposure Route	Parameter Code	Parameter Definition	Units	RME Value	RME Rationale/Reference	CT Value	CT Rationale/Reference	Intake Equation/Model Name
Inhalation	C	Contaminant Concentration in Soil	mg/kg	Chemical Specific	Chemical Specific	Chemical Specific	Chemical Specific	$CDI (mg/kg-day) = C \times IR \times ET \times EF \times ED \times 1/PEF \times 1/BW \times 1/AT$
	RR	Respiration Rate	m3/hour	0.55	USEPA, 1997	0.55	USEPA, 1997	
	ET	Exposure Time	hours/day	1.5	USEPA, 1997	1.5	USEPA, 1997	
	EF	Exposure Frequency	days/year	350	USEPA, 2001	234	USEPA, 1993	
	ED	Exposure Duration	years	24	USEPA, 1993	7	USEPA, 1993	
	PEF	Particulate Emission Factor	m3/kg	1.32E+09	Cowherd, et al., 1995	1.32E+09	Cowherd, et al., 1995	
	BW	Body Weight	kg	70	USEPA, 1997	70	USEPA, 1997	
	AT-C	Averaging Time (Cancer)	days	25,550	USEPA, 1989	25,550	USEPA, 1989	
	AT-N	Averaging Time (Non-Cancer)	days	8,760	USEPA, 1989	2,555	USEPA, 1989	

Notes

(1) In the absence of USEPA RAGS Part E ABS values, USEPA Region IV default values of 0.01% organics and 0.001% for inorganics were used.

Sources:

- Cowherd, et al., 1995: Rapid Assessment of Exposure to Particulate Emissions from Surface Contamination. OHEA. EPA/600/8-85/002.  
USEPA, 1989: Risk Assessment Guidance for Superfund Vol 1, Human Health Evaluation Manual, Part A. OERR. EPA/540/1-89/002.  
USEPA, 1993: "Superfund's Standard Default Exposure Factors for the Central Tendency and Reasonable Maximum Exposure." November, 1993.  
USEPA, 1997: Exposure Factors Handbook. Vol. 1: General Factors. ORD. EPA/600/P-95/002Fa.  
USEPA, 2001: Risk Assessment Guidance for Superfund Vol 1, Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment). EPA/540/R-99/005.

TABLE 6-9  
VALUES USED FOR DAILY INTAKE CALCULATION:  
SWMU 360  
RCRA FACILITY INVESTIGATION  
MCB, CAMP LEJEUNE, NORTH CAROLINA

Scenario Timeframe: Future  
Medium: Groundwater  
Exposure Medium: Groundwater  
Exposure Point: Tap Water - Drinking Water Scenic  
Receptor Population: Residents  
Receptor Age: Adult

Exposure Route	Parameter Code	Parameter Definition	Units	RME Value	RME Rationale/ Reference	CT Value	CT Rationale/ Reference	Intake Equation/ Model Name
Ingestion	C	Contaminant Concentration in Groundwater	mg/L	Chemical Specific	Chemical Specific	Chemical Specific	Chemical Specific	Chronic Daily Intake (CDI) (mg/kg-day) = $C \times IR-W \times EF \times ED \times 1/BW \times 1/AT$
	IR-W	Ingestion Rate of Groundwater	L/day	2	USEPA, 1993	1.4	USEPA, 1993	
	EF	Exposure Frequency	days/year	350	USEPA, 1993	234	USEPA, 1993	
	ED	Exposure Duration	years	24	USEPA, 2001	7	USEPA, 2001	
	BW	Body Weight	kg	70	USEPA, 1997	70	USEPA, 1997	
	AT-C	Averaging Time (Cancer)	days	25,550	USEPA, 1989	25,550	USEPA, 1989	
AT-N	Averaging Time (Non-Cancer)	days	8,760	USEPA, 1989	2,555	USEPA, 1989		
Dermal	C	Contaminant Concentration in Groundwater	mg/L	Chemical Specific	Chemical Specific	Chemical Specific	Chemical Specific	DAD (mg/kg-day) =  Inorganics $(C \times CF \times K_p \times SA \times EF \times ED \times ET) / (BW \times AT)$  Organics: $ET \leq t^*$ $(C \times CF \times (2 \times K_p \times \text{SQRT}(6 \times \text{tau} \times ET / \pi))) \times SA \times EF \times ED) / (BW \times AT)$  Organics: $ET > t^*$ $(C \times CF \times (K_p \times (ET / (1+B) + 2 \times \text{tau} \times ((1+3 \times B) / (1+B)))) \times SA \times EF \times ED) / (BW \times AT)$
	CF	Conversion Factor	L/cm3	1.00E-03	USEPA, 1989	1.00E-03	USEPA, 1989	
	SA	Surface Area Available for Contact	cm2	18,000	USEPA, 2001	18,000	USEPA, 2001	
	PC	Permeability Constant	cm/hour	Chemical Specific	USEPA, 1992	Chemical Specific	USEPA, 1992	
	tau	Lag Time	hour	Chemical Specific	USEPA, 2004	Chemical Specific	USEPA, 2004	
	t*	Time to Reach Steady State	hour	Chemical Specific	USEPA, 2004	Chemical Specific	USEPA, 2004	
	B	Permeability Coefficient of a Compound	NA	Chemical Specific	USEPA, 2004	Chemical Specific	USEPA, 2004	
	ET	Exposure Time	hours/day	0.58	USEPA, 2001	0.25	USEPA, 2001	
	EF	Exposure Frequency	days/year	350	USEPA, 1993	234	USEPA, 1993	
	ED	Exposure Duration	years	24	USEPA, 2001	7	USEPA, 2001	
	BW	Body Weight	kg	70	USEPA, 1997	70	USEPA, 1997	
	AT-C	Averaging Time (Cancer)	days	25,550	USEPA, 1989	25,550	USEPA, 1989	
	AT-N	Averaging Time (Non-Cancer)	days	8,760	USEPA, 1989	2,555	USEPA, 1989	

Sources:

- USEPA, 1989: Risk Assessment Guidance for Superfund Vol 1, Human Health Evaluation Manual, Part A. OERR. EPA/540/1-89/00.  
USEPA, 1992: Risk Assessment Guidance for Superfund Vol 1, Human Health Evaluation Manual Supplemental Guidance: Dermal Risk Assessment  
USEPA, 1993: "Superfund's Standard Default Exposure Factors for the Central Tendency and Reasonable Maximum Exposure." November, 199  
USEPA, 1997: Exposure Factors Handbook. Vol. 1: General Factors. ORD. EPA/600/P-95/002Fa

TABLE 6-9a  
VALUES USED FOR DAILY INTAKE CALCULATION:  
SWMU 360  
RCRA FACILITY INVESTIGATION  
MCB, CAMP LEJEUNE, NORTH CAROLINA

Scenario Timeframe: Future  
Medium: Groundwater  
Exposure Medium: Air  
Exposure Point: Tap  
Receptor Population: Residents  
Receptor Age: Adult

Exposure Route	Parameter Code	Parameter Definition	Units	RME Value	RME Rationale/ Reference	CT Value	CT Rationale/ Reference	Intake Equation/ Model Name
Inhalation	C	Contaminant Concentration in Groundwater	mg/L	Chemical Specific	Chemical Specific	Chemical Specific	Chemical Specific	Chronic Daily Intake (CDI) (mg/kg-day) = $C \times IR-W \times EF \times ED \times 1/BW \times 1/AT$
	IR-W	Ingestion Rate of Groundwater	L/day	2	USEPA, 1993	1.4	USEPA, 1993	
	EF	Exposure Frequency	days/year	350	USEPA, 1993	234	USEPA, 1993	
	ED	Exposure Duration	years	24	USEPA, 2001	7	USEPA, 2001	
	BW	Body Weight	kg	70	USEPA, 1997	70	USEPA, 1997	
	AT-C	Averaging Time (Cancer)	days	25,550	USEPA, 1989	25,550	USEPA, 1989	
	AT-N	Averaging Time (Non-Cancer)	days	8,760	USEPA, 1989	2,555	USEPA, 1989	

Sources:

USEPA, 1989: Risk Assessment Guidance for Superfund Vol 1, Human Health Evaluation Manual, Part A. OERR. EPA/540/1-89/00;  
USEPA, 1993: "Superfund's Standard Default Exposure Factors for the Central Tendency and Reasonable Maximum Exposure." November, 199  
USEPA, 1997: Exposure Factors Handbook. Vol. 1: General Factors. ORD. EPA/600/P-95/002F;

TABLE 6-10  
VALUES USED FOR DAILY INTAKE CALCULATION:  
SWMU 360  
RCRA FACILITY INVESTIGATION  
MCB, CAMP LEJEUNE, NORTH CAROLINA

Scenario Timeframe: Future
Medium: Subsurface Soil
Exposure Medium: Subsurface Soil
Exposure Point: Subsurface Soil
Receptor Population: Residents
Receptor Age: Young Child

Exposure Route	Parameter Code	Parameter Definition	Units	RME Value	RME Rationale/Reference	CT Value	CT Rationale/Reference	Intake Equation/Model Name
Ingestion	C	Contaminant Concentration in Soil	mg/kg	Chemical Specific	Chemical Specific	Chemical Specific	Chemical Specific	Chronic Daily Intake (CDI) (mg/kg-day) = $C \times IR \times CF \times Fi \times EF \times ED \times I/BW \times I/AT$
	IR-S	Ingestion Rate of Soil	mg/day	200	USEPA, 1993	100	USEPA, 1993	
	CF	Conversion Factor	kg/mg	1.00E-06	USEPA, 1989	1.00E-06	USEPA, 1989	
	FI	Fraction Ingested from Source	NA	1	Prof Judge	1	Prof Judge	
	EF	Exposure Frequency	days/year	350	USEPA, 2001	234	USEPA, 1993	
	ED	Exposure Duration	years	6	USEPA, 1993	2	USEPA, 1993	
	BW	Body Weight	kg	15	USEPA, 1997	15	USEPA, 1997	
	AT-C	Averaging Time (Cancer)	days	25,550	USEPA, 1989	25,550	USEPA, 1989	
AT-N	Averaging Time (Non-Cancer)	days	2,190	USEPA, 1989	730	USEPA, 1989		
Dermal	C	Contaminant Concentration in Soil	mg/kg	Chemical Specific	Chemical Specific	Chemical Specific	Chemical Specific	CDI (mg/kg-day) = $C \times CF \times SA \times AF \times ABS \times EF \times ED \times I/BW \times I/AT$
	CF	Conversion Factor	kg/mg	1.00E-06	USEPA, 1989	1.00E-06	USEPA, 1989	
	SA	Surface Area Available for Contact	cm <sup>2</sup> /day	2,800	USEPA, 2001	2,800	USEPA, 2001	
	AF	Soil to Skin Adherence Factor	mg/cm <sup>2</sup>	0.2	USEPA, 2001	0.04	USEPA, 2001	
	ABS	Absorption Factor	NA	(1)	USEPA, 2001	(1)	USEPA, 2001	
	EF	Exposure Frequency	days/year	350	USEPA, 2001	234	USEPA, 1993	
	ED	Exposure Duration	years	6	USEPA, 1993	2	USEPA, 1993	
	BW	Body Weight	kg	15	USEPA, 1997	15	USEPA, 1997	
AT-C	Averaging Time (Cancer)	days	25,550	USEPA, 1989	25,550	USEPA, 1989		
AT-N	Averaging Time (Non-Cancer)	days	2,190	USEPA, 1989	730	USEPA, 1989		

Notes

(1) In the absence of USEPA RAGS Part E ABS values, USEPA Region IV default values of 0.01% organics and 0.001% for inorganics were used.

Prof Judge - Professional Judgment

Sources:

USEPA, 1989: Risk Assessment Guidance for Superfund Vol 1, Human Health Evaluation Manual, Part A. OERR. EPA/540/1-89/002.

USEPA, 1993: "Superfund's Standard Default Exposure Factors for the Central Tendency and Reasonable Maximum Exposure." November, 1993.

USEPA, 1997: Exposure Factors Handbook. Vol. 1: General Factors. ORD. EPA/600/P-95/002Fa.

USEPA, 2001: Risk Assessment Guidance for Superfund Vol 1, Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment). EPA/540/R-99/005.

TABLE 6-10a  
VALUES USED FOR DAILY INTAKE CALCULATIONS  
SWMU 360  
RCRA FACILITY INVESTIGATION  
MCB, CAMP LEJEUNE, NORTH CAROLINA

Scenario Timeframe: Future
Medium: Subsurface Soil
Exposure Medium: Air
Exposure Point: Fugative dust
Receptor Population: Residents
Receptor Age: Young Child

Exposure Route	Parameter Code	Parameter Definition	Units	RME Value	RME Rationale/ Reference	CT Value	CT Rationale/ Reference	Intake Equation/ Model Name
Inhalation	C	Contaminant Concentration in Soil	mg/kg	Chemical Specific	Chemical Specific	Chemical Specific	Chemical Specific	$CDI \text{ (mg/kg-day)} = \frac{C \times IR \times ET \times EF \times ED \times 1}{PEF \times 1/BW \times 1/AT}$
	RR	Respiration Rate	m <sup>3</sup> /hour	0.308	USEPA, 1997	0.308	USEPA, 1997	
	ET	Exposure Time	hours/day	5.57	USEPA, 1997	5.57	USEPA, 1997	
	EF	Exposure Frequency	days/year	350	USEPA, 2001	234	USEPA, 1993	
	ED	Exposure Duration	years	6	USEPA, 1993	2	USEPA, 1993	
	PEF	Particulate Emission Factor	m <sup>3</sup> /kg	1.32E+09	Cowherd, et al., 1995	1.32E+09	Cowherd, et al., 1995	
	BW	Body Weight	kg	15	USEPA, 1997	15	USEPA, 1997	
	AT-C	Averaging Time (Cancer)	days	25,550	USEPA, 1989	25,550	USEPA, 1989	
AT-N	Averaging Time (Non-Cancer)	days	2,190	USEPA, 1989	730	USEPA, 1989		

Notes

(1) In the absence of USEPA RAGS Part E ABS values, USEPA Region IV default values of 0.01% organics and 0.001% for inorganics were used.

Sources:

Cowherd, et al., 1995: Rapid Assessment of Exposure to Particulate Emissions from Surface Contamination. OHEA. EPA/600/8-85/002.  
 USEPA, 1989: Risk Assessment Guidance for Superfund Vol 1, Human Health Evaluation Manual, Part A. OERR. EPA/540/1-89/002.  
 USEPA, 1993: "Superfund's Standard Default Exposure Factors for the Central Tendency and Reasonable Maximum Exposure." November, 1993.  
 USEPA, 1997: Exposure Factors Handbook. Vol. 1: General Factors. ORD. EPA/600/P-95/002Fa.  
 USEPA, 2001: Risk Assessment Guidance for Superfund Vol 1, Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment). EPA/540/R-99/005.

TABLE 6-11  
VALUES USED FOR DAILY INTAKE CALCULATION:  
SWMU 360  
RCRA FACILITY INVESTIGATION  
MCB, CAMP LEJEUNE, NORTH CAROLINA

Scenario Timeframe: Future  
Medium: Groundwater  
Exposure Medium: Groundwater  
Exposure Point: Tap Water - Drinking Water Scenario  
Receptor Population: Residents  
Receptor Age: Young Child

Exposure Route	Parameter Code	Parameter Definition	Units	RME Value	RME Rationale/ Reference	CT Value	CT Rationale/ Reference	Intake Equation/ Model Name
Ingestion	C	Contaminant Concentration in Groundwater	mg/L	Chemical Specific	Chemical Specific	Chemical Specific	Chemical Specific	Chronic Daily Intake (CDI) (mg/kg-day) = $C \times IR-W \times EF \times ED \times 1/BW \times 1/AT$
	IR-W	Ingestion Rate of Groundwater	L/day	1	USEPA, 1989	1	USEPA, 1989	
	EF	Exposure Frequency	days/year	350	USEPA, 1993	234	USEPA, 1993	
	ED	Exposure Duration	years	6	USEPA, 2001	2	USEPA, 1993	
	BW	Body Weight	kg	15	USEPA, 1997	15	USEPA, 1997	
	AT-C	Averaging Time (Cancer)	days	25,550	USEPA, 1989	25,550	USEPA, 1989	
AT-N	Averaging Time (Non-Cancer)	days	2,190	USEPA, 1989	730	USEPA, 1989		
Dermal	C	Contaminant Concentration in Groundwater	mg/L	Chemical Specific	Chemical Specific	Chemical Specific	Chemical Specific	DAD (mg/kg-day) =  Inorganics $(C * CF * Kp * SA * EF * ED * ET) / (BW * AT)$  Organics: $ET \leq t^*$ $(C * CF * (2 * Kp * \sqrt{6 * \tau * ET / \pi}) * SA * EF * ED) / (BW * AT)$  Organics: $ET > t^*$ $(C * CF * (Kp * (ET / (1 + B) + 2 * \tau * ((1 + 3 * B) / (1 + B)))) * SA * EF * ED) / (BW * AT)$
	CF	Conversion Factor	L/cm <sup>3</sup>	1.00E-03	USEPA, 1989	1.00E-03	USEPA, 1989	
	SA	Surface Area Available for Contact	cm <sup>2</sup>	6,600	USEPA, 2001	6,600	USEPA, 2001	
	PC	Permeability Constant	cm/hour	Chemical Specific	USEPA, 1992	Chemical Specific	USEPA, 1992	
	tau	Lag Time	hour	Chemical Specific	USEPA, 2004	Chemical Specific	USEPA, 2004	
	t*	Time to Reach Steady State	hour	Chemical Specific	USEPA, 2004	Chemical Specific	USEPA, 2004	
	B	Permeability Coefficient of a Compound	NA	Chemical Specific	USEPA, 2004	Chemical Specific	USEPA, 2004	
	ET	Exposure Time	hours/day	1	USEPA, 2001	0.33	USEPA, 2001	
	EF	Exposure Frequency	days/year	350	USEPA, 1993	234	USEPA, 1993	
	ED	Exposure Duration	years	6	USEPA, 2001	2	USEPA, 1993	
	BW	Body Weight	kg	15	USEPA, 1997	15	USEPA, 1997	
	AT-C	Averaging Time (Cancer)	days	25,550	USEPA, 1989	25,550	USEPA, 1989	
	AT-N	Averaging Time (Non-Cancer)	days	2,190	USEPA, 1989	730	USEPA, 1989	

Notes

Sources:

USEPA, 1989: Risk Assessment Guidance for Superfund Vol 1, Human Health Evaluation Manual, Part A. OERR. EPA/540/1-89/00:  
USEPA, 1992: Risk Assessment Guidance for Superfund Vol 1, Human Health Evaluation Manual Supplemental Guidance: Dermal Risk Assessment  
USEPA, 1993: "Superfund's Standard Default Exposure Factors for the Central Tendency and Reasonable Maximum Exposure." November, 199  
USEPA, 1997: Exposure Factors Handbook. Vol. 1: General Factors. ORD. EPA/600/P-95/002Fa

TABLE 6-12  
VALUES USED FOR DAILY INTAKE CALCULATIONS  
SWMU 360  
RCRA FACILITY INVESTIGATION  
MCB, CAMP LEJEUNE, NORTH CAROLINA

Scenario Timeframe: Future
Medium: Subsurface Soil
Exposure Medium: Subsurface Soil
Exposure Point: Subsurface Soil
Receptor Population: Construction Workers
Receptor Age: Adult

Exposure Route	Parameter Code	Parameter Definition	Units	RME Value	RME Rationale/Reference	CT Value	CT Rationale/Reference	Intake Equation/Model Name
Ingestion	C	Contaminant Concentration in Soil	mg/kg	Chemical Specific	Chemical Specific	--	--	Chronic Daily Intake (CDI) (mg/kg-day) = $C \times IR \times CF \times Fi \times EF \times ED \times 1/BW \times 1/AT$
	IR-S	Ingestion Rate of Soil	mg/day	480	USEPA, 1993	--	--	
	CF	Conversion Factor	kg/mg	1.00E-06	USEPA, 1989	--	--	
	FI	Fraction Ingested from Source	NA	1	Prof Judge	--	--	
	EF	Exposure Frequency	days/year	250	USEPA, 2001	--	--	
	ED	Exposure Duration	years	1	Prof Judge	--	--	
	BW	Body Weight	kg	70	USEPA, 1997	--	--	
	AT-C	Averaging Time (Cancer)	days	25,550	USEPA, 1989	--	--	
	AT-N	Averaging Time (Non-Cancer)	days	365	USEPA, 1989	--	--	
Dermal	C	Contaminant Concentration in Soil	mg/kg	Chemical Specific	Chemical Specific	--	--	CDI (mg/kg-day) = $C \times CF \times SA \times AF \times ABS \times EF \times ED \times 1/BW \times 1/AT$
	CF	Conversion Factor	kg/mg	1.00E-06	USEPA, 1989	--	--	
	SA	Surface Area Available for Contact	cm <sup>2</sup> /day	3,300	USEPA, 2001	--	--	
	AF	Soil to Skin Adherence Factor	mg/cm <sup>2</sup>	0.2	USEPA, 2001	--	--	
	ABS	Absorption Factor	NA	(1)	USEPA, 2001	--	--	
	EF	Exposure Frequency	days/year	250	USEPA, 2001	--	--	
	ED	Exposure Duration	years	1	Prof Judge	--	--	
	BW	Body Weight	kg	70	USEPA, 1997	--	--	
	AT-C	Averaging Time (Cancer)	days	25,550	USEPA, 1989	--	--	
	AT-N	Averaging Time (Non-Cancer)	days	365	USEPA, 1989	--	--	

Notes

(1) In the absence of USEPA RAGS Part E ABS values, USEPA Region IV default values of 0.01% organics and 0.001% for inorganics were used.

Prof Judge - Professional Judgment

Sources:

USEPA, 1989: Risk Assessment Guidance for Superfund Vol 1, Human Health Evaluation Manual, Part A. OERR. EPA/540/1-89/002.

USEPA, 1993: "Superfund's Standard Default Exposure Factors for the Central Tendency and Reasonable Maximum Exposure." November, 1993.

USEPA, 1997: Exposure Factors Handbook. Vol. 1: General Factors. ORD. EPA/600/P-95/002Fa.

USEPA, 2001: Risk Assessment Guidance for Superfund Vol 1, Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment). EPA/540/R-99/005.

TABLE 6-12a  
VALUES USED FOR DAILY INTAKE CALCULATIONS  
SWMU 360  
RCRA FACILITY INVESTIGATION  
MCB, CAMP LEJEUNE, NORTH CAROLINA

Scenario Timeframe: Future
Medium: Subsurface Soil
Exposure Medium: Air
Exposure Point: Fugative dust
Receptor Population: Construction Workers
Receptor Age: Adult

Exposure Route	Parameter Code	Parameter Definition	Units	RME Value	RME Rationale/Reference	CT Value	CT Rationale/Reference	Intake Equation/Model Name
Inhalation	C	Contaminant Concentration in Soil	mg/kg	Chemical Specific	Chemical Specific	--	--	$CDI (mg/kg\text{-}day) = C \times IR \times ET \times EF \times ED \times 1/PEF \times 1/BW \times 1/AT$
	RR	Respiration Rate	m <sup>3</sup> /hour	3.3	USEPA, 1997	--	--	
	ET	Exposure Time	hours/day	8	USEPA, 1991	--	--	
	EF	Exposure Frequency	days/year	250	USEPA, 2001	--	--	
	ED	Exposure Duration	years	1	Prof Judge	--	--	
	PEF	Particulate Emission Factor	m <sup>3</sup> /kg	4.33E+06	USEPA, 2001a	--	--	
	BW	Body Weight	kg	70	USEPA, 1997	--	--	
	AT-C	Averaging Time (Cancer)	days	25,550	USEPA, 1989	--	--	
	AT-N	Averaging Time (Non-Cancer)	days	365	USEPA, 1989	--	--	

Notes

(1) In the absence of USEPA RAGS Part E ABS values, USEPA Region IV default values of 0.01% organics and 0.001% for inorganics were used.

Prof Judge - Professional Judgment

Sources:

USEPA, 1989: Risk Assessment Guidance for Superfund Vol 1, Human Health Evaluation Manual, Part A. OERR. EPA/540/1-89/002.

USEPA, 1991: Risk Assessment Guidance for Superfund Vol 1, Human Health Evaluation Manual Supplemental Guidance: Standard Default Exposure Factors.

USEPA, 1997: Exposure Factors Handbook. Vol. 1: General Factors. ORD. EPA/600/P-95/002Fa.

USEPA, 2001: Risk Assessment Guidance for Superfund Vol 1, Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment). EPA/540/R-99/005.

TABLE 6-13  
MEDIUM-SPECIFIC EXPOSURE POINT CONCENTRATION SUMMARY  
SWMU 360  
RCRA FACILITY INVESTIGATION  
MCB, CAMP LEJEUNE, NORTH CAROLINA

Scenario Timeframe: Future
Medium: Subsurface Soil
Exposure Medium: Subsurface Soil
Exposure Point: Subsurface Soil

Chemical of Potential Concern	Units	Arithmetic Mean	95% Upper Confidence Level (95% UCL)	Maximum Detected Concentration	Maximum Qualifier	EPC Units	Reasonable Maximum Exposure			Central Tendency		
							Medium EPC Value	Medium EPC Statistic	Medium EPC Rationale	Medium EPC Value	Medium EPC Statistic	Medium EPC Rationale
Arsenic	mg/kg	0.664	0.864	2.2	J	mg/kg	0.864	W-Lognormal	(1)	0.864	W-Lognormal	(1)

EPC = Exposure Point Concentration

For non-detects, 1/2 sample quantitation limit was used as a proxy concentration.

(1) Conservative estimate of the arithmetic average concentration (95% UCL), based on the Shapiro-Wilks (W-) or D-Agostino (D-) distribution tests

TABLE 6-14  
MEDIUM-SPECIFIC EXPOSURE POINT CONCENTRATION SUMMARY  
SWMU 360  
RCRA FACILITY INVESTIGATION  
MCB, CAMP LEJEUNE, NORTH CAROLINA

Scenario Timeframe: Future
Medium: Groundwater
Exposure Medium: Groundwater
Exposure Point: Groundwater, total inorganics

Chemical of Potential Concern	Units	Arithmetic Mean	95% Upper Confidence Level (95% UCL)	Maximum Detected Concentration	Maximum Qualifier	EPC Units	Reasonable Maximum Exposure			Central Tendency		
							Medium EPC Value	Medium EPC Statistic	Medium EPC Rationale	Medium EPC Value	Medium EPC Statistic	Medium EPC Rationale
1,2-Dichloroethene (cis)	mg/L	0.0550	0.108	0.12		mg/L	0.12	Max	(1)	0.12	Max	(1)
Tetrachloroethene (PCE)	mg/L	0.0395	1.E-01	0.089		mg/L	0.089	Max	(1)	0.089	Max	(1)
Trichloroethene (TCE)	mg/L	0.0275	0.1	0.075		mg/L	0.075	Max	(1)	0.075	Max	(1)
Acetophenone	mg/L	0.00413	0.0842	0.001	J	mg/L	0.001	Max	(1)	0.001	Max	(1)
4,4'-DDE	mg/L	0.000148	0.000280	0.00024	J	mg/L	0.00024	Max	(1)	0.00024	Max	(1)
BHC, alpha-	mg/L	0.0000475	0.00175	0.000015	J	mg/L	0.000015	Max	(1)	0.000015	Max	(1)
BHC, beta-	mg/L	0.000438	52.5	0.0016	J	mg/L	0.0016	Max	(1)	0.0016	Max	(1)
BHC, delta-	mg/L	0.000105	0.000214	0.00019	J	mg/L	0.00019	Max	(1)	0.00019	Max	(1)
BHC, gamma- (Lindane)	mg/L	0.0000688	0.00013	0.0001	J	mg/L	0.0001	Max	(1)	0.0001	Max	(1)
Aldrin	mg/L	0.0000788	0.00015	0.00014	J	mg/L	0.00014	Max	(1)	0.00014	Max	(1)
Heptachlor	mg/L	0.0000658	0.00012	0.000088	J	mg/L	0.000088	Max	(1)	0.000088	Max	(1)
Heptachlor Epoxide	mg/L	0.000158	0.000	0.00045	J	mg/L	0.00045	Max	(1)	0.00045	Max	(1)
Arsenic	mg/L	0.00140	0.00393	0.0026	J	mg/L	0.0026	Max	(1)	0.0026	Max	(1)

EPC = Exposure Point Concentration

For non-detects, 1/2 sample quantitation limit was used as a proxy concentration.

(1) Region 4 Human Health Risk Assessment Bulletin, 1996

TABLE 6-15  
MEDIUM-SPECIFIC EXPOSURE POINT CONCENTRATION SUMMARY  
SWMU 360  
RCRA FACILITY INVESTIGATION  
MCB, CAMP LEJEUNE, NORTH CAROLINA

Scenario Timeframe: Future
Medium: Groundwater
Exposure Medium: Groundwater
Exposure Point: Groundwater, total inorganics

Chemical of Potential Concern	Units	Arithmetic Mean	95% Upper Confidence Level (95% UCL)	Maximum Detected Concentration	Maximum Qualifier	EPC Units	Reasonable Maximum Exposure			Central Tendency		
							Medium EPC Value	Medium EPC Statistic	Medium EPC Rationale	Medium EPC Value	Medium EPC Statistic	Medium EPC Rationale
1,2-Dichloroethene (cis)	mg/L	0.0210	1.81	0.037		mg/L	0.037	Max	(1)	0.037	Max	(1)
Tetrachloroethene (PCE)	mg/L	0.00655	0.0172	0.0081	J	mg/L	0.0081	Max	(1)	0.0081	Max	(1)
Trichloroethene (TCE)	mg/L	0.00675	0.0196	0.0085	J	mg/L	0.0085	Max	(1)	0.0085	Max	(1)

EPC = Exposure Point Concentration

For non-detects, 1/2 sample quantitation limit was used as a proxy concentration.

(1) Region 4 Human Health Risk Assessment Bulletin, 1996

TABLE 6-16  
NON-CANCER TOXICITY DATA -- ORAL/DERMAL  
SWMU 360  
RCRA FACILITY INVESTIGATION  
MCB, CAMP LEJEUNE, NORTH CAROLINA

Chemical of Potential Concern	Chronic/ Subchronic	Oral RfD Value	Oral RfD Units	Oral to Dermal Adjustment Factor (1)	Adjusted Dermal RfD (2)	Units	Primary Target Organ	Combined Uncertainty/Modifying Factors	Sources of RfD: Target Organ	Dates of RfD: Target Organ (3) (MM/DD/YY)
1,2-Dichloroethene (cis)	Subchronic	1.00E-02	mg/kg/day	100%	1.00E-02	mg/kg/day	CVS	3000/1	HEAST	7/1/1997
Tetrachloroethene (PCE)	Subchronic	1.00E-02	mg/kg/day	100%	1.00E-02	mg/kg/day	Liver / Whole Body	1000/1	IRIS	6/17/2004
Trichloroethene (TCE)	Subchronic	3.00E-04	mg/kg/day	15%	4.50E-05	mg/kg/day	Kidney / Liver / Fetus	3000/1	NCEA	8/1/2001
Acetophenone	Subchronic	1.00E-01	mg/kg/day	50%	NA	mg/kg/day	Whole Body	3000/1	NA	10/22/2003
4,4'-DDE	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
BHC, alpha-	NA	5.00E-04	mg/kg/day	97%	4.85E-04	mg/kg/day	NA	NA	NCEA	NA
BHC, beta-	NA	2.00E-04	mg/kg/day	91%	1.82E-04	mg/kg/day	NA	NA	NCEA	NA
BHC, delta-	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
BHC, gamma- (Lindane)	Subchronic	3.00E-04	mg/kg/day	97%	2.91E-04	mg/kg/day	Liver / Kidney	1000/1	IRIS	11/12/2003
Aldrin	Chronic	3.00E-05	mg/kg/day	50%	1.50E-05	mg/kg/day	Liver	1000/1	IRIS	4/29/2004
Heptachlor	Subchronic	5.00E-04	mg/kg/day	72%	3.60E-04	mg/kg/day	Liver	300/1	IRIS	9/18/2000
Heptachlor Epoxide	Subchronic	1.30E-05	mg/kg/day	72%	9.36E-06	mg/kg/day	Liver	1000/1	IRIS	2/19/2004
Arsenic	Chronic	3.00E-04	mg/kg/day	41%	1.23E-04	mg/kg/day	Skin / CVS	3/1	IRIS	1/7/2004

Notes:

- (1) Refer to table presented as subsection of Appendix K .
- (2) Adjusted dermal RfD = Oral RfD \* Adj Factor
- (3) For IRIS values, provide the date IRIS was searched.  
For HEAST values, provide the date of HEAST.  
For NCEA values, provide the date of the article provided by NCEA.

Target Organ Abbreviations:  
CVS = Cardiovascular System

Sources:  
IRIS = Integrated Risk Information System  
HEAST= Health Effects Assessment Summary Tables  
NCEA = National Center for Environmental Assessment, USEPA

NA = Not Applicable

TABLE 6-17  
NON-CANCER TOXICITY DATA – INHALATION  
SWMU 360  
RCRA FACILITY INVESTIGATION  
MCB, CAMP LEJEUNE, NORTH CAROLINA

Chemical of Potential Concern	Chronic/ Subchronic	Value Inhalation RfC	Units	Adjusted Inhalation RfD (1)	Units	Primary Target Organ	Combined Uncertainty/Modifying Factors	Sources of RfC:RfD: Target Organ	Dates (2) (MM/DD/YY)
1,2-Dichloroethene (cis)	NA	NA	NA	1.00E-02	mg/kg/day	NA	NA	RE	NA
Tetrachloroethene (PCE)	Chronic	4.9E-01	mg/m3	1.70E-01	mg/kg/day	Liver / Kidney / Brain	300/1	NCEA	6/20/1997
Trichloroethene (TCE)	Subchronic	3.5E-02	mg/m3	1.00E-02	mg/kg/day	CNS / Liver / Endocrine	1000/1	NCEA	8/1/2001
Acetophenone	NA	NA	NA	NA	NA	NA	NA	NA	NA
4,4'-DDE	NA	NA	NA	NA	NA	NA	NA	NA	NA
BHC, alpha-	NA	NA	NA	5.00E-04	mg/kg/day	NA	NA	RE	NA
BHC, beta-	NA	NA	NA	2.00E-04	mg/kg/day	NA	NA	RE	NA
BHC, delta-	NA	NA	NA	NA	NA	NA	NA	NA	NA
BHC, gamma- (Lindane)	NA	NA	NA	3.00E-04	mg/kg/day	NA	NA	RE	NA
Aldrin	NA	NA	NA	3.00E-05	mg/kg/day	NA	NA	RE	NA
Heptachlor	NA	NA	NA	5.00E-04	mg/kg/day	NA	NA	RE	NA
Heptachlor Epoxide	NA	NA	NA	1.30E-05	mg/kg/day	NA	NA	RE	NA
Arsenic	NA	NA	NA	NA	NA	NA	NA	NA	NA

Notes:

- (1) Provide equation used for derivation in text.
- (2) For IRIS values, provide the date IRIS was searched.  
For HEAST values, provide the date of HEAST.  
For NCEA values, provide the date of the article provided by NCEA.

NA = Not Applicable

Target Organ Abbreviations:  
CNS = Central Nervous System

Sources:  
NCEA = National Center for Environmental Assessment, USEPA  
RE = Region 9 Route Extrapolation

TABLE 6-18  
 CANCER TOXICITY DATA -- ORAL/DERMAL  
 SWMU 360  
 RCRA FACILITY INVESTIGATION  
 MCB, CAMP LEJEUNE, NORTH CAROLINA

Chemical of Potential Concern	Oral Cancer Slope Factor	Oral to Dermal Adjustment Factor (1)	Adjusted Dermal Cancer Slope Factor (2)	Units	Weight of Evidence/ Cancer Guideline Description	Source	Date (3) (MM/DD/YY)
1,2-Dichloroethene (cis)	NA	NA	NA	NA	NA	NA	NA
Tetrachloroethene (PCE)	5.20E-02	100%	5.20E-02	(mg/kg/day) <sup>-1</sup>	C	NCEA	7/1/1985
Trichloroethene (TCE)	4.00E-01	15%	2.67E+00	(mg/kg/day) <sup>-1</sup>	B2	NCEA	10/1/2000
Acetophenone	NA	NA	NA	NA	NA	NA	NA
4,4'-DDE	3.40E-01	70%	4.86E-01	(mg/kg/day) <sup>-1</sup>	B2	IRIS	6/2/2004
BHC, alpha-	6.30E+00	97%	6.49E+00	(mg/kg/day) <sup>-1</sup>	B2	IRIS	9/18/2000
BHC, beta-	1.80E+00	91%	1.98E+00	(mg/kg/day) <sup>-1</sup>	C	IRIS	4/29/2004
BHC, delta-	1.80E+00	50%	3.60E+00	(mg/kg/day) <sup>-1</sup>	B2	IRIS	7/1/1997
BHC, gamma- (Lindane)	1.30E+00	97%	1.34E+00	(mg/kg/day) <sup>-1</sup>	B2-C	HEAST	7/1/1997
Aldrin	1.70E+01	50%	3.40E+01	(mg/kg/day) <sup>-1</sup>	B2	IRIS	4/29/2004
Heptachlor	4.50E+00	72%	6.25E+00	(mg/kg/day) <sup>-1</sup>	B2	IRIS	9/18/2000
Heptachlor Epoxide	9.10E+00	72%	1.26E+01	(mg/kg/day) <sup>-1</sup>	B2	IRIS	2/19/2004
Arsenic	1.50E+00	41%	3.66E+00	(mg/kg/day) <sup>-1</sup>	A	IRIS	1/7/2004

Notes:

- (1) Refer to table presented as subsection of Appendix K
- (2) Adjusted dermal CSF = Oral CSF / Adj Factor
- (3) For IRIS values, provide the date IRIS was searched.  
 For HEAST values, provide the date of HEAST.  
 For NCEA values, provide article date provided by NCEA.

NA = Not Applicable

Sources:

IRIS = Integrated Risk Information System  
 HEAST = Health Effects Assessment Summary Tables  
 NCEA = National Center for Environmental Assessment, USEPA

EPA Group:

- A - Human carcinogen
- B1 - Probable human carcinogen - indicates that limited human data are available
- B2 - Probable human carcinogen - indicates sufficient evidence in animals and inadequate or no evidence in humans
- C - Possible human carcinogen
- D - Not classifiable as a human carcinogen
- E - Evidence of noncarcinogenicity

Weight of Evidence:

- Known/Likely (EPA classes A, B1, B2, C)
- Cannot be Determined (EPA class D)
- Not Likely (EPA class E)

TABLE 6-19  
 CANCER TOXICITY DATA -- INHALATION  
 SWMU 360  
 RCRA FACILITY INVESTIGATION  
 MCB, CAMP LEJEUNE, NORTH CAROLINA

Chemical of Potential Concern	Unit Risk	Units	Adjustment (1)	Inhalation Cancer Slope Factor	Units	Weight of Evidence/ Cancer Guideline Description	Source	Date (2) (MM/DD/YY)
1,2-Dichloroethene (cis)	NA	NA	NA	NA	NA	NA	NA	NA
Tetrachloroethene (PCE)	5.7E-06	ug/m3	3,500	1.00E-02	mg/kg/day	C	NCEA	4/1/1987
Trichloroethene (TCE)	1.1E-04	ug/m3	3,500	4.00E-01	mg/kg/day	B2	NCEA	10/1/2000
Acetophenone	NA	NA	NA	NA	NA	NA	NA	NA
4,4'-DDE	NA	NA	3,500	3.40E-01	mg/kg/day	B2	RE	6/2/2004
BHC, alpha-	1.8E-03	ug/m3	3,500	6.30E+00	mg/kg/day	B2	IRIS	9/18/2000
BHC, beta-	5.1E-04	ug/m3	3,500	1.80E+00	mg/kg/day	C	IRIS	4/29/2004
BHC, delta-	5.1E-04	ug/m3	3,500	1.79E+00	mg/kg/day	B2	IRIS	9/18/2000
BHC, gamma- (Lindane)	NA	NA	3,500	1.30E+00	mg/kg/day	C	RE	7/1/1997
Aldrin	4.9E-03	ug/m3	3,500	1.72E+01	mg/kg/day	B2	IRIS	4/29/2004
Heptachlor	1.3E-03	ug/m3	3,500	4.55E+00	mg/kg/day	B2	IRIS	9/18/2000
Heptachlor Epoxide	2.6E-03	ug/m3	3,500	9.10E+00	mg/kg/day	B2	IRIS	2/19/2004
Arsenic	4.3E-03	ug/m3	3,500	1.51E+01	mg/kg/day	A	IRIS	1/7/2004

Notes:

- (1) Adjustment Factor applied to Unit Risk to calculate Inhalation Slope Factor =  
 $70\text{kg} \times 1/20\text{m}^3/\text{day} \times 1000\text{ug}/\text{mg}$
- (2) For IRIS values, provide the date IRIS was searched.  
 For HEAST values, provide the date of HEAST.  
 For NCEA values, provide the date of the article provided by NCEA.

EPA Group:

- A - Human carcinogen
- B1 - Probable human carcinogen - indicates that limited human data are available
- B2 - Probable human carcinogen - indicates sufficient evidence in an inadequate or no evidence in humans
- C - Possible human carcinogen
- D - Not classifiable as a human carcinogen
- E - Evidence of noncarcinogenicity

Sources:

- IRIS = Integrated Risk Information System
- NCEA = National Center for Environmental Assessment, USEPA
- RE = Region 9 Route Extrapolation

NA = Not Applicable

Weight of Evidence:

- Known/Likely (EPA classes A, B1, B2, C)
- Cannot be Determined (EPA class D)
- Not Likely (EPA class E)

TABLE 6-20  
 SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPC:  
 REASONABLE MAXIMUM EXPOSURE  
 SWMU 360  
 RCRA FACILITY INVESTIGATION  
 MCB, CAMP LEJEUNE, NORTH CAROLINA

Scenario Timeframe: Future  
 Receptor Population: Residents  
 Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Chemical	Carcinogenic Risk				Chemical	Non-Carcinogenic Hazard Quotient <sup>1</sup>				
				Ingestion	Inhalation	Dermal	Exposure Routes Total		Primary Target Organ	Ingestion	Inhalation	Dermal	Exposure Routes Total
Subsurface Soil	Subsurface Soil	Subsurface Soil	Arsenic	6.1E-07	3.8E-11	1.8E-07	7.9E-07	Arsenic	(o) Skin / CVS	3.9E-03	--	1.2E-03	5.1E-03
			(Total)	6.1E-07	3.8E-11	1.8E-07	7.9E-07	(Total)		3.9E-03	--	1.2E-03	5.1E-03
Groundwater	Groundwater	Tap	1,2-Dichloroethene (cis)	--	--	--	--	1,2-Dichloroethene (cis)	(o) CVS	3.3E-01	3.3E-01	2.8E-02	6.9E-01
			Tetrachloroethene (PCE)	4.3E-05	4.3E-05	2.6E-05	1.1E-04	Tetrachloroethene (PCE)	(o) Liver / Whole Body, (i) Liver / Kidney / Brair	2.4E-01	2.4E-01	1.4E-01	6.3E-01
			Trichloroethene (TCE)	2.8E-04	2.8E-04	3.1E-04	8.8E-04	Trichloroethene (TCE)	(o) Kidney / Liver / Fetus, (i) CNS / Liver / Endocrine	6.8E+00	6.8E+00	7.6E+00	2.1E+01
			Acetophenone	--	--	--	--	Acetophenone	(o) Whole Body	--	--	--	--
			4,4'-DDE	7.7E-07	--	7.9E-06	8.7E-06	4,4'-DDE	NA	--	--	--	--
			BHC, alpha-	8.9E-07	--	--	8.9E-07	BHC, alpha-	NA	8.2E-04	--	--	8.2E-04
			BHC, beta-	2.7E-05	--	--	2.7E-05	BHC, beta-	NA	2.2E-01	--	--	2.2E-01
			BHC, delta-	3.2E-06	--	--	3.2E-06	BHC, delta-	NA	--	--	--	--
			BHC, gamma- (Lindane)	1.2E-06	--	5.4E-07	1.8E-06	BHC, gamma- (Lindane)	(o) Liver / Kidney	9.1E-03	--	4.1E-03	1.3E-02
			Aldrin	2.2E-05	--	4.1E-06	2.6E-05	Aldrin	(o) Liver	1.3E-01	--	2.3E-02	1.5E-01
			Heptachlor	3.7E-06	--	3.0E-06	6.7E-06	Heptachlor	(o) Liver	4.8E-03	--	3.9E-03	8.7E-03
			Heptachlor Epoxide	3.8E-05	--	--	3.8E-05	Heptachlor Epoxide	(o) Liver	9.5E-01	--	--	9.5E-01
			Arsenic	3.7E-05	--	2.8E-07	3.7E-05	Arsenic	(o) Skin / CVS	2.4E-01	--	1.8E-03	2.4E-01
			(Total)	4.6E-04	3.3E-04	3.5E-04	1.1E-03	(Total)	9.0E+00	7.4E+00	7.8E+00	2.4E+01	
Groundwater	Groundwater	Tap	1,2-Dichloroethene (cis)	--	--	--	--	1,2-Dichloroethene (cis)	(o) CVS	1.0E-01	1.0E-01	8.6E-03	2.1E-01
			Tetrachloroethene (PCE)	4.0E-06	4.0E-06	2.3E-06	1.0E-05	Tetrachloroethene (PCE)	(o) Liver / Whole Body, (i)	2.2E-02	2.2E-02	1.3E-02	5.8E-02
			Trichloroethene (TCE)	3.2E-05	3.2E-05	3.5E-05	9.9E-05	Trichloroethene (TCE)	(o) Kidney / Liver / Fetus, (i)	7.8E-01	7.8E-01	8.6E-01	2.4E+00
			(Total)	3.6E-05	3.6E-05	3.8E-05	1.1E-04	(Total)		9.0E-01	9.0E-01	8.8E-01	2.7E+00

Notes:  
 Target Organ Abbreviations:  
 CNS = Central Nervous System  
 CVS = Cardiovascular System

Total Risk Across Subsurface Soil: 7.9E-07  
 Total Risk Across Shallow Groundwater: 1.1E-03  
 Total Risk Across Deep Groundwater: 1.1E-04  
 Total Risk Across All Media and All Exposure Routes: 1.2E-03

Total Hazard Index Across Subsurface Soil: 0.01  
 Total Hazard Index Across Shallow Groundwater: 24.19  
 Total Hazard Index Across Deep Groundwater: 7.58  
 Total Hazard Index Across All Media and All Exposure Routes: 26.87

(o) Oral exposure  
 (i) Inhalation exposure

Inhalation Exposure Routes:  
 Inhalation Central Nervous System HI = 6.85  
 Inhalation Endocrine System HI = 6.85  
 Inhalation Kidney HI = 0.24  
 Inhalation Liver HI = 7.09

Oral and Dermal Exposure Routes:  
 Oral / Dermal Whole Body HI = 0.39  
 Oral / Dermal Cardiovascular System HI = 0.60  
 Oral / Dermal Skin HI = 0.24  
 Oral / Dermal Kidney HI = 7.75  
 Oral / Dermal Liver HI = 15.95  
 Oral / Dermal Fetus HI = 14.41

TABLE 6-21  
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPC  
CENTRAL TENDENCY  
SWMU 360  
RCRA FACILITY INVESTIGATION  
MCB, CAMP LEJEUNE, NORTH CAROLINA

Scenario Timeframe: Future  
Receptor Population: Residents  
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Chemical	Carcinogenic Risk				Chemical	Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total		Primary Target Organ	Ingestion	Inhalation	Dermal	Exposure Routes Total
Subsurface Soil	Subsurface Soil	Subsurface Soil	Arsenic	5.9E-08	7.4E-12	4.9E-09	6.4E-08	Arsenic	(o) Skin / CVS	1.3E-03	--	1.1E-04	1.4E-03
			(Total)	5.9E-08	7.4E-12	4.9E-09	6.4E-08	(Total)		1.3E-03	--	1.1E-04	1.4E-03
Groundwater	Groundwater	Tap	1,2-Dichloroethene (cis)	--	--	--	--	1,2-Dichloroethene (cis)	(o) CVS	1.5E-01	1.5E-01	1.2E-02	3.2E-01
			Tetrachloroethene (PCE)	5.9E-06	5.9E-06	3.3E-06	1.5E-05	Tetrachloroethene (PCE)	(o) Liver / Whole Body, (i) Liver / Kidney / Brair	1.1E-01	1.1E-01	6.3E-02	2.9E-01
			Trichloroethene (TCE)	3.8E-05	3.8E-05	4.0E-05	1.2E-04	Trichloroethene (TCE)	(o) Kidney / Liver / Fetus, (i) CNS / Liver / Endocrine	3.2E+00	3.2E+00	3.3E+00	9.7E+00
			Acetophenone	--	--	--	--	Acetophenone	(o) Whole Body	--	--	--	--
			4,4'-DDE	1.0E-07	--	1.0E-06	1.1E-06	4,4'-DDE	NA	--	--	--	--
			BHC, alpha-	1.2E-07	--	--	1.2E-07	BHC, alpha-	NA	3.8E-04	--	--	3.8E-04
			BHC, beta-	3.7E-06	--	--	3.7E-06	BHC, beta-	NA	1.0E-01	--	--	1.0E-01
			BHC, delta-	4.4E-07	--	--	4.4E-07	BHC, delta-	NA	--	--	--	--
			BHC, gamma- (Lindane)	1.7E-07	--	6.9E-08	2.4E-07	BHC, gamma- (Lindane)	(o) Liver / Kidney	4.3E-03	--	1.8E-03	6.1E-03
			Aldrin	3.1E-06	--	5.2E-07	3.6E-06	Aldrin	(o) Liver	6.0E-02	--	1.0E-02	7.0E-02
			Heptachlor	5.1E-07	--	3.9E-07	8.9E-07	Heptachlor	(o) Liver	2.3E-03	--	1.7E-03	4.0E-03
			Heptachlor Epoxide	5.3E-06	--	--	5.3E-06	Heptachlor Epoxide	(o) Liver	4.4E-01	--	--	4.4E-01
			Arsenic	5.0E-06	--	2.4E-08	5.0E-06	Arsenic	(o) Skin / CVS	1.1E-01	--	5.3E-04	1.1E-01
			(Total)	6.3E-05	4.4E-05	4.5E-05	1.5E-04	(Total)	4.2E+00	3.5E+00	3.4E+00	1.1E+01	
Groundwater	Groundwater	Tap	1,2-Dichloroethene (cis)	--	--	--	--	1,2-Dichloroethene (cis)	(o) CVS	4.7E-02	4.7E-02	3.8E-03	9.9E-02
			Tetrachloroethene (PCE)	5.4E-07	5.4E-07	3.0E-07	1.4E-06	Tetrachloroethene (PCE)	(o) Liver / Whole Body, (i)	1.0E-02	1.0E-02	5.8E-03	2.7E-02
			Trichloroethene (TCE)	4.4E-06	4.4E-06	4.5E-06	1.3E-05	Trichloroethene (TCE)	(o) Kidney / Liver / Fetus, (i)	3.6E-01	3.6E-01	3.8E-01	1.1E+00
			(Total)	4.9E-06	4.9E-06	4.8E-06	1.5E-05	(Total)		4.2E-01	4.2E-01	3.9E-01	1.2E+00

Notes:  
Target Organ Abbreviations:  
CNS = Central Nervous System  
CVS = Cardiovascular System

Total Risk Across Subsurface Soil = 6.4E-08  
Total Risk Across Shallow Groundwater = 1.5E-04  
Total Risk Across Deep Groundwater = 1.5E-05  
Total Risk Across All Media and All Exposure Routes = 1.7E-04

Total Hazard Index Across Subsurface Soil = 0.00  
Total Hazard Index Across Shallow Groundwater = 11.09  
Total Hazard Index Across Deep Groundwater = 1.22  
Total Hazard Index Across All Media and All Exposure Routes = 12.32

(o) Oral exposure  
(i) Inhalation exposure

Inhalation Exposure Routes:  
Inhalation Central Nervous System HI = 1.71  
Inhalation Endocrine System HI = 3.21  
Inhalation Kidney HI = 0.11  
Inhalation Liver HI = 3.52

Oral and Dermal Exposure Routes:  
Oral / Dermal Whole Body HI = 0.18  
Oral / Dermal Cardiovascular System HI = 0.28  
Oral / Dermal Skin HI = 0.11  
Oral / Dermal Kidney HI = 6.54  
Oral / Dermal Liver HI = 7.74  
Oral / Dermal Fetus HI = 6.54

TABLE 6-22  
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPC:  
REASONABLE MAXIMUM EXPOSURE  
SWMU 360  
RCRA FACILITY INVESTIGATION  
MCB, CAMP LEJEUNE, NORTH CAROLINA

Scenario Timeframe: Future  
Receptor Population: Residents  
Receptor Age: Young Child

Medium	Exposure Medium	Exposure Point	Chemical	Carcinogenic Risk				Chemical	Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total		Primary Target Organ	Ingestion	Inhalation	Dermal	Exposure Routes Total
Subsurface Soil	Subsurface Soil	Subsurface Soil	Arsenic	1.4E-06	9.3E-11	2.9E-07	1.7E-06	Arsenic	(o) Skin / CVS	3.7E-02	--	7.5E-03	4.4E-02
			(Total)	1.4E-06	9.3E-11	2.9E-07	1.7E-06	(Total)		3.7E-02	--	7.5E-03	4.4E-02
Shallow Groundwater	Shallow Groundwater	Tap	1,2-Dichloroethene (cis)	--	--	--	--	1,2-Dichloroethene (cis)	(o) CVS	7.7E-01	--	6.5E-02	8.3E-01
			Tetrachloroethene (PCE)	2.5E-05	--	1.4E-05	4.0E-05	Tetrachloroethene (PCE)	(o) Liver / Whole Body, (i) Liver / Kidney / Brain	5.7E-01	--	3.2E-01	8.9E-01
			Trichloroethene (TCE)	1.6E-04	--	1.8E-04	3.4E-04	Trichloroethene (TCE)	(o) Kidney / Liver / Fetus, (i) CNS / Liver / Endocrine	1.6E+01	--	1.7E+01	3.3E+01
			Acetophenone	--	--	--	--	Acetophenone	(o) Whole Body	--	--	--	--
			4,4'-DDE	4.5E-07	--	4.4E-06	4.9E-06	4,4'-DDE	NA	--	--	--	--
			BHC, alpha-	5.2E-07	--	--	5.2E-07	BHC, alpha-	NA	1.9E-03	--	--	1.9E-03
			BHC, beta-	1.6E-05	--	--	1.6E-05	BHC, beta-	NA	5.1E-01	--	--	5.1E-01
			BHC, delta-	1.9E-06	--	--	1.9E-06	BHC, delta-	NA	--	--	--	--
			BHC, gamma- (Lindane)	7.1E-07	--	3.0E-07	1.0E-06	BHC, gamma- (Lindane)	(o) Liver / Kidney	2.1E-02	--	9.1E-03	3.0E-02
			Aldrin	1.3E-05	--	2.3E-06	1.5E-05	Aldrin	(o) Liver	3.0E-01	--	5.2E-02	3.5E-01
			Heptachlor	2.2E-06	--	1.7E-06	3.9E-06	Heptachlor	(o) Liver	1.1E-02	--	8.8E-03	2.0E-02
			Heptachlor Epoxide	2.2E-05	--	--	2.2E-05	Heptachlor Epoxide	(o) Liver	2.2E+00	--	--	2.2E+00
			Arsenic	2.1E-05	--	2.1E-07	2.2E-05	Arsenic	(o) Skin / CVS	5.5E-01	--	5.4E-03	5.6E-01
			(Total)	2.7E-04	--	2.0E-04	4.7E-04	(Total)		2.1E+01	--	1.8E+01	3.8E+01
Deep Groundwater	Deep Groundwater	Tap	1,2-Dichloroethene (cis)	--	--	--	--	1,2-Dichloroethene (cis)	(o) CVS	2.4E-01	--	2.0E-02	2.6E-01
			Tetrachloroethene (PCE)	2.3E-06	--	1.3E-06	3.6E-06	Tetrachloroethene (PCE)	(o) Liver / Whole Body, (i)	5.2E-02	--	3.0E-02	8.1E-02
			Trichloroethene (TCE)	1.9E-05	--	2.0E-05	3.9E-05	Trichloroethene (TCE)	(o) Kidney / Liver / Fetus, (i)	1.8E+00	--	1.9E+00	3.7E+00
			(Total)	2.1E-05	--	2.1E-05	4.2E-05	(Total)		2.1E+00	--	2.0E+00	4.1E+00

Notes:  
Target Organ Abbreviations:  
CNS = Central Nervous System  
CVS = Cardiovascular System

Total Risk Across Subsurface Soil: 1.7E-06  
Total Risk Across Shallow Groundwater: 2.7E-04  
Total Risk Across Deep Groundwater: 4.2E-05  
Total Risk Across All Media and All Exposure Routes: 5.1E-04

Total Hazard Index Across Subsurface Soil: 0.04  
Total Hazard Index Across Shallow Groundwater: 38.47  
Total Hazard Index Across Deep Groundwater: 4.08  
Total Hazard Index Across All Media and All Exposure Routes: 42.57

(o) Oral exposure  
(i) Inhalation exposure

Inhalation Exposure Routes:  
Inhalation Central Nervous System HI = 0.00  
Inhalation Endocrine System HI = 0.00  
Inhalation Kidney HI = 0.00  
Inhalation Liver HI = 0.00

Oral and Dermal Exposure Routes:  
Oral / Dermal Whole Body HI = 0.89  
Oral / Dermal Cardiovascular System HI = 1.44  
Oral / Dermal Skin HI = 0.60  
Oral / Dermal Kidney HI = 33.06  
Oral / Dermal Liver HI = 36.54  
Oral / Dermal Fetus HI = 33.03

TABLE 6-23  
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPC:  
CENTRAL TENDENCY  
SWMU 360  
RCRA FACILITY INVESTIGATION  
MCB, CAMP LEJEUNE, NORTH CAROLINA

Scenario Timeframe: Future  
Receptor Population: Residents  
Receptor Age: Young Child

Medium	Exposure Medium	Exposure Point	Chemical	Carcinogenic Risk				Chemical	Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total		Primary Target Organ	Ingestion	Inhalation	Dermal	Exposure Routes Total
Subsurface Soil	Subsurface Soil	Subsurface Soil	Arsenic	1.6E-07	2.1E-11	1.3E-08	1.7E-07	Arsenic	(o) Skin / CVS	1.2E-02	--	1.0E-03	1.3E-02
			(Total)	1.6E-07	2.1E-11	1.3E-08	1.7E-07	(Total)		1.2E-02	--	1.0E-03	1.3E-02
Shallow Groundwater	Shallow Groundwater	Tap	1,2-Dichloroethene (cis)	--	--	--	--	1,2-Dichloroethene (cis)	(o) CVS	5.1E-01	--	2.4E-02	5.4E-01
			Tetrachloroethene (PCE)	5.7E-06	--	1.9E-06	7.5E-06	Tetrachloroethene (PCE)	(o) Liver / Whole Body, (i) Liver / Kidney / Brain	3.8E-01	--	1.2E-01	5.0E-01
			Trichloroethene (TCE)	3.7E-05	--	2.2E-05	5.9E-05	Trichloroethene (TCE)	(o) Kidney / Liver / Fetus, (i) CNS / Liver / Endocrine	1.1E+01	--	6.5E+00	1.7E+01
			Acetophenone	--	--	--	--	Acetophenone	(o) Whole Body	--	--	--	--
			4,4'-DDE	1.0E-07	--	5.7E-07	6.7E-07	4,4'-DDE	NA	--	--	--	--
			BHC, alpha-	1.2E-07	--	--	1.2E-07	BHC, alpha-	NA	1.3E-03	--	--	1.3E-03
			BHC, beta-	3.5E-06	--	--	3.5E-06	BHC, beta-	NA	3.4E-01	--	--	3.4E-01
			BHC, delta-	4.2E-07	--	--	4.2E-07	BHC, delta-	NA	--	--	--	--
			BHC, gamma- (Lindane)	1.6E-07	--	3.9E-08	2.0E-07	BHC, gamma- (Lindane)	(o) Liver / Kidney	1.4E-02	--	3.5E-03	1.8E-02
			Aldrin	2.9E-06	--	2.9E-07	3.2E-06	Aldrin	(o) Liver	2.0E-01	--	2.0E-02	2.2E-01
			Heptachlor	4.8E-07	--	2.2E-07	7.0E-07	Heptachlor	(o) Liver	7.5E-03	--	3.4E-03	1.1E-02
			Heptachlor Epoxide	5.0E-06	--	--	5.0E-06	Heptachlor Epoxide	(o) Liver	1.5E+00	--	--	1.5E+00
			Arsenic	4.8E-06	--	1.5E-08	4.8E-06	Arsenic	(o) Skin / CVS	3.7E-01	--	1.2E-03	3.7E-01
			(Total)	6.0E-05	--	2.5E-05	8.5E-05	(Total)		1.4E+01	--	6.7E+00	2.1E+01
Deep Groundwater	Deep Groundwater	Tap	1,2-Dichloroethene (cis)	--	--	--	--	1,2-Dichloroethene (cis)	(o) CVS	1.6E-01	--	7.4E-03	1.7E-01
			Tetrachloroethene (PCE)	5.1E-07	--	1.7E-07	6.8E-07	Tetrachloroethene (PCE)	(o) Liver / Whole Body, (i)	3.5E-02	--	1.1E-02	4.6E-02
			Trichloroethene (TCE)	4.2E-06	--	2.5E-06	6.7E-06	Trichloroethene (TCE)	(o) Kidney / Liver / Fetus, (i)	1.2E+00	--	7.4E-01	2.0E+00
			(Total)	4.7E-06	--	2.7E-06	7.4E-06	(Total)		1.4E+00	--	7.6E-01	2.2E+00

Notes:  
Target Organ Abbreviations:  
CNS = Central Nervous System  
CVS = Cardiovascular System

Total Risk Across Subsurface Soil = 1.7E-07  
Total Risk Across Shallow Groundwater = 8.5E-05  
Total Risk Across Deep Groundwater = 7.4E-06  
Total Risk Across All Media and All Exposure Routes = 9.3E-05

Total Hazard Index Across Subsurface Soil = 0.01  
Total Hazard Index Across Shallow Groundwater = 20.72  
Total Hazard Index Across Deep Groundwater = 2.46  
Total Hazard Index Across All Media and All Exposure Routes = 12.90

(o) Oral exposure  
(i) Inhalation exposure

Inhalation Exposure Routes:  
Inhalation Central Nervous System HI = 0.00  
Inhalation Endocrine System HI = 0.00  
Inhalation Kidney HI = 0.00  
Inhalation Liver HI = 0.00

Oral and Dermal Exposure Routes:  
Oral / Dermal Whole Body HI = 0.50  
Oral / Dermal Cardiovascular System HI = 0.92  
Oral / Dermal Skin HI = 0.38  
Oral / Dermal Kidney HI = 17.25  
Oral / Dermal Liver HI = 19.47  
Oral / Dermal Fetus HI = 17.23

TABLE 6-24  
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPC:  
REASONABLE MAXIMUM EXPOSURE  
SWMU 360  
RCRA FACILITY INVESTIGATION  
MCB, CAMP LEJEUNE, NORTH CAROLINA

Scenario Timeframe: Future
Receptor Population: Construction Workers
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Chemical	Carcinogenic Risk				Chemical	Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total		Primary Target Organ	Ingestion	Inhalation	Dermal	Exposure Routes Total
Subsurface Soil	Subsurface Soil	Subsurface Soil	Arsenic	8.7E-08	1.1E-08	8.7E-09	1.1E-07	Arsenic	(o) Skin / CVS	1.4E-02	--	1.4E-03	1.5E-02
			(Total)	8.7E-08	1.1E-08	8.7E-09	1.1E-07	(Total)		1.4E-02	--	1.4E-03	1.5E-02

Notes:

Target Organ Abbreviations:

CVS = Cardiovascular System

(o) Oral exposure

(i) Inhalation exposure

Total Risk Across Subsurface Soil 1.1E-07  
Total Risk Across All Media and All Exposure Routes 1.1E-07

Total Hazard Index Across Subsurface Soil 0.01  
Hazard Index Across All Media and All Exposure Routes 0.01

Oral and Dermal Exposure Routes:  
Oral / Dermal Cardiovascular System HI = 0.01  
Oral / Dermal Skin HI = 0.01

**TABLE 6-25**  
**SUMMARY OF UNCERTAINTIES IN THE RESULTS OF THE**  
**HUMAN HEALTH RISK ASSESSMENT**  
**SWMU 360**  
**RCRA FACILITY INVESTIGATION**  
**MCB, CAMP LEJEUNE, NORTH CAROLINA**

	Potential Magnitude for Over-Estimation of Risks	Potential Magnitude for Under-Estimation of Risks	Potential Magnitude for Over or Under-Estimation of Risks
<b><u>Environmental Sampling and Analysis</u></b>			
Sufficient samples may not have been taken to characterize the media being evaluated.			Moderate
Systematic or random errors in the chemical analysis may yield erroneous data.			Low
<b><u>Selection of COPCs</u></b>			
The use of site-specific background and USEPA Region IV COPC screening concentrations in selecting COPCs in all media of concern.		Low	
<b><u>Exposure Assessment</u></b>			
The standard assumptions regarding body weight, exposure period, life expectancy, population characteristics, and lifestyle may not be representative of the actual exposure situations.			Moderate
The use of the 95th percentile upper confidence level data for the normal or lognormal distribution in the estimation of the RME.			Low
The amount of media intake is assumed to be constant and representative of any actual exposure.			Low
<b><u>Toxicological Assessment</u></b>			
Toxicological indices derived from high dose animal studies, extrapolated to low dose human exposure.	Moderate		
<b><u>Risk Characterization</u></b>			
Assumption of additivity in the quantitation of cancer risks without consideration of synergism, antagonism, promotion and initiation.			Moderate
Assumption of additivity in the estimation of systemic health effects without consideration of synergism, antagonism, etc.			Moderate
Additivity of risks by individual exposure pathways (dermal and ingestion and inhalation).			Low

**Notes:**

- Low - Assumptions categorized as "low" may effect risk estimates by less than one order of magnitude.
- Moderate - Assumptions categorized as "moderate" may effect estimates of risk by between one and two orders of magnitude.
- High - Assumptions categorized as "high" may effect estimates of risk by more than two orders of magnitude.

Source: Risk Assessment Guidance for Superfund, Volume 1, Part A: Human Health Evaluation Manual. USEPA, 1989.

**Baker**

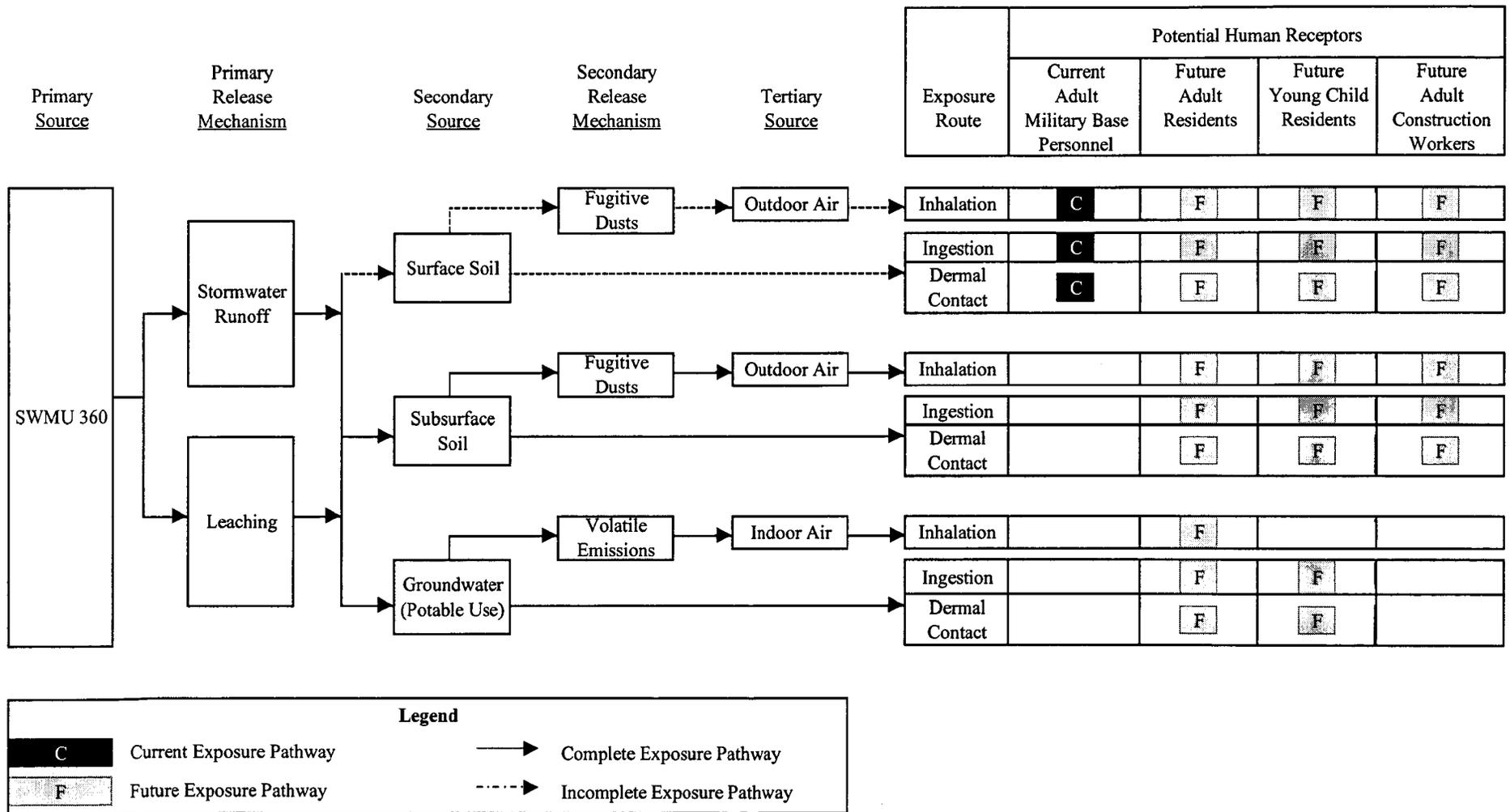
*Baker Environmental, Inc.*

**SECTION 6.0**

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*FIGURES*

**FIGURE 6-1**  
**FLOWCHART OF POTENTIAL EXPOSURE PATHWAYS AND RECEPTORS**  
**SWMU 360**  
**RCRA FACILITY INVESTIGATION**  
**MCB, CAMP LEJEUNE, NORTH CAROLINA**



## 7.0 ECOLOGICAL RISK ASSESSMENT

The overall purpose of an ecological risk assessment (ERA) is to evaluate the likelihood that adverse ecological effects would occur or are occurring as a result of exposure to one or more physical or chemical stressors. The assessment evaluates the potential effects of chemicals on terrestrial and aquatic receptors (e.g., flora and fauna) and their habitats, including the consideration of protected species and sensitive or critical habitats. It also identifies particular chemical stressors that may cause adverse effects (ecological COPCs).

Because no risk assessment guidance has been developed specifically for the RCRA program, guidance designed for Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) sites was followed. The following guidance documents were consulted during the risk assessment process:

- Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments. USEPA 1997.
- Supplemental Guidance to RAGS: Region IV Bulletins, Ecological Risk Assessment. USEPA 2001b. Originally published November 1995. Website version last updated November 30, 2001 <<http://www.epa.gov/region4/waste/ots/ecolbul.htm>>
- Amended Guidance on Ecological Risk Assessment at Military Bases: Process Considerations, Timing of Activities, and Inclusion of Stakeholders. USEPA Region IV, Memorandum 4WD-OTS, 2000a.
- Navy Policy for Conducting Ecological Risk Assessments. Chief of Naval Operations (CNO) 1999.
- Guidelines for Performing Screening Level Ecological Risk Assessments Within the North Carolina Division of Waste Management, NC DENR 2003.

This section presents a Screening Level Ecological Risk Assessment (SLERA) and Step 3A of the Baseline Ecological Risk Assessment (BERA) for SWMU 360, MCB Camp Lejeune, North Carolina. The SLERA includes Steps 1 and 2 of the USEPA's eight-step process as outlined in the Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments, Interim Final (USEPA, 1997a). The risk evaluation is organized into the following components (NC DENR, 2003):

Step 1: Helps to answer the question: "Is there ecology here to protect?"

- Ecological Setting
- Fate and Transport Mechanisms
- Potentially Complete Exposure Pathways

Step 2: Answers the question. "Are ecological effects possible?"

- Data Collection and Evaluation
- Abiotic Screen

Step 3A: Refining the List of Chemicals of Potential Concern

- Summary and Conclusions
- Risk Characterization
- Uncertainty

Step 3A is only conducted if potential ecological effects are possible based on the results of Steps 1 and 2. The conclusion of the SLERA and Step 3A (if applicable) will be one of the following (NC DENR, 2003):

- The risks are not significant to cause adverse impacts.
- The risks posed by the contaminants require immediate response (focused removal study).
- The potential for adverse impacts cannot be ruled out, and must be further defined in the subsequent steps of the ERA process (i.e., site must proceed to BERA).
- Data are inadequate to complete the risk characterization. Large data gaps need to be addressed prior to completion of the screening process.

The following sections describe the general technical approach and results of the risk evaluation at SWMU 360.

## **7.1 Step 1 – Screening-Level Problem Formulation and Ecological Effects Evaluation**

In screening-level problem formulation, a preliminary conceptual model for the site is developed. It includes a description of the ecological setting, discussion of contaminants known or suspected to be present at the site, and potential contaminant fate and transport mechanisms. Potentially complete exposure pathways are also identified (USEPA, 1997). Information gathered as part of Step 1 of the SLERA is used to answer the question: "Is there ecology here to protect?"

### **7.1.1 Ecological Setting**

An understanding of the ecological setting of the site is an important component of the SLERA. A discussion of the ecological setting generally includes a description of facility operations, the regional ecological setting, and the site-specific ecological setting. A detailed description of MCB, Camp Lejeune, including the history and mission of the base and a summary of hazardous wastes generated, is provided in Section 2.2 of the Phase II CSI Report (Baker, 2002). Section 2.0 of the Phase II CSI Report provides detailed information on the regional ecological setting, including topography and surface features, surface water hydrology, geology, hydrogeology, land use and demographics, climatology, water supply, ecological characteristics, wetlands, and threatened and endangered species. Information on the site-specific ecological setting follows.

The ecological setting of SWMU 360 was evaluated via examination of historical information and during a site visit conducted July 11, 2003. During the site visit, which lasted approximately 45 minutes, the Checklist for Ecological Assessments/Sampling was completed. (Appendix A, NC DENR, 2003; also located in Appendix B, USEPA, 1997a). This checklist, including photographs of the site taken during the site visit, is presented as Appendix M.

SWMU 360 is a 300-gallon waste oil UST formerly located near warehouse Building 1817. Building 1817 is located in the Hadnot Point Industrial Area between Duncan Street and "O" Street and one block northeast of McHugh Boulevard or the former Main Service Road (Figure 1-2). The actual SWMU is located in the eastern portion of the compound, which is

occupied by a Hazardous Materials Unit and is being used as a temporary staging area for batteries, refrigeration units, and other used equipment prior to disposal and/ or reutilization. The entire compound is fenced and access is limited. A new wash pad and an associated oil/water separator have been built near the UST excavation and are used by the Marine Units occupying the facility.

Due to the industrial nature of the site, terrestrial habitat is limited. Within the fenced area of the Building 1817 compound, the ground surface is half paved (western portion) and half gravel (eastern portion). The gravel area includes some sand and hard-packed dirt with very sparse herbaceous growth, which tends to be concentrated along the fence line. Outside the compound, vegetation (grasses and herbaceous species) is somewhat more prevalent, but is generally restricted to the fence line and side of Building 1817 (Photos 5 and 6 in Appendix M). Due to the high traffic in this area, soils are compacted and provide poor habitat for invertebrates. In turn, the study area does not represent a good foraging area for avian species. Foraging by small mammals is also unlikely, due to the low habitat quality and the distance to suitable terrestrial habitat. Ecological receptors in the study area would, in all likelihood, be limited to insects and other small arthropods. With the exception of insects, no animals were observed at the site during the July 2003 site visit. An aerial view of SWMU 360 is presented as Figure 7-1. As indicated on the figure, the closest terrestrial habitat is located over 200 feet northeast of the SWMU.

The area surrounding SWMU 360 is generally flat. Surface water flow across SWMU 360 area is controlled. Due to the industrial nature of the study area, rainwater runoff is collected in roof gutters, storm water sewer inlets in parking areas, and in drainage ditches along roads. Direct infiltration occurs in grassy and gravel areas surrounding the Building 1817 compound. The wash pad associated with SWMU 360 is designed to capture water from vehicle wash downs, and to an extent, captures some rainwater. Water in the wash pad drains to the oil/water separator, which in turn drains to the sanitary sewer.

No surface water features are present on or immediately adjacent to SWMU 360. Groundwater at the site flows in a southeast direction (Section 3.4.2.2; Figure 3-5). The nearest downgradient surface water is Cogdels Creek, a fresh water body located approximately 1500 feet to the southeast of the SWMU (Figure 1-1).

No protected species have been reported or observed at SWMU 360. The site is not located within any areas identified as ecologically protected or of significant natural value. No

endangered species were noted during the site visit nor were endangered species referenced at the site during the endangered species survey (LeBlond et al., 1994).

### **7.1.2 Fate and Transport Mechanisms**

A transport pathway describes the mechanisms whereby chemicals may be transported from a source of contamination to ecologically relevant media. Transport pathways for SWMU 360 are illustrated in the preliminary ecological conceptual model (Figure 7-2). As depicted in the preliminary ecological conceptual model, the primary mechanisms for chemical transport from potential source areas are believed to include the following:

- Leaking of waste oils from the former UST to surrounding subsurface soils.
- Spills and leakage of waste materials to surface and subsurface soils from the wash rack and oil/water separator.
- Leaching/desorption of chemicals from soil to groundwater and subsequent discharge to surface water bodies.
- Uptake of chemicals in surface soils or off-site surface water or sediment by biota and food-web transfer to upper trophic level receptors.
- Volatile emissions from surface soils and from erosion releasing fugitive dusts to the atmosphere.

Although a potentially complete and significant pathway, as per USEPA Region IV Guidance (USEPA Region IV, 2000), transfer of chemicals to upper trophic level ecological receptors via food chain uptake is beyond the scope of the SLERA, and therefore, is not evaluated.

### **7.1.3 Potentially Complete Exposure Pathways**

An exposure pathway links a source of contamination with one or more receptors through exposure via one or more media. Exposure, and thus potential risk, can only occur if each of the following components exists:

- A source and mechanism of chemical release into the environment
- An environmental transport medium
- A point of potential contact between an ecological receptor and the medium
- A feasible exposure route at the contact point

A discussion of potential complete exposure pathways for ecological receptors at SWMU 360 is presented below. Specific pathways addressed by the SLERA are also identified.

#### 7.1.3.1 Groundwater Exposure Pathway

The sources of contamination for the groundwater exposure pathway are the former UST, wash rack, oil/water separator, and surrounding soils that may have been contaminated by leaks or spills from these sources. Release mechanisms are leaching/desorption of chemicals to subsurface soil and vertical migration with infiltrating precipitation to groundwater (or leaching/desorption directly to groundwater).

Groundwater is not used by ecological receptors, and therefore, the groundwater exposure pathway does not include a point of contact at which an ecological receptor may be exposed to contaminants. Although the groundwater exposure pathway is incomplete, groundwater can act as an environmental transport medium if chemicals migrate with groundwater to an aquatic habitat. Based on groundwater contours (see Section 3.4.2), groundwater flow direction in the surficial aquifer is to the southeast. Groundwater may discharge to Cogdels Creek, a freshwater creek located 1500 feet southeast of the SWMU. Potential exposures resulting from the migration of chemicals with groundwater to off-site aquatic habitats are addressed in the discussion of the surface water and sediment exposure pathway below.

#### 7.1.3.2 Surface Water and Sediment Exposure Pathway

The source of contamination for the surface water and sediment exposure pathway is the former UST, wash rack, oil/water separator, and surrounding soils that may have been contaminated by leaks or spills from these sources. Contaminants may have leaked to subsurface soils or may have been spilled on to the ground surface. Soil contaminants may have subsequently contaminated groundwater via vertical migration with infiltrating precipitation or direct leaching/desorption. When groundwater migrates from the study area and discharges to off-site aquatic habitats, sediments or surface waters may become contaminated.

Aquatic life (e.g., fish and invertebrates) may be exposed to chemicals that have migrated to off-site aquatic habitats via incidental ingestion, direct contact, and ingestion of plant and/or animal tissues (i.e., food chain transfer). Aquatic vegetation within these areas may be exposed to chemicals directly from the water (direct contact) or through root uptake from the substrate. Mammals and birds using the aquatic habitat as potential food and/or drinking water sources may be exposed to chemicals in surface water and sediment through ingestion, direct contact, and food chain transfer.

Other receptors that may forage within aquatic areas include reptiles and amphibians. The potential exposure routes for reptiles and amphibians are ingestion of surface water and sediment, direct contact with surface water and sediment, and food chain transfer. For all potential receptors, exposures from food chain transfer will be limited to those chemicals that bioaccumulate in lower trophic level organisms or biomagnify through successive trophic levels.

There is no direct evidence that groundwater from the SWMU is migrating to a surface water body. However, because groundwater flow is in the direction of a freshwater creek 1500 feet from the site, the surface water and sediment exposure pathway for aquatic receptors was evaluated as a conservative measure, by comparing groundwater analytical data to NC DENR recommended surface water screening values for freshwater.

#### 7.1.3.3 Surface and Subsurface Soil Exposure Pathway

The release source for the subsurface and surface soil exposure pathway is the material that may have leaked or spilled from the former UST or from the wash area and oil/water separator at the SWMU. Contaminants may remain in soils or leach to groundwater. Horizontal migration of contaminants may occur via erosion of surface soils by surface runoff during precipitation or via fugitive dust emissions. Due to the flat topography of the study area and controlled nature of surface water runoff (Section 7.1.1), horizontal migration of contaminants in surface soils would be minimized. No signs of soil erosion were evident at the study area. The potential for contaminant migration via fugitive dust emissions is addressed in the air exposure pathway.

In general, soil invertebrates such as earthworms may be exposed to chemicals in surface soil through direct contact and ingestion. Terrestrial plants may be exposed to chemicals in surface soil through root uptake. Terrestrial birds may be exposed to chemicals in surface soil through

incidental ingestion and food chain transfer. Dermal absorption in birds is limited or prevented by feathers; however, preening will contribute to incidental ingestion. Mammals and reptiles may be exposed to chemicals in surface soil through incidental ingestion and food chain transfer. Dermal absorption in mammals and reptiles is reduced or prevented by fur and scales, respectively. Grooming by mammals will contribute to incidental ingestion. Due to the active industrial nature of the SWMU 360 study area and negligible terrestrial habitat, ecological receptors at the site are unlikely (with the exception of insects and limited herbaceous plants); therefore, there is no potential point of contact between ecological receptors and SWMU surface soils. For this reason, the surface soil exposure pathway is incomplete and was not evaluated in the SLERA.

The subsurface soil exposure pathway is also incomplete and was not evaluated. Subsurface soil is not considered a complete exposure pathway for terrestrial receptors for the following reasons:

- The mass of most root systems is within the surface soil
- Most soil heterotrophic activity is within the surface organic layer
- Soil invertebrates occur on the surface or within the oxidized root zone

#### 7.1.3.4 Air Exposure Pathway

Contaminated surface soil may serve as a release source for the air exposure pathway (fugitive dust emissions from wind erosion). In addition to this release mechanism, volatilization of chemicals from surface soil may occur. Terrestrial mammals, birds, and reptiles may be exposed to chemicals in fugitive dust emissions and volatilization via inhalation. Because much of the study area is paved or covered with buildings, fugitive dust emissions would be minimized. However, there are substantial areas of the site that consist of gravel and bare ground which could generate dust. As with the surface soil exposure pathway, the air exposure pathway is considered incomplete due to the lack of terrestrial habitat (and thus the lack of ecological receptors) at the study area. The lack of receptors means that there is no point of contact between ecological receptors and fugitive dusts. Fugitive dusts can migrate substantial distances with wind. However, concentrations of VOCs in surface soils at this SWMU were low (Section 4). Furthermore, for upper trophic level receptors, the inhalation exposure pathway is considered insignificant compared to ingestion pathways (Suter et. al., 2000; USEPA, 1997; USEPA, 2000b); therefore, if dusts were to migrate to a terrestrial habitat, potential risks to ecological

receptors in that habitat would not be of concern. This pathway is not indicated in the ecological conceptual model.

#### **7.1.4 Conclusions of Step 1**

Step 1 of the SLERA posed the question: "Is there ecology here to protect?" Based on information regarding the ecological setting of the site, fate and transport mechanisms, and potentially complete exposure pathways, which are discussed in the preceding sections, there is no suitable terrestrial habitat at or near the study area to protect. No aquatic habitats are present at or near the study area. Although there is a substantial distance between the SWMU and the nearest downgradient surface water body, potential migration of contaminated groundwater to off-site aquatic habitats is a concern and is evaluated in the following sections as a conservative measure.

### **7.2 Step 2 - Screening-Level Preliminary Exposure Estimate and Risk Calculation**

Step 2 of the ERA process consists of the preliminary exposure estimate and risk calculation. The following sections describe the data available for the preliminary exposure estimate and the methods and results of the abiotic screen.

#### **7.2.1 Data Used in the SLERA**

Data available for the SLERA at SWMU 360 include surface soil, subsurface soil, and groundwater data collected for the Phase II SWMU CSI (Baker, 2002a) and the current RFI field investigation. The Phase II CSI and RFI field investigations were conducted in series with specific goals for each investigation. The Phase II investigation was conducted to evaluate if activities associated with the SWMU had possibly impacted the surrounding environment. Therefore, the samples collected as part of this investigation were located as near the SWMU as physically possible or in areas where evidence of possible environmental impact had been observed. If a specific group of contaminants were not detected in the samples (e.g., volatiles), then they were eliminated as potential contaminants of concern for that particular SWMU. As such, subsequent investigations did not include any group of contaminants that had been eliminated as a potential contaminant of concern. Likewise, if a particular group of contaminants had been delineated during any investigation or combination of investigations, further investigation of these compounds would not be considered necessary.

As part of the Phase II CSI, one surface (0-1 foot bgs) and two subsurface (greater than one foot bgs) soil samples were collected from each of four temporary well borings for a total of four surface soil and eight subsurface soil samples. Four groundwater samples were collected from four temporary wells. Soil and groundwater samples were analyzed for VOCs, SVOCs, pesticides, and RCRA metals.

The RFI field investigation included collection of 11 surface soil samples (zero to one foot bgs) and 78 subsurface soil samples (greater than one foot bgs) from 17 soil borings, 59 groundwater grab samples from soil borings, and 12 groundwater samples from groundwater monitoring wells (not including QC samples). The groundwater monitoring well samples included nine monitoring wells screened in the surficial aquifer and three monitoring wells screened in the upper Castle Hayne aquifer. Two of the surficial wells were located upgradient of the SWMU (SWMU360-MW06 and SWMU360-MW08) and seven were located downgradient. Surface soil samples collected for the RFI were analyzed for VOCs by a mobile laboratory (benzene, PCE, TCE, cis-DCE, trans-DCE, methylene chloride, and 1,1-DCE). Subsurface soil samples were analyzed for some combination of the following: VOCs by a mobile laboratory, VOCs by a fixed base laboratory, pesticides by a fixed base laboratory, or RCRA metals by a fixed based laboratory (Table 2-1). Groundwater grab samples were analyzed for VOCs by a mobile laboratory, and groundwater monitoring well samples were analyzed for TCL VOCs, TCL SVOCs, pesticides, and/or RCRA metals by a fixed base laboratory (Table 2-1).

A subset of the available data was used for the SWMU 360 SLERA. Because the surface and subsurface soil exposure pathways were incomplete (Section 7.1.3), surface and subsurface soil data were not used in the SLERA. Groundwater data collected from temporary wells during the Phase II investigation were included in the SLERA. Groundwater grab sample data collected during the RFI were not included in the SLERA because these data were from a mobile laboratory and were not validated. Groundwater monitoring well data from the RFI, which were analyzed at a fixed-based laboratory and were validated, were included in the risk evaluation. Only data from shallow monitoring wells were evaluated because water in deeper aquifers is less likely to discharge to a surface water body. Two of the RFI samples (SWMU360-MW06 and SWMU360-MW08) were collected from locations upgradient of the site and were used to estimate site-specific background concentrations. Groundwater data evaluated in the SLERA are summarized on Table 7-1 and are presented in full in Appendix N.

Duplicate samples were included in the data set by the following means. In instances where the original and duplicate sample were both detected or both non-detected the values were averaged for the risk assessment. In instances when the original and duplicate samples contained one detection and one non-detection, the detected value was averaged with one-half of the detection limit of the non-detected value and the sample was considered a detection.

### **7.2.2 Abiotic Screen**

The screening-level exposure estimate and risk calculation provides a highly conservative evaluation of potential ecological risks at a site. Although upper trophic level receptors (e.g., terrestrial mammals, piscivorous birds) may be identified as potential receptors at the site, the SLERA is limited to a comparison of analytical data to media-specific screening values. Screening values used in the SLERA were recommended by NC DENR (2003) and are consistent with ecological screening values established by USEPA Region IV (USEPA Region IV 1995, updated April 2001). The sections that follow describe the various criteria and toxicological benchmarks used as screening values (toxicological thresholds) for chemicals analyzed in groundwater. NC DENR's recommended chemical-specific surface water screening values are summarized on Table 7-2. The screening values represent conservative exposure thresholds above which adverse ecological effects may occur.

#### **7.2.2.1 Media-Specific Screening Values**

##### *Surface Water Screening Values – USEPA Region IV*

Surface water screening values (SWSVs) used in this evaluation were obtained from the NC DENR Guidelines for Performing SLERAs (NC DENR 2003). Surface water was not sampled at this site; however, fresh surface water screening values were used to screen groundwater contaminant concentrations.

The NC DENR recommended chronic freshwater SWSVs for the RCRA metals cadmium and lead, as well as the chronic value for trivalent chromium, are expressed as a function of water hardness. As a conservative measure, chromium in site groundwater was assumed to be hexavalent chromium, the more toxic form of the element. Therefore the screening value for hexavalent chromium, which is not hardness based, was used in the risk assessment. Screening values for cadmium, copper, lead, nickel, and zinc are ideally calculated based on site-specific

hardness values. Hardness is usually calculated for each groundwater sample using the following equation (Franson, 1992):

$$\text{Hardness} = 2.497 * [\text{Calcium}](\text{mg/L}) + 4.118 * [\text{Magnesium}](\text{mg/L})$$

However, because calcium and magnesium are not included in the RCRA metals analysis, these inorganic constituents were not analyzed in the groundwater samples used in the SLERA, and site-specific hardness could not be calculated. A default hardness of 50 mg calcium carbonate per liter ( $\text{CaCO}_3/\text{L}$ ) was used in place of a mean of site-specific hardness value to calculate SWSVs for total recoverable metals as follows (USEPA, 2002):

- Cadmium:  $\text{SWSV} = e^{(0.7409 * \ln(\text{hardness value}) - 4.719)}$
- Lead:  $\text{SWSV} = e^{(1.273 * \ln(\text{hardness value}) - 4.705)}$

In the SLERA, only total recoverable metals data for groundwater were considered. This is done as a conservative measure. For some metals (including arsenic, cadmium, chromium, lead, mercury, and selenium), the dissolved fraction more closely indicates the bioavailable fraction of the metal; therefore, the use of total recoverable metals data for these chemicals is likely to overestimate potential risks. The uncertainty that this data adds to the risk assessment is addressed in Section 7.2.3.

The SWSV selected for pentachlorophenol is expressed as a function of pH. A default pH value of 7.8 standard units (S.U.) was used to adjust the chronic criterion for this organic chemical (USEPA, 2002).

#### *Surface Water Screening Values – North Carolina Water Quality Standards*

North Carolina Surface Water Quality Standards for Aquatic Life were obtained from the North Carolina guidelines for performing SLERAs (NC DENR, 2003). These standards were originally published as North Carolina Administrative Code (NCAC) Section 15A NCAC 2B (NC DENR, 1998).

#### 7.2.2.2 Hazard Quotient Calculation

A hazard quotient (HQ) was calculated for each chemical by dividing the maximum exposure concentration of the chemical by the ecological screening value for that chemical:

$$\text{Hazard Quotient} = \frac{\text{Maximum Exposure Concentration}}{\text{Screening Value}}$$

The maximum exposure concentration is estimated as the maximum detected concentration of the chemical or, in cases where the chemical was not detected in a given media, the maximum sample detection limit (MDL) (NC DENR, 2003). HQs equal to or exceeding 1.0 indicate the potential for risk since the estimated exposure exceeds the estimated effects concentration. However, screening values and exposure estimates are derived using intentionally conservative assumptions such that HQs greater than or equal to one do not necessarily indicate that risks are present or impacts are occurring. Rather, they identify chemical-pathway-receptor combinations requiring further evaluation. Following the same reasoning, HQs that are less than one indicate that risks are very unlikely; a conclusion of no unacceptable risk may be reached with high confidence.

Chemicals were identified as COPCs if they fell in to one or more of the following categories (NC DENR 2003):

- Category 1 – Chemicals whose maximum detection exceeds the NC DENR media-specific ecological screening value (HQ> 1.0; chemical detected).
- Category 2 – Chemicals that were not detected in any samples for a given media, but for which the MDL exceeded the NC DENR media specific ecological screening value (HQ>1.0; chemical not detected).
- Category 3 – Chemicals that have no NC DENR ecological screening value but were detected above the laboratory sample quantitation level (SQL) (No screening value; chemical detected).
- Category 4 – Chemicals that were not detected above the laboratory SQL and have no NC DENR ecological screening value (No screening value; chemical not detected).

- Category 5 – Chemicals for which the maximum detection or the MDL exceeds the North Carolina Surface Water Quality Standards (for aqueous samples only).

Any tentatively identified compounds (TICs) or unknown chemicals present at the site would have been identified as preliminary COPCs and included as Category 3 contaminants; however, no such chemicals were present at SWMU 360. Chemicals that do not fall in to one or more of the contaminant categories were not identified as COPCs. Chemicals could be classified into more than one category only if one of those categories was Category 5. Furthermore, because of the differential toxicity of many contaminants to ecological versus human receptors, the COPCs for ecological receptors may differ from those selected for the human health risk assessment.

#### 7.2.2.3 Results of the Abiotic Screen

The results of the abiotic screen for groundwater are presented in the following section. Chemicals identified as ecological COPCs based on the abiotic screen proceed to Step 3A of the ERA (Section 7.3).

##### 7.2.2.3.1 *Groundwater*

Groundwater data used in the SLERA included four samples collected from temporary monitoring wells in April 2002 and nine samples (seven site samples and two upgradient samples) collected from groundwater monitoring wells in July 2003. Samples collected in 2002 were analyzed for VOCs, SVOCs, pesticides, and RCRA metals. Samples collected in 2003 were analyzed for VOCs, pesticides, and RCRA metals. Three of the 2003 samples were additionally analyzed for SVOCs. All monitoring wells evaluated in the SLERA were screened in the surficial aquifer. Groundwater data were compared to fresh surface water screening values. Table 7-3 presents HQ calculations for groundwater.

Ninety-nine chemicals were identified as ecological COPCs in groundwater. One VOC (PCE), five pesticides (4,4'-DDT, gamma-BHC, gamma-chlordane, heptachlor, and heptachlor epoxide), and one RCRA metal (selenium) were identified as Category 1 COPCs because maximum detected concentrations exceeded fresh surface water screening values. Three of these COPCs (4,4'-DDT, gamma-BHC, and selenium) were also classified in Contaminant Category 5 because maximum detected concentrations exceeded NCWQS for freshwater aquatic life. The HQ (calculated with NC DENR screening values) for PCE was 60.71. HQs for

Category 1 pesticide COPCs ranged from 1.25 (gamma-BHC) to 118.42 (heptachlor epoxide). The HQ for selenium was 1.14. Figure 7-3 presents detected concentrations of Category 1 COPCs that exceed NC DENR screening values or NCWQS for freshwater aquatic life.

Eleven SVOCs, seven pesticides, and four RCRA metals were classified as Category 2 COPCs because they were not detected in groundwater but their maximum detection limits exceeded screening values. HQs for Category 2 COPCs ranged from 1.12 (for hexachloroethane) to 125,000 (for toxaphene).

The VOCs cis-DCE and TCE; the SVOCs 2-methylphenol, 4-methylphenol, acetophenone, fluorene, and phenanthrene; the pesticides alpha-chlordane and gamma-chlordane; and the RCRA metals barium and chromium were identified as Category 3 COPCs because they were detected in groundwater, but freshwater screening values were not available to evaluate potential risks.

Twenty-two VOCs, 31 SVOCs, and three pesticides were identified as Category 4 COPCs because they were not detected and soil screening values are not available.

Finally, two VOCs, six pesticides, and four RCRA metals were identified as Category 5 COPCs because maximum detected concentrations or MDLs exceeded NCWQS for freshwater. Three of these chemicals (carbon tetrachloride, toluene, and aldrin) were identified solely as Category 5 COPCs while the remaining nine were identified in Category 5 and in one additional category (Table 7-3).

### **7.2.3 Uncertainties Associated with the SLERA**

The procedures used in this evaluation are subject to uncertainties because of the limitations of the available data and the need to make certain assumptions and extrapolations based on incomplete information. Uncertainties associated with the SLERA for SWMU 360 and their effects on risk conclusions are presented and discussed below.

#### Limitations of Available Data Set

- Groundwater data were used to evaluate potential risks to off-site aquatic habitat that may be affected by groundwater discharge from the SWMU. There is no evidence that

groundwater from the site reaches a surface water body, nor is there an indication that ecological COPCs identified in Step 2 are migrating outside the study area. However, evaluation of the groundwater migration pathway is included as a conservative approach aimed at preventing the elimination of chemicals from the list of COPCs when they may, in fact, be contributing unacceptable risks to the environment.

- Groundwater grab samples from the RFI, which were analyzed at a mobile laboratory, were not included in the SLERA. However, the inclusion of RFI data would not change the conclusions of the risk evaluation for groundwater. Groundwater grab samples were analyzed for VOCs. Nine VOCs were detected in groundwater grab samples. Of these, PCE was detected at concentrations exceeding ecological screening criteria in one groundwater grab sample (SWMU360-GW05 collected from soil boring 360-S05). This exceedence is included in the discussion of PCE contamination in groundwater in Section 7.3.6.1. No other VOCs in groundwater grab samples were detected at concentrations exceeding ecological screening criteria.

#### Identification of Ecological COPCs

- There is uncertainty regarding potential risk that may be contributed by chemicals that were identified as COPCs but were not detected in site media (Category 2 and Category 4 COPCs). It is as likely that the concentrations of these chemicals at the SWMU are at or near zero and that they are not present in ecologically harmful concentrations. The identification of such chemicals as COPCs is a conservative measure designed to be highly protective, but is likely to overestimate the potential for adverse effects.
- There is also uncertainty regarding the potential risk that may be contributed by chemicals that have no surface water screening values (Category 3 and Category 4 COPCs). Because toxicological data regarding the potential effects of such chemicals on ecological receptors is not available, it is not possible to quantitatively evaluate risks to ecological receptors. The identification of such chemicals as COPCs is a highly conservative approach aimed at preventing the elimination of compounds that could have harmful impacts on the environment from the list of COPCs. Although this approach is conservative, the absence of toxicological data on these chemicals adds uncertainty to the conclusions of the risk assessment and may lead to an underestimation or overestimation of potential ecological impacts contributed by the SWMU.

### Exposure Point Concentrations

- As is typical in a SLERA, a finite number of samples of environmental media are used to develop the exposure estimates. Evaluation of the maximum measured concentration provides a conservative estimate of the maximum risks that may be contributed by site media. For relatively immobile media such as soil, evaluation of maximum concentrations may reflect potential risk to individual organisms that are immobile or those with a limited home range. However, the most realistic exposure estimates for mobile species with relatively large home ranges and for species *populations* (even those that are immobile or have limited home ranges) are those based on the mean chemical concentrations. This is reflected in the wildlife dietary exposure models contained in the Wildlife Exposure Factors Handbook (USEPA, 1993), which specify the use of average media concentrations. For mobile media such as groundwater, the use of maximum media concentrations as exposure estimates is even more conservative because concentrations of contaminants in such media are more prone to change with mixing of the water column. The use of mean concentrations to estimate exposure in a refinement (Step 3a of the baseline ERA) is more likely to provide a more accurate picture of potential risks contributed by the site.
- Current USEPA guidance (USEPA, 1995 and 2002) indicates that the dissolved fraction of some metals (arsenic, cadmium, chromium, copper, lead, mercury, nickel, selenium, and zinc) more closely estimates the bioavailable fraction of these metals in the water column. In the SLERA, maximum total recoverable metal concentrations in groundwater were used as exposure point concentrations in the screening level risk calculation assuming discharge to surface waters. The use of total recoverable metals data for these chemicals is likely to overestimate potential risks; however, because the fraction of dissolved metals may change upon discharge to surface water, the use of total metals concentrations in groundwater is more appropriate than the use of dissolved concentrations.

### Media-specific Screening Values

- In the case of chromium, to be conservative, screening levels were estimated from the hexavalent form of the element. Trivalent chromium, which is orders of magnitude less

toxic than hexavalent chromium, is most likely to be the predominant form in the environment.

- Surface water screening levels are established to be protective of *most* of the potential ecological receptors. However, some species will not be protected by the values because of their increased sensitivity to the chemicals. For example, the Ambient Water Quality Criteria developed by the USEPA, in theory, only protect 95 percent of the exposed species. Therefore, there may be some sensitive species present that may not be protected with these criteria. In addition, most of the values are established using laboratory tests, where the concentrations of certain water quality parameters (pH, total organic carbon) that may influence toxicity are most likely at different concentrations than in surface waters that may be influenced by the study area.
- Groundwater data were used to evaluate potential risks to aquatic receptors in off-site aquatic habitats via a comparison of data to fresh surface water screening values. Because there is no clear indication that groundwater is, in fact, discharging to an aquatic habitat off-site, the inclusion of this evaluation in the risk assessment is a conservative approach. Evaluation of surface water and sediment data would provide a more realistic evaluation of potential risks to an aquatic habitat; however, no such data were collected because no connection between the source of contamination at the site and any specific aquatic habitat was established.

#### Chemical Mixtures

- Information on the ecotoxicological effects of chemical interactions is generally lacking. Therefore, chemicals must be evaluated on a compound-by-compound basis during the comparison to screening values (as is standard for ecological risk assessments). This could result in an underestimation of risk (if there are additive or synergistic effects among chemicals) or an overestimation of risks (if there are antagonistic effects among chemicals).

#### Bioaccumulative Chemicals

- Many of the chemicals identified as ecological COPCS at SWMU 360 have been identified as important bioaccumulative chemicals by the USEPA (USEPA, 2000a).

Bioaccumulative chemicals may pose unacceptable risks to upper trophic level receptors even if no unacceptable risk is posed to primary receptors. Because ecological screening values are typically based on toxicological studies of primary receptors (e.g., terrestrial plants and invertebrates), the abiotic screen alone may underestimate the number of COPCs at the SWMU. An evaluation of risks to upper trophic level receptors is beyond the scope of the SLERA. The bioaccumulative potential of individual chemicals is considered in Step 3A of the BERA when determining the need for further evaluation.

### **7.3 Step 3A – Refinement of the List of Chemicals of Potential Concern**

The SLERA for SWMU 360 indicated that, based on a set of conservative exposure assumptions, there are multiple chemicals that may present a risk to ecological receptors at the site. Therefore, SWMU 360 was carried on to Step 3a of the ERA process. In Step 3a, the ecological COPCs identified in Step 2 are further evaluated to determine which chemicals, if any, can be removed from further ecological consideration. The Step 3A evaluation examines multiple factors that improve the realism of the risk evaluation while protecting the environment. These factors include consideration of population-level effects; use of alternative screening values; an evaluation of background data; consideration of the frequency and distribution of detections; consideration of bioavailability, dilution, and natural attenuation; and any chemical or site-specific considerations that may be relevant. These factors were used to weigh the evidence of potential risk for each COPC identified for each media and to assess whether the COPC should be carried on to Step 3b of the BERA. The specific assumptions and methods that were modified for Step 3a are identified below, along with justification for each modification. If re-evaluation of the conservative exposure assumptions supports an acceptable risk determination, then additional evaluation of ecological risk is not required at the site (USEPA, 1997; CNO, 1999).

#### **7.3.1 Refinement of Exposure and Effects Level Estimates**

During Steps 1 and 2, maximum chemical concentrations of detected chemicals were used as conservative estimates of receptor exposure to calculate HQs. Generally many of the receptors evaluated in SLERAs are relatively immobile or have a limited home range. In such cases, individuals are more likely to be impacted by locations of maximum concentration. However, average contaminant concentrations are more appropriate for evaluating impacts to *populations* of soil invertebrates, sediment invertebrates, and aquatic receptors. Arithmetic means were

calculated for all compounds identified as COPCs in the SLERA. For COPCs detected in sewer than 100 percent of the samples, arithmetic means were calculated using one half the detection limit of non-detected compounds. These means were used to estimate the exposure of ecological receptors to site contaminants. If the arithmetic mean for a given chemical was greater than the maximum detected concentration, the maximum detected concentration was used as the exposure estimate.

Effects levels used in Steps 1 and 2 were NC DENR media screening values. In Step 3A, screening values were introduced, when available, for chemicals that did not have screening values established by NC DENR. All screening values used in Step 3A are provided on Table 7-4. Screening values that were introduced for Step 3a are shaded on the table. Introduced screening values for fresh surface water included (in order of preference), those established by NC DENR for chemical classes, USEPA Region V fresh surface water screening values for RCRA hazardous constituents (USEPA, 2003b), and USEPA Region III BTAG screening values for fresh surface waters (USEPA, 2004).

A mean HQ was calculated for each COPC using the refined estimates of exposure and effects. Because chemicals with mean HQs less than one are not likely to pose unacceptable risks to populations of ecological receptors, such chemicals were not considered to be risk-driving COPCs and were not recommended for further ecological evaluation. Before removal of a chemical from further evaluation based upon a mean HQ less than 1.0, the distribution of detections above screening values was examined to determine if hot spots of contamination may be present at the site that would contribute unacceptable risk.

Results of the refinement of exposure assumptions for groundwater are summarized on Table 7-5. Those COPCs that were removed from further consideration because mean HQs were less than one are indicated on the tables by the comment "Mean HQ < 1.0."

### **7.3.2 Comparison to Background Data**

Inorganics in groundwater that were selected as COPCs based on the SLERA were compared to background data. Groundwater background data were obtained from two sources. Base background data were obtained from the Draft Base Background Groundwater Investigation (Baker, 2002b). Background groundwater data were collected from locations throughout the Base away from identified sites in relatively undisturbed areas. In the Base Background

Groundwater Investigation, groundwater data were divided into two categories, including upper (shallow) and lower (deep) portions of the surficial aquifer. Groundwater samples at SWMU 360 were collected from the shallow portions of the surficial aquifer (less than 25 feet bgs); therefore, they were compared to the background data set for the upper surficial aquifer. Site-specific background data were obtained from groundwater monitoring wells SWMU360-MW06 and SWMU360-MW08, located upgradient of the SWMU.

In accordance with USEPA Region IV Human Health Risk Assessment Bulletins, Supplement to RAGS, maximum site concentrations were compared to two times the base background mean (USEPA Region IV, 2001c). The comparison is useful for determining whether or not the presence of chemicals at the site should be considered site related or may be considered naturally occurring. Inorganic constituents with background concentrations (two times the mean) that exceed maximum site concentrations are not considered risk-driving COPCs and are not recommended for further evaluation. Organic compounds, unlike inorganic analytes, are not ubiquitous in nature and were not analyzed as part of the Base Background Groundwater Investigation.

Maximum site concentrations were also compared to maximum concentrations of chemicals detected in upgradient monitoring wells. This comparison indicated whether or not chemicals at the site should be considered site related or related to upgradient sources. Upgradient monitoring wells were analyzed for VOCs, pesticides, and inorganic analytes.

Table 7-5 presents background data and results of comparisons to maximum groundwater concentrations at SWMU 360. No COPCs were removed from further consideration based on comparisons to background data.

### **7.3.3 Frequency and Distribution of Detections**

Chemicals not detected in any environmental samples are unlikely to be present in sufficient volume to contribute significant risks to receptors at a site, especially at the population level. Those COPCs that were not detected in groundwater were removed from further consideration and are indicated on Table 7-5 by the comment "Not Detected."

It should be noted that COPCs detected infrequently may also be removed from further consideration after evaluation of a variety of factors including the distribution of detections, the

magnitude of potential risks, and site history and presence or absence of chemical precursors in any site media. When appropriate, a discussion of such COPCs will be included in the text.

#### **7.3.4 Considerations of Bioavailability**

The USEPA has identified certain chemicals as "important bioaccumulative chemicals" (USEPA, 2000a). Bioaccumulative chemicals may pose unacceptable risks to upper trophic level receptors even if no unacceptable risk is posed to primary receptors. Although an evaluation of risks to upper trophic level receptors is not included in the SLERA, consideration of the bioaccumulative potential of each COPC was made before determining the need for additional evaluation of a particular chemical. Those chemicals identified as important bioaccumulative chemicals by the USEPA are indicated in the third column from the right on Table 7-5.

In the SLERA, only total recoverable metals data for groundwater were considered. However, for many metals (arsenic, cadmium, chromium, copper, lead, mercury, nickel, selenium, and zinc) only the dissolved fraction of the metal is bioavailable; therefore, the use of total recoverable metals data is likely to overestimate potential risks. In the comparison of groundwater data to surface water screening values, the use of total metals concentrations, although conservative, is more appropriate than the use of dissolved concentrations because the fraction of dissolved metals may change upon discharge to surface water. Therefore, dissolved groundwater data was not considered in the refined risk evaluation.

#### **7.3.5 Dilution and Natural Attenuation**

The risk evaluation for groundwater assumes discharge to a surface water body with no natural attenuation or dilution. Buchman (1999) recommends the use of a dilution factor of 10 to account for the dilution expected during migration and upon discharge of groundwater to surface water in the absence of site-specific dilution factors. For those COPCs with mean HQs exceeding 1.0 before dilution is accounted for, a dilution factor of 10 would result in mean HQs less than 1.0 for isopropylbenzene, PCE, TCE, 2,4,6-trichlorophenol, 2,4-dinitrophenol, 3,3'-dichlorobenzidine, 4,6-dinitro-2-methylphenol, atrazine, dibenz(a,h)anthracene, dibenzofuran, hexachlorobutadiene, indeno(1,2,3-cd)pyrene, phenanthrene, endosulfan II, gamma-chlordane, cadmium, and mercury (Table 7-5) and these chemicals would not be recommended for further evaluation. Refined HQs for all remaining ecological COPCs with the exception of anthracene, benzo(a)anthracene, benzo(a)pyrene, hexachlorobenzene, 4,4'-DDT and toxaphene would be less than eight if dilution

were accounted for. Considerations of dilution were not used as a sole criterion for removing a COPC from further consideration.

### 7.3.6 Additional Considerations

Additional factors that were considered when determining the need for further evaluation of an ecological COPC include but are not limited to the following:

- Identification of chemicals as common laboratory contaminants.
- For chemicals lacking screening values, comparison to range of available screening values for chemicals in the same chemical class.
- For chemicals with screening values not based on toxicological studies, consideration of toxicological-based screening values from the scientific literature.

Chemical-specific considerations for groundwater COPCs are addressed in the following section.

#### 7.3.6.1 Groundwater COPCs

Cis-1,2- DCE was identified as a Category 3 COPC because it was detected in groundwater but no screening value had been established by NC DENR with which to evaluate potential risks. Cis-DCE was detected in nine of eleven groundwater samples and had a maximum detected concentration of 750 ug/L. This concentration is less than the minimum available screening value established for trans-DCE by USEPA Region IV (1350 ug/L), which is closely related chemically. Based on the comparison of detected concentrations to the Region IV screening value established for a similar chemical, it is unlikely that cis-DCE is present in groundwater at concentrations that would pose unacceptable ecological risks, and no further evaluation is recommended.

PCE was identified as a Category 1 COPC in the SLERA because it was detected in groundwater at concentrations exceeding NC DENR fresh surface water screening values. PCE was detected in five of 10 groundwater monitoring well samples and had a maximum HQ of 60.71. The mean HQ for PCE was 6.45. Detected concentrations exceeded the surface water screening value of 84 µg/kg at three locations. As indicated on Figure 7-3, maximum concentrations of PCE were

found in monitoring well 1817-MW01 (5100 J  $\mu\text{g/L}$ , low dilution), located northeast of the wash pad in the vicinity of the former UST. The second-highest detection in a monitoring well was found downgradient of 1817-MW01, in well 360-MW01 (160  $\mu\text{g/L}$ ). PCE concentrations also slightly exceeded screening values in sample 360-GW01 (89  $\mu\text{g/L}$ ), which was collected from temporary monitoring well TW01 located just upgradient of 1817-MW01. Detections of PCE in groundwater were limited to the central portion of the site, suggesting that substantial migration off-site is not occurring. PCE concentrations in the farthest downgradient samples (360-MW03 and 360-MW04) were lower than ecological screening values. Data from groundwater grab samples (collected from the site but not included in the ecological data set) also show decreasing concentrations of PCE with increasing distance from the source area. The only mobile lab sample with PCE concentrations exceeding the ecological screening level was collected from soil boring 360-SB05, located near monitoring well 360-MW01 (Section 4.0). In addition, as stated in Section 7.3.5, if reasonable estimates of dilution with migration and discharge to surface water were accounted for, the mean HQ of PCE would be less than 1.0. Based on the above considerations, PCE in groundwater is not expected to pose adverse ecological risks and no further evaluation is recommended.

TCE was identified as a Category 3 COPC because it was detected but a NC DENR screening criterion was not available. USEPA Region V has established a freshwater screening value for TCE of 47  $\mu\text{g/L}$  (USEPA, 2003). TCE was detected in eight of eleven groundwater samples; only the maximum detected concentration (460  $\mu\text{g/L}$  in 1817-MW01) exceeded the Region V screening value. This sample was collected from a monitoring well located northeast of the wash pad in the vicinity of the former UST, and coincided with the maximum PCE detection. TCE concentrations in the farthest downgradient samples (360-MW03 and 360-MW04) were lower than ecological screening values, suggesting that substantial migration off-site is not occurring. In addition, as stated in Section 7.3.5, if reasonable estimates of dilution with migration and discharge to surface water were accounted for, the mean HQ of TCE would be less than 1.0. Based on the above considerations, TCE in groundwater is not expected to pose adverse ecological risks and no further evaluation is recommended.

Acetophenone was identified as a Category 3 COPC because it was detected but a USEPA Region IV screening criterion for fresh surface water was not available. Acetophenone was detected in one of seven groundwater samples (360-GW01, located near the former UST) at 1J  $\mu\text{g/L}$ . This concentration is within the range of screening values for other SVOCs (0.07  $\mu\text{g/L}$

for hexachlorocyclopentadiene to 3500 µg/L for 2-nitrophenol). Acetophenone was not detected in downgradient groundwater samples, indicating that migration off-site is unlikely. Based on these considerations, acetophenone is not expected to pose unacceptable risks to ecological receptors and further evaluation is not recommended.

Phenanthrene was identified as a Category 3 COPC because it was detected but a NC DENR screening criteria for phenanthrene of 3.6 µg/L (USEPA, 2003). Phenanthrene was detected in two of seven groundwater samples; only the maximum detected concentration (4 µg/L in SWMU360-GW04) exceeded the Region V screening value. The HQ at this location (1.11) indicates a low potential for adverse ecological effects. Furthermore, as stated in Section 7.3.5, if reasonable estimates of dilution with migration and discharge to surface water were accounted for, the mean HQ of phenanthrene would be less than 1.0. Phenanthrene was not detected in the farthest downgradient groundwater samples (360-MW03 and 360-MW04), suggesting that migration off-site is not occurring. Based on the above considerations, TCE in groundwater is not expected to pose adverse ecological risks and no further evaluation is recommended.

The pesticides 4,4'-DDT, alpha-chlordane, gamma-chlordane, heptachlor, and heptachlor epoxide were identified as Category 1 COPCs in the SLERA because detected concentrations exceeded NC DENR fresh surface water screening values. Mean HQs for each of these pesticides exceeded 1.0, ranging from 9.63 (gamma-chlordane) to 110 (4,4'-DDT). Detections of 4,4'-DDT, alpha-chlordane, gamma-chlordane, and heptachlor were limited to the groundwater sample collected from 360-TW01, near the center of the study area, while heptachlor epoxide was detected in both the ground water sample from 360-TW01 and from 360-TW04 (Figure 7-3). Because detections of these pesticides were limited to the central portion of the site and there is no evidence of off-site migration, 4,4'-DDT, alpha-chlordane, gamma-chlordane, heptachlor, and heptachlor epoxide are not expected to pose unacceptable ecological risk, and no further evaluation is recommended.

#### **7.4 Risk Characterization**

The risk characterization integrates the results of the SLERA and Step 3A. The likelihood of adverse effects occurring as a result of exposure to a stressor is evaluated. The ecological significance of the risks characterized at the site is discussed considering the types and magnitudes of the effects and their spatial and temporal patterns. Ecologically significant risks are defined as those potential adverse risks or impacts to ecological integrity that affect

populations, communities, and ecosystems, rather than individuals (i.e., measured impacts to individuals do not necessarily indicate impacts to the ecosystem).

Groundwater in the surficial aquifer was evaluated for the potential to cause adverse effects to ecological receptors assuming that the groundwater discharges in to a surface water body. There is no evidence that groundwater from the surficial aquifer is currently discharging to surface water; however, the assessment was conducted as a conservative measure. Of the 99 chemicals identified as groundwater ecological COPCs in the SLERA, based on additional considerations addressed in Step 3A of the BERA, none are expected to pose unacceptable risks to ecological receptors. Additional ecological evaluation of groundwater at SWMU 360 is not recommended.

#### **7.5 Uncertainties Associated with Step 3A of the BERA**

Many of the uncertainties identified in Section 7.2.3 also apply to the refined screening level risk calculation. Additionally, many uncertainties present in the screening level risk calculation are reduced or eliminated with the Step 3a evaluation. No additional uncertainties have been identified for Step 3A of the BERA at SWMU 360.

#### **7.6 Summary**

Based on Step 1 of the SLERA, terrestrial habitat at SWMU 360 is negligible and does not warrant ecological evaluation. No aquatic habitat is present on or near the study area. An evaluation of groundwater contamination was conducted as a conservative measure to evaluate potential risks to aquatic habitats into which groundwater from the SWMU may discharge. Based upon the results of the SLERA and Step 3A of the BERA, potential aquatic receptors in off-site habitats are not estimated to be at unacceptable levels of risk from groundwater contamination associated with SWMU 360. No further ecological evaluation of SWMU 360 is recommended.



**Baker**

*Baker Environmental, Inc.*

**SECTION 7.0**

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*TABLES*

TABLE 7-1

SUMMARY OF ANALYTICAL DATA USED IN THE SCREENING LEVEL ECOLOGICAL RISK ASSESSMENT  
 SWMU 360  
 RCRA FACILITY INVESTIGATION - CTO 142  
 MCB, CAMP LEJEUNE, NORTH CAROLINA

Media	Sample ID	Date Sampled	Sample Interval (Feet)	Analysis				QA/QC Samples taken	Comments
				ICL VOCs (OLMO 4.2)	ICL SVOCs (OLMO 4.2)	ICL Pesticides (OLMO 4.2)	RCRA Metals (ILMO 4.1)		
Groundwater	SWMU360-GW01	4/9/2002	18 - 28	X	X	X	X		in source area
	SWMU360-GW02	4/9/2002	18 - 28	X	X	X	X		in source area
	SWMU360-GW03	4/9/2002	18 - 28	X	X	X	X		in source area
	SWMU360-GW04	4/9/2002	18 - 28	X	X	X	X		in source area
	SWMU360-MW01	7/24/2003	18 - 28	X	X	X	X	DUP	in source area
	SWMU360-MW02	7/24/2003	18 - 28	X	X	X	X		in source area
	SWMU360-MW03	7/22/2003	18 - 28	X		X	X		down gradient
	SWMU360-MW04	7/23/2003	18 - 28	X		X	X		down gradient
	SWMU360-MW05	7/22/2003	15 - 25	X		X	X		side-gradient
	SWMU360-MW06	7/22/2003	17 - 27	X		X	X		up gradient, site background
	SWMU360-MW07	7/22/2003	15 - 25	X	X	X	X		side-gradient
	SWMU360-MW08	7/22/2003	16.9 - 26.9	X		X	X		up gradient, site background
	1817-MW01	7/24/2003	15 - 25	X		X	X		in source area

**TABLE 7-2**  
**USEPA REGION IV ECOLOGICAL SCREENING VALUES**  
**SWMU 360**  
**RCRA FACILITY INVESTIGATION (CTO-0143)**  
**MCB CAMP LEJUENE, NORTH CAROLINA**

Analyte	NCDENR Recommended Surface Water Screening Values - Freshwater	
	(ug/L)	Comment
<b>Volatile Organics:</b>		
1,1,1-Trichloroethane	528	
1,1,2,2-Tetrachloroethane	240	
1,1,2-Trichloro-1,2,2-trifluoroethane	NA	
1,1,2-Trichloroethane	940	
1,1-Dichloroethane	NA	
1,1-Dichloroethene	303	
1,2-Dibromoethane	NA	
1,2-Dibromo-3-chloropropane (DBCP)	NA	
1,2-Dichloroethane	2000	
1,2-Dichloropropane	525	
2-Butanone	NA	
2-Hexanone	NA	
4-Methyl-2-Pentanone	NA	
Acetone	NA	
Benzene	53	
Bromodichloromethane	NA	
Bromoform	293	
Bromomethane	110	
Carbon Disulfide	NA	
Carbon Tetrachloride	352	
Chlorobenzene	195	
Chloroethane	NA	
Chloroform	289	
Chloromethane	5500	
cis-1,2-Dichloroethene	NA	
cis-1,3-Dichloropropene	24.4	
Cyclohexane	NA	
Dibromochloromethane	NA	
Dichlorodifluoromethane	NA	
Ethylbenzene	453	
Methyl tert-butyl ether	NA	
Isopropylbenzene (Cumene)	NA	
Methyl Acetate	NA	
Methyl Cyclohexane	NA	
Methylene Chloride	1930	
Styrene	NA	
Tetrachloroethene	84	
Toluene	175	
trans-1,2-Dichloroethene	1350	
trans-1,3-Dichloropropene	24.4	Cis and Trans isomers
Trichloroethene (TCE)	NA	
Trichlorofluoromethane	NA	
Vinyl Chloride	NA	
Xylene (Total)	NA	
<b>Semivolatile Organics:</b>	0	
1,1'-Biphenyl	NA	
1,2,4-Trichlorobenzene	44.9	
1,2-Dichlorobenzene	15.8	
1,3-Dichlorobenzene	50.2	
1,4-Dichlorobenzene	11.2	
2,2'-Oxybis (1-Chloropropane)	NA	
2,4,5-Trichlorophenol	NA	
2,4,6-Trichlorophenol	3.2	
2,4-Dichlorophenol	36.5	
2,4-Dimethylphenol	21.2	
2,4-Dinitrophenol	6.2	
2,4-Dinitrotoluene	310	
2,6-Dinitrotoluene	NA	

**TABLE 7-2**  
**USEPA REGION IV ECOLOGICAL SCREENING VALUES**  
**SWMU 360**  
**RCRA FACILITY INVESTIGATION (CTO-0143)**  
**MCB CAMP LEJUENE, NORTH CAROLINA**

Analyte	NCDENR Recommended Surface Water Screening Values - Freshwater	
	(ug/L)	Comment
<b>Semivolatile Organics (Cont):</b>		
2-Chloronaphthalene	NA	
2-Chlorophenol	43.8	
2-Methylnaphthalene	NA	
2-Methylphenol	NA	
2-Nitroaniline	NA	
2-Nitrophenol	3500	
3,3'-Dichlorobenzidine	NA	
3-Nitroaniline	NA	
4,6-Dinitro-2-Methylphenol	2.3	
4-Bromophenyl-Phenylether	12.2	
4-Chloro-3-Methylphenol	0.3	
4-Chloroaniline	NA	
4-Chlorophenyl-Phenylether	NA	
4-Methylphenol	NA	
4-Nitroaniline	NA	
4-Nitrophenol	82.8	
Acenaphthene	17	
Acenaphthylene	NA	
Acetophenone	NA	
Anthracene	NA	
Atrazine	NA	
Benzaldehyde	NA	
Benzo(a)anthracene	NA	
Benzo(a)pyrene	NA	
Benzo(b)fluoranthene	NA	
Benzo(g,h,i)perylene	NA	
Benzo(k)fluoranthene	NA	
bis(2-Chloroethyl)ether	2380	
bis(2-Chloroethoxy)methane	NA	
bis(2-Ethylhexyl)phthalate	0.299	
Butylbenzylphthalate	22	
Caprolactam	NA	
Carbazole	NA	
Chrysene	NA	
Dibenzo(a,h)anthracene	NA	
Dibenzofuran	NA	
Diethylphthalate	521	
Dimethylphthalate	330	
Di-n-butylphthalate	9.4	
Di-n-octylphthalate	0.3	value for bis(2-ethylhexyl)phthalate
Fluoranthene	39.8	
Fluorene	NA	
Hexachlorobenzene	NA	
Hexachlorobutadiene	0.93	
Hexachlorocyclopentadiene	0.07	
Hexachloroethane	9.8	
Indeno(1,2,3-cd)pyrene	NA	
Isophorone	1170	
Naphthalene	62	
Nitrobenzene	270	
n-Nitroso-di-n-propylamine	NA	
n-Nitrosodiphenylamine	58.5	
Pentachlorophenol	12.79430308	pH = 7.8 S.U.
Phenanthrene	NA	
Phenol	256	
Pyrene	NA	
PAHs (total)	0	

**TABLE 7-2**  
**USEPA REGION IV ECOLOGICAL SCREENING VALUES**  
**SWMU 360**  
**RCRA FACILITY INVESTIGATION (CTO-0143)**  
**MCB CAMP LEJUENE, NORTH CAROLINA**

Analyte	NCDENR Recommended Surface Water Screening Values - Freshwater	
	(ug/L)	Comment
<b>PCBs/Pesticides:</b>	0	
Aldrin	0.3	
alpha-Chlordane	NA	
gamma-Chlordane	NA	
4,4'-DDT	0.001	
4,4'-DDE	10.5	
4,4'-DDD	0.0064	
Dieldrin	0.0019	
Endrin	0.0023	
Endrin aldehyde	NA	
Endrin ketone	NA	
alpha-BHC	500	
beta-BHC	5000	
delta-BHC	0.08	Value for gamma-BHC
gamma-BHC (lindane)	0.08	
Heptachlor	0.0038	
Heptachlor epoxide	0.0038	
Endosulfan I	0.056	
Endosulfan II	0.056	
Endosulfan sulfate	NA	
Methoxychlor	0.03	
Toxaphene	0.0002	
<b>Total Inorganics:</b>	0	
Arsenic	190	Trivalent (+3) form
Barium	NA	
Cadmium	0.161931454	Hardness = 50 mg CaCO3/L (default)(2)
Chromium (Total)	NA	
Lead	1.316537634	Hardness = 50 mg CaCO3/L (default)
Mercury	0.012	
Selenium	5	
Silver	0.012	

**Notes:**

NA = Not Applicable/ Not Established

NCDENR = North Carolina Department of Environment and Natural Resources

(2) Hardness based calculation updated to reflect current ambient water quality criteria (USEPA 2002).

**TABLE 7-2**  
**USEPA REGION IV ECOLOGICAL SCREENING VALUES**  
**SWMU 360**  
**RCRA FACILITY INVESTIGATION (CTO-0143)**  
**MCB CAMP LEJUENE, NORTH CAROLINA**

Analyte	North Carolina	
	Surface Water Quality Standard for Aquatic Life - Fresh Water <sup>(2)</sup>	
	(ug/L)	Comment
<b>Volatile Organics:</b>		
1,1,1-Trichloroethane	NA	
1,1,2,2-Tetrachloroethane	NA	
1,1,2-Trichloro-1,2,2-trifluoroethane	NA	
1,1,2-Trichloroethane	NA	
1,1-Dichloroethane	NA	
1,1-Dichloroethene	NA	
1,2-Dibromoethane	NA	
1,2-Dibromo-3-chloropropane (DBCP)	NA	
1,2-Dichloroethane	NA	
1,2-Dichloropropane	NA	
2-Butanone	NA	
2-Hexanone	NA	
4-Methyl-2-Pentanone	NA	
Acetone	NA	
Benzene	NA	
Bromodichloromethane	NA	
Bromoform	NA	
Bromomethane	NA	
Carbon Disulfide	NA	
Carbon Tetrachloride	0.4	
Chlorobenzene	NA	
Chloroethane	NA	
Chloroform	NA	
Chloromethane	NA	
cis-1,2-Dichloroethene	NA	
cis-1,3-Dichloropropene	NA	
Cyclohexane	NA	
Dibromochloromethane	NA	
Dichlorodifluoromethane	NA	
Ethylbenzene	NA	
Methyl tert-butyl ether	NA	
Isopropylbenzene (Cumene)	NA	
Methyl Acetate	NA	
Methyl Cyclohexane	NA	
Methylene Chloride	NA	
Styrene	NA	
Tetrachloroethene	NA	
Toluene	0.36	
trans-1,2-Dichloroethene	NA	
trans-1,3-Dichloropropene	NA	
Trichloroethene (TCE)	NA	
Trichlorofluoromethane	NA	
Vinyl Chloride	NA	
Xylene (Total)	NA	
<b>Semivolatile Organics:</b>	NA	
1,1'-Biphenyl	NA	
1,2,4-Trichlorobenzene	NA	
1,2-Dichlorobenzene	NA	
1,3-Dichlorobenzene	NA	
1,4-Dichlorobenzene	NA	
2,2'-Oxybis (1-Chloropropane)	NA	
2,4,5-Trichlorophenol	NA	
2,4,6-Trichlorophenol	NA	
2,4-Dichlorophenol	NA	
2,4-Dimethylphenol	NA	
2,4-Dinitrophenol	NA	
2,4-Dinitrotoluene	NA	
2,6-Dinitrotoluene	NA	

TABLE 7-2  
 USEPA REGION IV ECOLOGICAL SCREENING VALUES  
 SWMU 360  
 RCRA FACILITY INVESTIGATION (CTO-0143)  
 MCB CAMP LEJUENE, NORTH CAROLINA

Analyte	North Carolina	
	Surface Water Quality Standard for Aquatic Life - Fresh Water <sup>(2)</sup>	
	(ug/L)	Comment
<b>Semivolatile Organics (Cont):</b>		
2-Chloronaphthalene	NA	
2-Chlorophenol	NA	
2-Methylnaphthalene	NA	
2-Methylphenol	NA	
2-Nitroaniline	NA	
2-Nitrophenol	NA	
3,3'-Dichlorobenzidine	NA	
3-Nitroaniline	NA	
4,6-Dinitro-2-Methylphenol	NA	
4-Bromophenyl-Phenylether	NA	
4-Chloro-3-Methylphenol	NA	
4-Chloroaniline	NA	
4-Chlorophenyl-Phenylether	NA	
4-Methylphenol	NA	
4-Nitroaniline	NA	
4-Nitrophenol	NA	
Acenaphthene	NA	
Acenaphthylene	NA	
Acetophenone	NA	
Anthracene	NA	
Atrazine	NA	
Benzaldehyde	NA	
Benzo(a)anthracene	NA	
Benzo(a)pyrene	NA	
Benzo(b)fluoranthene	NA	
Benzo(g,h,i)perylene	NA	
Benzo(k)fluoranthene	NA	
bis(2-Chloroethyl)ether	NA	
bis(2-Chloroethoxy)methane	NA	
bis(2-Ethylhexyl)phthalate	NA	
Butylbenzylphthalate	NA	
Caprolactam	NA	
Carbazole	NA	
Chrysene	NA	
Dibenzo(a,h)anthracene	NA	
Dibenzofuran	NA	
Diethylphthalate	NA	
Dimethylphthalate	NA	
Di-n-butylphthalate	NA	
Di-n-octylphthalate	NA	
Fluoranthene	NA	
Fluorene	NA	
Hexachlorobenzene	NA	
Hexachlorobutadiene	NA	
Hexachlorocyclopentadiene	NA	
Hexachloroethane	NA	
Indeno(1,2,3-cd)pyrene	NA	
Isophorone	NA	
Naphthalene	NA	
Nitrobenzene	NA	
n-Nitroso-di-n-propylamine	NA	
n-Nitrosodiphenylamine	NA	
Pentachlorophenol	NA	
Phenanthrene	NA	
Phenol	NA	
Pyrene	NA	
PAHs (total)	NA	

TABLE 7-2  
 USEPA REGION IV ECOLOGICAL SCREENING VALUES  
 SWMU 360  
 RCRA FACILITY INVESTIGATION (CTO-0143)  
 MCB CAMP LEJUENE, NORTH CAROLINA

Analyte	North Carolina	
	Surface Water Quality Standard for Aquatic Life - Fresh Water <sup>(2)</sup>	
	(ug/L)	Comment
<b>PCBs/Pesticides:</b>	NA	
Aldrin	0.002	
alpha-Chlordane	NA	
gamma-Chlordane	NA	
4,4'-DDT	0.001	
4,4'-DDE	NA	
4,4'-DDD	NA	
Dieldrin	0.002	
Endrin	NA	
Endrin aldehyde	NA	
Endrin ketone	NA	
alpha-BHC	NA	
beta-BHC	NA	
delta-BHC	NA	
gamma-BHC (lindane)	0.01	
Heptachlor	NA	
Heptachlor epoxide	NA	
Endosulfan I	NA	
Endosulfan II	NA	
Endosulfan sulfate	NA	
Methoxychlor	0.03	
Toxaphene	0.0002	
<b>Total Inorganics:</b>	NA	
Arsenic	50	
Barium	NA	
Cadmium	0.4	
Chromium (Total)	50	
Lead	25	
Mercury	0.012	
Selenium	5	
Silver	0.06	

**Notes:**

NA = Not Applicable/ Not Established

<sup>(2)</sup> North Carolina Water Quality Standards (North Carolina Administrative Code Title 15A, Subchapter 2L) October 25, 1995

**TABLE 7-3**  
**SELECTION OF ECOLOGICAL COPCs IN GROUNDWATER**  
**SWMU 360**  
**RCRA FACILITY INVESTIGATION (CTO-0143)**  
**MCB CAMP LEJEUNE, NORTH CAROLINA**

Analyte	Contaminant Frequency/Range					NCDENR Freshwater CSV	Maximum Hazard Quotient	North Carolina Freshwater Surface Water Quality Standard	Exceeds NCWQS?	Groundwater COPC?	Contaminant Category
	Frequency of Detection	Range of Positive Detections	Location of Maximum Concentration	Range of Detection Limits	Concentration Used For Screening <sup>(1)</sup>						
<b>VOLATILES (ug/L)</b>											
1,1,1-Trichloroethane	0/11	NA	NA	5U - 10U	10.00	528	0.02	NA	NA	No	
1,1,2,2-Tetrachloroethane	0/11	NA	NA	5U - 10U	10.00	240	0.04	NA	NA	No	
1,1,2-Trichloroethane	0/11	NA	NA	5U - 10U	10.00	940	0.01	NA	NA	No	
1,1,2-Trichlorotrifluoroethane	0/11	NA	NA	5U - 10U	10.00	NA	NA	NA	NA	Yes	4
1,1-Dichloroethane	0/11	NA	NA	5U - 10U	10.00	NA	NA	NA	NA	Yes	4
1,1-Dichloroethene	0/11	NA	NA	5U - 10U	10.00	303	0.03	NA	NA	No	
1,2,4-Trichlorobenzene	1/11	2J - 2J	SWMU360-GW03	5U - 10U	2.00	44.9	0.04	NA	NA	No	
1,2-Dibromo-3-Chloropropane	0/11	NA	NA	5U - 10U	10.00	NA	NA	NA	NA	Yes	4
1,2-Dibromoethane	0/11	NA	NA	5U - 10U	10.00	NA	NA	NA	NA	Yes	4
1,2-Dichlorobenzene	0/11	NA	NA	5U - 10U	10.00	15.8	0.63	NA	NA	No	
1,2-Dichloroethane	0/11	NA	NA	5U - 10U	10.00	2000	<0.01	NA	NA	No	
1,2-Dichloropropane	0/11	NA	NA	5U - 10U	10.00	525	0.02	NA	NA	No	
1,3-Dichlorobenzene	0/11	NA	NA	5U - 10U	10.00	50.2	0.20	NA	NA	No	
1,4-Dichlorobenzene	0/11	NA	NA	5U - 10U	10.00	11.2	0.89	NA	NA	No	
2-Butanone	0/11	NA	NA	10U - 13U	13.00	NA	NA	NA	NA	Yes	4
2-Hexanone	0/11	NA	NA	10U - 13U	13.00	NA	NA	NA	NA	Yes	4
4-Methyl-2-Pentanone	0/11	NA	NA	10U - 13U	13.00	NA	NA	NA	NA	Yes	4
Acetone	0/11	NA	NA	10U - 13U	13.00	NA	NA	NA	NA	Yes	4
Benzene	0/11	NA	NA	5U - 10U	10.00	53	0.19	NA	NA	Yes	4
Bromodichloromethane	0/11	NA	NA	5U - 10U	10.00	NA	NA	NA	NA	No	
Bromoform	0/11	NA	NA	5U - 10U	10.00	293	0.03	NA	NA	Yes	4
Bromomethane	0/11	NA	NA	5U - 10U	10.00	110	0.09	NA	NA	No	
Carbon Disulfide	0/11	NA	NA	5U - 10U	10.00	NA	NA	NA	NA	Yes	4
Carbon Tetrachloride	0/11	NA	NA	5U - 10U	10.00	352	0.03	0.4	Yes	Yes	5
Chlorobenzene	0/11	NA	NA	5U - 10U	10.00	195	0.05	NA	NA	No	
Chloroethane	0/11	NA	NA	5U - 10U	10.00	NA	NA	NA	NA	Yes	4
Chloroform	0/11	NA	NA	5U - 10U	10.00	289	0.03	NA	NA	No	
Chloromethane	0/11	NA	NA	5U - 10U	10.00	5500	<0.01	NA	NA	No	
cis-1,2-Dichloroethene	9/11	2.4J - 750DL	1817-MW01	10U	750.00	NA	NA	NA	NA	Yes	3
cis-1,3-Dichloropropene	0/11	NA	NA	5U - 10U	10.00	24.4	0.41	NA	NA	No	
Cyclohexane	0/11	NA	NA	5U - 10U	10.00	NA	NA	NA	NA	Yes	4
Dibromochloromethane	0/11	NA	NA	5U - 10U	10.00	NA	NA	NA	NA	Yes	4
Dichlorodifluoromethane	0/11	NA	NA	5U - 10U	10.00	NA	NA	NA	NA	Yes	4
Ethyl Benzene	0/11	NA	NA	5U - 10U	10.00	453	0.02	NA	NA	No	
Isopropylbenzene	0/11	NA	NA	5U - 10U	10.00	NA	NA	NA	NA	Yes	4
Methyl Acetate	0/11	NA	NA	5U - 10U	10.00	NA	NA	NA	NA	Yes	4
Methyl tert-butyl Ether	0/11	NA	NA	5U - 10U	10.00	NA	NA	NA	NA	Yes	4
Methylcyclohexane	0/11	NA	NA	5U - 10U	10.00	NA	NA	NA	NA	Yes	4

TABLE 7-3  
SELECTION OF ECOLOGICAL COPCs IN GROUNDWATER  
SWMU 360  
RCRA FACILITY INVESTIGATION (CTO-0143)  
MCB CAMP LEJEUNE, NORTH CAROLINA

Analyte	Contaminant Frequency/Range					NCDENR Freshwater CSV	Maximum Hazard Quotient	North Carolina Freshwater Surface Water Quality Standard	Exceeds NCWQS?	Groundwater COPC?	Contaminant Category
	Frequency of Detection	Range of Positive Detections	Location of Maximum Concentration	Range of Detection Limits	Concentration Used For Screening <sup>(1)</sup>						
<b>VOLATILES (ug/L)(Cont.):</b>											
Methylene Chloride	0/11	NA	NA	5U - 10U	10.00	1930	<0.01	NA	NA	No	
Styrene	0/11	NA	NA	5U - 10U	10.00	NA	NA	NA	NA	Yes	4
Tetrachloroethene	5/10	17 - 5100DL	1817-MW01	5U - 10U	5100.00	84	60.71	NA	NA	Yes	1
Toluene	0/11	NA	NA	5U - 10U	10.00	175	0.06	0.36	Yes	Yes	5
trans-1,2-Dichloroethene	1/11	3J - 3J	1817-MW01	5U - 10U	3.00	1350	<0.01	NA	NA	No	
trans-1,3-Dichloropropene	0/11	NA	NA	5U - 10U	10.00	24.4	0.41	NA	NA	No	
Trichloroethene	8/11	5 - 460DL	1817-MW01	10U	460.00	NA	NA	NA	NA	Yes	3
Trichlorofluoromethane	0/11	NA	NA	5U - 10U	10.00	NA	NA	NA	NA	Yes	4
Vinyl Chloride	0/11	NA	NA	5U - 10U	10.00	NA	NA	NA	NA	Yes	4
Xylenes, total	0/11	NA	NA	5U - 15U	15.00	NA	NA	NA	NA	Yes	4
<b>SEMIVOLATILES (ug/L)</b>											
1,1-Biphenyl	0/7	NA	NA	10UJ - 11U	11.00	NA	NA	NA	NA	Yes	4
2,2-oxybis(1-Chloropropane)	0/7	NA	NA	10UJ - 11U	11.00	NA	NA	NA	NA	Yes	4
2,4,5-Trichlorophenol	0/7	NA	NA	10UJ - 11U	11.00	NA	NA	NA	NA	Yes	4
2,4,6-Trichlorophenol	0/7	NA	NA	10UJ - 11U	11.00	3.2	3.44	NA	NA	Yes	2
2,4-Dichlorophenol	0/7	NA	NA	10UJ - 11U	11.00	36.5	0.30	NA	NA	No	
2,4-Dimethylphenol	0/7	NA	NA	10UJ - 11U	11.00	21.2	0.52	NA	NA	No	
2,4-Dinitrophenol	0/7	NA	NA	21UJ - 56U	56.00	6.2	9.03	NA	NA	Yes	2
2,4-Dinitrotoluene	0/7	NA	NA	10UJ - 11U	11.00	310	0.04	NA	NA	No	
2,6-Dinitrotoluene	0/7	NA	NA	10UJ - 11U	11.00	NA	NA	NA	NA	Yes	4
2-Chloronaphthalene	0/7	NA	NA	10UJ - 11U	11.00	NA	NA	NA	NA	Yes	4
2-Chlorophenol	0/7	NA	NA	10UJ - 11U	11.00	43.8	0.25	NA	NA	No	
2-Methylnaphthalene	0/7	NA	NA	10UJ - 11U	11.00	NA	NA	NA	NA	Yes	4
2-Methylphenol	1/7	1J - 1J	SWMU360-GW04	10UJ - 11U	1.00	NA	NA	NA	NA	Yes	3
2-Nitroaniline	0/7	NA	NA	10UJ - 22U	22.00	NA	NA	NA	NA	Yes	4
2-Nitrophenol	0/7	NA	NA	10UJ - 11U	11.00	3500	<0.01	NA	NA	No	
3+4-Methylphenols	2/7	2J - 4J	SWMU360-GW04	10UJ - 11U	4.00	NA	NA	NA	NA	Yes	3
3,3-Dichlorobenzidine	0/7	NA	NA	20U - 22U	22.00	NA	NA	NA	NA	Yes	4
3-Nitroaniline	0/7	NA	NA	10UJ - 22U	22.00	NA	NA	NA	NA	Yes	4
4,6-Dinitro-2-methylphenol	0/7	NA	NA	20U - 22U	22.00	2.3	9.57	NA	NA	Yes	2
4-Bromophenyl-phenylether	0/7	NA	NA	10UJ - 11U	11.00	12.2	0.90	NA	NA	No	
4-Chloro-3-methylphenol	0/7	NA	NA	10UJ - 11U	11.00	0.3	36.67	NA	NA	Yes	2
4-Chloroaniline	0/7	NA	NA	10UJ - 11U	11.00	NA	NA	NA	NA	Yes	4
4-Chlorophenyl-phenylether	0/7	NA	NA	10UJ - 11U	11.00	NA	NA	NA	NA	Yes	4
4-Nitroaniline	0/7	NA	NA	10UJ - 22U	22.00	NA	NA	NA	NA	Yes	4
4-Nitrophenol	0/7	NA	NA	20U - 22U	22.00	82.8	0.27	NA	NA	No	
Acenaphthene	0/7	NA	NA	10UJ - 11U	11.00	17	0.65	NA	NA	No	
Acenaphthylene	0/7	NA	NA	10UJ - 11U	11.00	NA	NA	NA	NA	Yes	4

TABLE 7-3  
SELECTION OF ECOLOGICAL COPCS IN GROUNDWATER  
SWMU 360  
RCRA FACILITY INVESTIGATION (CTO-0143)  
MCB CAMP LEJEUNE, NORTH CAROLINA

Analyte	Contaminant Frequency/Range					NCDENR Freshwater CSV	Maximum Hazard Quotient	North Carolina Freshwater Surface Water Quality Standard	Exceeds NCWQS?	Groundwater COPC?	Contaminant Category
	Frequency of Detection	Range of Positive Detections	Location of Maximum Concentration	Range of Detection Limits	Concentration Used For Screening <sup>(1)</sup>						
<b>SEMIVOLATILES (ug/L)(Cont.)</b>											
Acetophenone	1/7	1J - 1J	SWMU360-GW04	10UJ - 11U	1.00	NA	NA	NA	NA	Yes	3
Anthracene	0/7	NA	NA	10UJ - 11U	11.00	NA	NA	NA	NA	Yes	4
Atrazine	0/7	NA	NA	10UJ - 11U	11.00	NA	NA	NA	NA	Yes	4
Benzaldehyde	0/7	NA	NA	10UJ - 11U	11.00	NA	NA	NA	NA	Yes	4
Benzo(a)anthracene	0/7	NA	NA	10UJ - 11U	11.00	NA	NA	NA	NA	Yes	4
Benzo(a)pyrene	0/7	NA	NA	10UJ - 11U	11.00	NA	NA	NA	NA	Yes	4
Benzo(b)fluoranthene	0/7	NA	NA	10UJ - 11U	11.00	NA	NA	NA	NA	Yes	4
Benzo(g,h,i)perylene	0/7	NA	NA	10UJ - 11U	11.00	NA	NA	NA	NA	Yes	4
Benzo(k)fluoranthene	0/7	NA	NA	10UJ - 11U	11.00	NA	NA	NA	NA	Yes	4
Butylbenzylphthalate	0/7	NA	NA	10UJ - 11U	11.00	22	0.50	NA	NA	No	
Caprolactam	0/7	NA	NA	10UJ - 11U	11.00	NA	NA	NA	NA	Yes	4
Carbazole	0/7	NA	NA	10UJ - 11U	11.00	NA	NA	NA	NA	Yes	4
Chrysene	0/7	NA	NA	10UJ - 11U	11.00	NA	NA	NA	NA	Yes	4
Di-n-butylphthalate	0/7	NA	NA	10UJ - 11U	11.00	9.4	1.17	NA	NA	Yes	2
Di-n-octyl phthalate	0/7	NA	NA	10UJ - 11U	11.00	0.3	36.67	NA	NA	Yes	2
Dibenz(a,h)anthracene	0/7	NA	NA	10UJ - 11U	11.00	NA	NA	NA	NA	Yes	4
Dibenzofuran	0/7	NA	NA	10UJ - 11U	11.00	NA	NA	NA	NA	Yes	4
Diethylphthalate	0/7	NA	NA	10UJ - 11U	11.00	521	0.02	NA	NA	No	
Dimethylphthalate	0/7	NA	NA	10UJ - 11U	11.00	330	0.03	NA	NA	No	
Fluoranthene	0/7	NA	NA	10UJ - 11U	11.00	39.8	0.28	NA	NA	No	
Fluorene	1/7	0.9J - 0.9J	SWMU360-GW04	10UJ - 11U	0.90	NA	NA	NA	NA	Yes	3
Hexachlorobenzene	0/7	NA	NA	10UJ - 11U	11.00	NA	NA	NA	NA	Yes	4
Hexachlorobutadiene	0/7	NA	NA	10UJ - 11U	11.00	0.93	11.83	NA	NA	Yes	2
Hexachlorocyclopentadiene	0/7	NA	NA	10UJ - 11U	11.00	0.07	157.14	NA	NA	Yes	2
Hexachloroethane	0/7	NA	NA	10UJ - 11U	11.00	9.8	1.12	NA	NA	Yes	2
Indeno(1,2,3-cd)pyrene	0/7	NA	NA	10UJ - 11U	11.00	NA	NA	NA	NA	Yes	4
Isophorone	0/7	NA	NA	10UJ - 11U	11.00	1170	<0.01	NA	NA	No	
N-Nitroso-di-n-propylamine	0/7	NA	NA	10UJ - 11U	11.00	NA	NA	NA	NA	Yes	4
N-Nitrosodiphenylamine	0/7	NA	NA	10UJ - 11U	11.00	58.5	0.19	NA	NA	No	
Naphthalene	0/7	NA	NA	10UJ - 11U	11.00	62	0.18	NA	NA	No	
Nitrobenzene	0/7	NA	NA	10UJ - 11U	11.00	270	0.04	NA	NA	No	
Pentachlorophenol	0/7	NA	NA	20U - 22U	22.00	12,794	1.72	NA	NA	Yes	2
Phenanthrene	2/7	0.9J - 4J	SWMU360-GW04	10UJ - 11U	4.00	NA	NA	NA	NA	Yes	3
Phenol	0/7	NA	NA	10UJ - 11U	11.00	256	0.04	NA	NA	No	
Pyrene	0/7	NA	NA	10UJ - 11U	11.00	NA	NA	NA	NA	Yes	4
bis(2-Chloroethoxy)methane	0/7	NA	NA	10UJ - 11U	11.00	NA	NA	NA	NA	Yes	4
bis(2-Chloroethyl)ether	0/7	NA	NA	10UJ - 11U	11.00	2380	<0.01	NA	NA	No	
bis(2-Ethylhexyl)phthalate	0/7	NA	NA	10UJ - 11U	11.00	0.299	36.79	NA	NA	Yes	2

TABLE 7-3  
SELECTION OF ECOLOGICAL COPCs IN GROUNDWATER  
SWMU 360  
RCRA FACILITY INVESTIGATION (CTO-0143)  
MCB CAMP LEJEUNE, NORTH CAROLINA

Analyte	Contaminant Frequency/Range				NCDENR Freshwater CSV	Maximum Hazard Quotient	North Carolina Freshwater Surface Water Quality Standard	Exceeds NCWQS?	Groundwater COPC?	Contaminant Category	
	Frequency of Detection	Range of Positive Detections	Location of Maximum Concentration	Range of Detection Limits							Concentration Used For Screening <sup>(1)</sup>
<b>PESTICIDES (ug/L)</b>											
4,4-DDD	0/11	NA	NA	0.1UJ - 1UJ	1.00	0.0064	156.25	NA	NA	Yes	2
4,4-DDE	1/11	0.24J - 0.24J	SWMU360-GW01	0.1UJ - 0.5UJ	0.24	10.5	0.02	NA	NA	No	
4,4-DDT	1/11	0.11J - 0.11J	SWMU360-GW01	0.1UJ - 1.5U	0.11	0.001	110.00	0.001	Yes	Yes	1, 5
Aldrin	1/11	0.14J - 0.14J	SWMU360-GW01	0.05U - 0.25U	0.14	0.3	0.47	0.002	Yes	Yes	5
alpha-BHC	1/11	0.015J - 0.015J	SWMU360-GW02	0.05UJ - 0.25U	0.02	500	<0.01	NA	NA	No	
alpha-Chlordane	1/11	0.088J - 0.088J	SWMU360-GW01	0.051UJ - 0.5U	0.09	NA	NA	NA	NA	Yes	3
beta-BHC	1/11	1.6J - 1.6J	SWMU360-GW04	0.051UJ - 0.1UJ	1.60	5000	<0.01	NA	NA	No	
delta-BHC	2/11	0.18J - 0.19J	SWMU360-GW01	0.05UJ - 0.052UJ	0.19	0.08	2.38	NA	NA	Yes	1
Dieldrin	0/11	NA	NA	0.1UJ - 0.5U	0.50	0.0019	263.16	0.002	Yes	Yes	2, 5
Endosulfan I	0/11	NA	NA	0.051UJ - 0.5U	0.50	0.056	8.93	NA	NA	Yes	2
Endosulfan II	0/11	NA	NA	0.1UJ - 1U	1.00	0.056	17.86	NA	NA	Yes	2
Endosulfan Sulfate	0/11	NA	NA	0.1UJ - 1U	1.00	NA	NA	NA	NA	Yes	4
Endrin	0/11	NA	NA	0.1UJ - 1U	1.00	0.0023	434.78	NA	NA	Yes	2
Endrin aldehyde	0/11	NA	NA	0.1UJ - 1U	1.00	NA	NA	NA	NA	Yes	4
Endrin ketone	0/11	NA	NA	0.1UJ - 2.5UJ	2.50	NA	NA	NA	NA	Yes	4
gamma-BHC	1/11	0.1J - 0.1J	SWMU360-GW01	0.05U - 0.25U	0.10	0.08	1.25	0.01	Yes	Yes	1, 5
gamma-Chlordane	1/11	0.1J - 0.1J	SWMU360-GW01	0.05U - 0.25U	0.10	NA	NA	NA	NA	Yes	3
Heptachlor	1/11	0.088J - 0.088J	SWMU360-GW01	0.05U - 0.25U	0.09	0.0038	23.16	NA	NA	Yes	1
Heptachlor epoxide	2/11	0.13J - 0.45J	SWMU360-GW04	0.05U - 0.052UJ	0.45	0.0038	118.42	NA	NA	Yes	1
Methoxychlor	0/11	NA	NA	0.5U - 2.5U	2.50	0.03	83.33	0.03	Yes	Yes	2, 5
Toxaphene	0/11	NA	NA	5U - 25U	25.00	0.0002	125000	0.0002	Yes	Yes	2, 5
<b>TOTAL METALS (ug/L)</b>											
Arsenic	1/11	2.6J - 2.6J	SWMU360-GW02	2U - 3.6U	2.60	190	0.01	50	No	No	
Barium	11/11	27.1J - 145J	SWMU360-MW05	NA	145.00	NA	NA	NA	NA	Yes	3
Cadmium	0/11	NA	NA	0.4U - 1U	1.00	0.1619	6.18	0.4	Yes	Yes	2, 5
Chromium	2/11	1.3J - 7.6	SWMU360-GW02	0.5UJ - 0.8U	7.60	NA	NA	50	No	Yes	3
Lead	0/11	NA	NA	1.1U - 2.9U	2.90	1.3165	2.20	25	No	Yes	2
Mercury	0/11	NA	NA	0.1UJ - 0.2U	0.20	0.012	16.67	0.012	Yes	Yes	2, 5
Selenium	4/11	3.25 - 5.7	1817-MW01	2.1UJ - 2.6U	5.70	5	1.14	5	Yes	Yes	1, 5
Silver	0/11	NA	NA	0.5U - 1.7UJ	1.70	0.012	141.67	0.06	Yes	Yes	2, 5

**TABLE 7-3  
SELECTION OF ECOLOGICAL COPCs IN GROUNDWATER  
SWMU 360  
RCRA FACILITY INVESTIGATION (CTO-0143)  
MCB CAMP LEJEUNE, NORTH CAROLINA**

Analyte	Contaminant Frequency/Range				Concentration Used For Screening <sup>(1)</sup>	NCDENR Freshwater CSV	Maximum Hazard Quotient	North Carolina Freshwater Surface Water Quality Standard	Exceeds NCWQS?	Groundwater COPC?	Contaminant Category
	Frequency of Detection	Range of Positive Detections	Location of Maximum Concentration	Range of Detection Limits							

**Notes:**

<sup>(1)</sup> Maximum concentration. If contaminant was not detected, equals the maximum detection limit.

COPC = Contaminant of Potential Concern

CSV = Chronic Screening Value

Hazard Quotient = Contaminant Concentration/ CSV

J = Estimated Value

MDL = Maximum detection limit

mg/L = milligram per liter

NA = Not Available

NCDENR = North Carolina Department of Environment and Natural Resources

NCWQS = North Carolina Water Quality Standard

SQL = Sample quantitation limit

U = Chemical was not detected above the method detection limit

ug/L = microgram per liter

UJ = Chemical was not detected above the method detection limit; method detection limit is an estimated value.

**Contaminant Categories**

- 1 Contaminant was found in concentrations exceeding its screening value.
- 2 Contaminant was not found in concentrations exceeding the SQL; however, the MDL exceed its screening value.
- 3 Contaminant was found in concentrations exceeding its SQL; however, there is no current screening value for the contaminant.
- 4 Contaminant was not found in concentrations exceeding the SQL and there is no current screening value for the contaminant.
- 5 Contaminant's SQL (if not detected) or maximum concentration exceeds the NCWQS.

**TABLE 7-4**  
**MEDIA-SPECIFIC SCREENING VALUES FOR STEP 3A**  
**SWMU 360**  
**RCRA FACILITY INVESTIGATION (CTO-0143)**  
**MCB CAMP LEJUENE, NORTH CAROLINA**

Analyte	Step 3A Surface Water Screening Values - Freshwater		
	(ug/L)	Reference <sup>(1)</sup>	Comment
<b>Volatile Organics:</b>			
1,1,1-Trichloroethane	528		
1,1,2,2-Tetrachloroethane	240		
1,1,2-Trichloro-1,2,2-trifluoroethane	NA		
1,1,2-Trichloroethane	940		
1,1-Dichloroethane	47	USEPA, 2003	
1,1-Dichloroethene	303		
1,2-Dibromoethane	NA		
1,2-Dibromo-3-chloropropane (DBCP)	NA		
1,2-Dichloroethane	2000		
1,2-Dichloropropane	525		
2-Butanone	2,200	USEPA, 2003	
2-Hexanone	99	USEPA, 2003	
4-Methyl-2-Pentanone	170	USEPA, 2003	
Acetone	1,700	USEPA, 2003	
Benzene	53		
Bromodichloromethane	4,320	USEPA, 2003	
Bromoform	293		
Bromomethane	110		
Carbon Disulfide	15	USEPA, 2003	
Carbon Tetrachloride	352		
Chlorobenzene	195		
Chloroethane	NA		
Chloroform	289		
Chloromethane	5500		
cis-1,2-Dichloroethene	NA		
cis-1,3-Dichloropropene	24.4		
Cyclohexane	NA		
Dibromochloromethane	9.7	USEPA, 2003	
Dichlorodifluoromethane	NA		
Ethylbenzene	453		
Methyl tert-butyl ether	11070	USEPA Region III, 2004	
Isopropylbenzene (Cumene)	2.6	USEPA Region III, 2004	
Methyl Acetate	NA		
Methyl Cyclohexane	NA		
Methylene Chloride	1930		
Styrene	32,000	USEPA, 2003	
Tetrachloroethene	84		
Toluene	175		
trans-1,2-Dichloroethene	1350		
trans-1,3-Dichloropropene	24.4		Cis and Trans isomers
Trichloroethene (TCE)	47	USEPA, 2003	
Trichlorofluoromethane	NA		
Vinyl Chloride	930	USEPA, 2003	
Xylene (Total)	27	USEPA, 2003	
<b>Semivolatile Organics:</b>			
1,1'-Biphenyl	14	USEPA Region III, 2004	
1,2,4-Trichlorobenzene	44.9		
1,2-Dichlorobenzene	15.8		
1,3-Dichlorobenzene	50.2		
1,4-Dichlorobenzene	11.2		
2,2'-Oxybis (1-Chloropropane)	NA		
2,4,5-Trichlorophenol	NA		
2,4,6-Trichlorophenol	3.2		
2,4-Dichlorophenol	36.5		
2,4-Dimethylphenol	21.2		
2,4-Dinitrophenol	6.2		
2,4-Dinitrotoluene	310		

TABLE 7-4  
**MEDIA-SPECIFIC SCREENING VALUES FOR STEP 3A**  
**SWMU 360**  
**RCRA FACILITY INVESTIGATION (CTO-0143)**  
**MCB CAMP LEJUENE, NORTH CAROLINA**

Analyte	Step 3A Surface Water Screening Values - Freshwater		
	(ug/L)	Reference <sup>(1)</sup>	Comment
<b>Semivolatile Organics (Cont.):</b>			
2,6-Dinitrotoluene	81	USEPA, 2003	
2-Chloronaphthalene	0.396	USEPA, 2003	
2-Chlorophenol	43.8		
2-Methylnaphthalene	330	USEPA, 2003	
2-Methylphenol	67	USEPA, 2003	
2-Nitroaniline	NA		
2-Nitrophenol	3500		
3,3'-Dichlorobenzidine	4.5	USEPA, 2003	
3-Nitroaniline	NA		
4,6-Dinitro-2-Methylphenol	2.3		
4-Bromophenyl-Phenylether	12.2		
4-Chloro-3-Methylphenol	0.3		
4-Chloroaniline	232	USEPA, 2003	
4-Chlorophenyl-Phenylether	NA		
4-Methylphenol	25	USEPA, 2003	
4-Nitroaniline	NA		
4-Nitrophenol	82.8		
Acenaphthene	17		
Acenaphthylene	4,840	USEPA, 2003	
Acetophenone	NA		
Anthracene	0.035	USEPA, 2003	
Atrazine	1.8	USEPA Region III, 2004	
Benzaldehyde	NA		
Benzo(a)anthracene	0.025	USEPA, 2003	
Benzo(a)pyrene	0.014	USEPA, 2003	
Benzo(b)fluoranthene	9.07	USEPA, 2003	
Benzo(g,h,i)perylene	7.64	USEPA, 2003	
Benzo(k)fluoranthene	NA		
bis(2-Chloroethyl)ether	2380		
bis(2-Chloroethoxy)methane	NA		
bis(2-Ethylhexyl)phthalate	0.30		
Butylbenzylphthalate	22		
Caprolactam	NA		
Carbazole	NA		
Chrysene	NA		
Dibenzo(a,h)anthracene	4	USEPA, 2003	
Dibenzofuran	3.7	USEPA Region III, 2004	
Dibenzothiophene	NA		
Diethylphthalate	521		
Dimethylphthalate	330		
Di-n-butylphthalate	9.4		
Di-n-octylphthalate	0.3		value for bis(2-ethylhexyl)phthalate
Fluoranthene	39.8		
Fluorene	19	USEPA, 2003	
Hexachlorobenzene	0.0003	USEPA, 2003	
Hexachlorobutadiene	0.93		
Hexachlorocyclopentadiene	0.07		
Hexachloroethane	9.8		
Indeno(1,2,3-cd)pyrene	4.31	USEPA, 2003	
Isophorone	1170		
Naphthalene	62		
Nitrobenzene	270		
n-Nitroso-di-n-propylamine	NA		
n-Nitrosodiphenylamine	58.5		
Pentachlorophenol	12.8		pH = 7.8 S.U.
Phenanthrene	3.6	USEPA, 2003	
Phenol	256		

**TABLE 7-4  
 MEDIA-SPECIFIC SCREENING VALUES FOR STEP 3A  
 SWMU 360  
 RCRA FACILITY INVESTIGATION (CTO-0143)  
 MCB CAMP LEJUENE, NORTH CAROLINA**

Analyte	Step 3A Surface Water Screening Values - Freshwater		
	(ug/L)	Reference <sup>(1)</sup>	Comment
<b>Semivolatile Organics (Cont.):</b>			
Pyrene	0.3	USEPA, 2003	
PAHs (total)	17		Value for acenaphthene
<b>PCBs/Pesticides:</b>			
Aldrin	0.3		
alpha-Chlordane	0.0043	NCDENR, 2003	Total Chlordane
gamma-Chlordane	0.0043	NCDENR, 2003	Total Chlordane
4,4'-DDT	0.001		
4,4'-DDE	10.5		
4,4'-DDD	0.0064		
Dieldrin	0.0019		
Endrin	0.0023		
Endrin aldehyde	0.15	USEPA, 2003	
Endrin ketone	NA		
alpha-BHC	500		
beta-BHC	5,000		
delta-BHC	0.08		Value for gamma-BHC
gamma-BHC (lindane)	0.08		
Heptachlor	0.0038		
Heptachlor epoxide	0.0038		
Endosulfan I	0.056		
Endosulfan II	0.056		
Endosulfan sulfate	2.22	USEPA, 2003	
Methoxychlor	0.03		
Toxaphene	0.0002		
<b>Total Inorganics:</b>			
Arsenic	190		Trivalent (+3) form
Barium	220	USEPA, 2003	
Cadmium	0.16	NCDENR 2003, USEPA 2002	Hardness = 50 mg CaCO <sub>3</sub> /L (default) <sup>(2)</sup>
Chromium (Total)	11	NCDENR, 2003	Value for Chromium VI
Lead	1.32		Hardness = 50 mg CaCO <sub>3</sub> /L (default)
Mercury	0.012		
Selenium	5		
Silver	0.012		

**Notes:**

NA = Not Applicable/ Not Established

NCDENR = North Carolina Department of Environment and Natural Resources

USEPA = United States Environmental Protection Agency

<sup>(1)</sup> Non-shaded values are USEPA Region IV screening values obtained from *Guidelines for Performing Screening Level Ecological Risk Assessments within the North Carolina Division of Waste Management* (NCDENR 2003)

<sup>(2)</sup> USEPA Region IV hardness based calculation updated to reflect current ambient water quality criteria (USEPA 2002).

Shading indicates a screening value not included in NCDENR 2003.

**TABLE 7-5**  
**REFINED ASSESSMENT OF ECOLOGICAL CONTAMINANTS OF POTENTIAL CONCERN IN GROUNDWATER**  
**SWMU 360**  
**RCRA FACILITY INVESTIGATION (CTO-0143)**  
**MCB CAMP LEJEUNE, NORTH CAROLINA**

Ecological Contaminant of Potential Concern based on Steps 1 and 2	Contaminant Category <sup>(1)</sup>	Refined Risk Screening					Maximum Concentration in Upgradient Monitoring Wells	Base Background Comparison			Frequency of Detection		Important Bio-accumulative Chemical? <sup>(2)</sup>	Further Evaluation Recommended based on Step 3A?	Comments
		Arithmetic Mean (Half Non-Detects)	Refined Surface Water Screening Value (SWSV) <sup>(3)</sup>	North Carolina Freshwater Surface Water Quality Standard	Refined SWSV Mean HQ <sup>(4)</sup>	NCWQS Mean HQ <sup>(4)</sup>		Maximum Site Concentration	2 X Mean Background <sup>(6)</sup>	Maximum Site Concentration Less than 2X Mean Background?	Frequency of Detection	Contaminant Detected?			
<b>VOLATILES (ug/L)</b>															
1,1,2-Trichlorotrifluoroethane	4	4.0909	NA	NA	NA	NA	ND	ND	NA	NA	0/11	No	No	No	Not Detected
1,1-Dichloroethane	4	4.0909	47	NA	0.09	NA	ND	ND	NA	NA	0/11	No	No	No	Mean HQ < 1.0
1,2-Dibromo-3-Chloropropane	4	4.0909	NA	NA	NA	NA	ND	ND	NA	NA	0/11	No	No	No	Not Detected
1,2-Dibromoethane	4	4.0909	NA	NA	NA	NA	ND	ND	NA	NA	0/11	No	No	No	Not Detected
2-Butanone	4	5.5455	2200	NA	<0.01	NA	ND	ND	NA	NA	0/11	No	No	No	Mean HQ < 1.0
2-Hexanone	4	5.5455	99	NA	0.06	NA	ND	ND	NA	NA	0/11	No	No	No	Mean HQ < 1.0
4-Methyl-2-Pentanone	4	5.5455	170	NA	0.03	NA	ND	ND	NA	NA	0/11	No	No	No	Mean HQ < 1.0
Acetone	4	5.5455	1700	NA	<0.01	NA	ND	ND	NA	NA	0/11	No	No	No	Mean HQ < 1.0
Bromodichloromethane	4	4.0909	4320	NA	<0.01	NA	ND	ND	NA	NA	0/11	No	No	No	Mean HQ < 1.0
Carbon Disulfide	4	4.0909	15	NA	0.27	NA	ND	ND	NA	NA	0/11	No	No	No	Mean HQ < 1.0
Carbon Tetrachloride	5	4.0909	352	0.4	0.01	10.23	ND	ND	NA	NA	0/11	No	No	No	Mean HQ < 1.0
Chloroethane	4	4.0909	NA	NA	NA	NA	ND	ND	NA	NA	0/11	No	No	No	Mean HQ < 1.0
cis-1,2-Dichloroethene	3	98.9	NA	NA	NA	NA	31.00	750.00 DL	NA	NA	9/11	Yes	No	No	See text
Cyclohexane	4	4.0909	NA	NA	NA	NA	ND	ND	NA	NA	0/11	No	No	No	Not Detected
Dibromochloromethane	4	4.0909	9.7	NA	0.42	NA	ND	ND	NA	NA	0/11	No	No	No	Mean HQ < 1.0
Dichlorodifluoromethane	4	4.0909	NA	NA	NA	NA	ND	ND	NA	NA	0/11	No	No	No	Not Detected
Isopropylbenzene	4	4.0909	2.6	NA	1.57	NA	ND	ND	NA	NA	0/11	No	No	No	Not Detected
Methyl Acetate	4	4.0909	NA	NA	NA	NA	ND	ND	NA	NA	0/11	No	No	No	Mean HQ < 1.0
Methyl tert-butyl Ether	4	4.0909	11070	NA	<0.01	NA	ND	ND	NA	NA	0/11	No	No	No	Not Detected
Methylcyclohexane	4	4.0909	NA	NA	NA	NA	ND	ND	NA	NA	0/11	No	No	No	Not Detected
Styrene	4	4.0909	32000	NA	<0.01	NA	ND	ND	NA	NA	0/11	No	No	No	Mean HQ < 1.0
Tetrachloroethene	1	541.55	84	NA	6.45	NA	ND	5100.00 DL	NA	NA	5/10	Yes	No	No	See text
Toluene	5	4.0909	175	0.36	0.02	11.36	ND	ND	NA	NA	0/11	No	No	No	Mean HQ < 1.0
Trichloroethene	3	55.7182	47	NA	1.19	NA	5.50 J	460.00 DL	NA	NA	8/11	Yes	No	No	See text
Trichlorofluoromethane	4	4.0909	NA	NA	NA	NA	ND	ND	NA	NA	0/11	No	No	No	Not Detected
Vinyl Chloride	4	4.0909	930	NA	<0.01	NA	ND	ND	NA	NA	0/11	No	No	No	Mean HQ < 1.0
Xylenes, total	4	5.6818	27	NA	0.21	NA	ND	ND	NA	NA	0/11	No	No	No	Mean HQ < 1.0
<b>SEMI-VOLATILES (ug/L)</b>															
1,1-Biphenyl	4	5.0714	14	NA	0.36	NA	NA	ND	NA	NA	0/7	No	No	No	Mean HQ < 1.0
2,2-oxybis(1-Chloropropane)	4	5.0714	NA	NA	NA	NA	NA	ND	NA	NA	0/7	No	No	No	Not Detected
2,4,5-Trichlorophenol	4	5.0714	NA	NA	NA	NA	NA	ND	NA	NA	0/7	No	No	No	Not Detected
2,4,6-Trichlorophenol	2	5.0714	3.2	NA	1.58	NA	NA	ND	NA	NA	0/7	No	No	No	Not Detected
2,4-Dinitrophenol	2	19.2857	6.2	NA	3.11	NA	NA	ND	NA	NA	0/7	No	No	No	Not Detected
2,6-Dinitrotoluene	4	5.0714	81	NA	0.06	NA	NA	ND	NA	NA	0/7	No	No	No	Mean HQ < 1.0
2-Chloronaphthalene	4	5.0714	0.396	NA	12.81	NA	NA	ND	NA	NA	0/7	No	No	No	Not Detected
2-Methylnaphthalene	4	5.0714	330	NA	0.02	NA	NA	ND	NA	NA	0/7	No	No	No	Mean HQ < 1.0
2-Methylphenol	3	4.5	67	NA	0.01	NA	NA	1.00 J	NA	NA	1/7	Yes	No	No	Mean HQ < 1.0
2-Nitroaniline	4	8.0714	NA	NA	NA	NA	NA	ND	NA	NA	0/7	No	No	No	Not Detected
3+4-Methylphenols	3	4.5	25	NA	0.16	NA	NA	4.00 J	NA	NA	2/7	Yes	No	No	Mean HQ < 1.0
3,3-Dichlorobenzidine	4	10.4286	4.5	NA	2.32	NA	NA	ND	NA	NA	0/7	No	No	No	Not Detected
3-Nitroaniline	4	8.0714	NA	NA	NA	NA	NA	ND	NA	NA	0/7	No	No	No	Not Detected
4,6-Dinitro-2-methylphenol	2	10.4286	2.3	NA	4.53	NA	NA	ND	NA	NA	0/7	No	No	No	Not Detected
4-Chloro-3-methylphenol	2	5.0714	0.3	NA	16.90	NA	NA	ND	NA	NA	0/7	No	No	No	Not Detected
4-Chloroaniline	4	5.0714	232	NA	0.02	NA	NA	ND	NA	NA	0/7	No	No	No	Mean HQ < 1.0
4-Chlorophenyl-phenylether	4	5.0714	NA	NA	NA	NA	NA	ND	NA	NA	0/7	No	Yes	No	Not Detected

TABLE 7-5  
 REFINED ASSESSMENT OF ECOLOGICAL CONTAMINANTS OF POTENTIAL CONCERN IN GROUNDWATER  
 SWMU 360  
 RCRA FACILITY INVESTIGATION (CTO-0143)  
 MCB CAMP LEJEUNE, NORTH CAROLINA

Ecological Contaminant of Potential Concern based on Steps 1 and 2	Contaminant Category <sup>(1)</sup>	Refined Risk Screening					Maximum Concentration in Upgradient Monitoring Wells	Base Background Comparison			Frequency of Detection		Important Bio-accumulative Chemical? <sup>(3)</sup>	Further Evaluation Recommended based on Step 3A?	Comments
		Arithmetic Mean (Half Non-Detects)	Refined Surface Water Screening Value (SWSV) <sup>(2)</sup>	North Carolina Freshwater Surface Water Quality Standard	Refined SWSV Mean HQ <sup>(2)</sup>	NCWQS Mean HQ <sup>(2)</sup>		Maximum Site Concentration	2 X Mean Background <sup>(6)</sup>	Maximum Site Concentration Less than 2X Mean Background?	Frequency of Detection	Contaminant Detected?			
<b>SEMIVOLATILES (ug/L)(Cont.)</b>															
4-Nitroaniline	4	8.0714	NA	NA	NA	NA	NA	ND	NA	NA	0/7	No	No	No	Not Detected
Acenaphthylene	4	5.0714	4840	NA	<0.01	NA	NA	ND	NA	NA	0/7	No	Yes	No	Mean HQ < 1.0
Acetophenone	3	4.5	NA	NA	NA	NA	NA	1.00 J	NA	NA	1/7	Yes	No	No	See text
Anthracene	4	5.0714	0.035	NA	144.90	NA	NA	ND	NA	NA	0/7	No	Yes	No	Not Detected
Atrazine	4	5.0714	1.8	NA	2.82	NA	NA	ND	NA	NA	0/7	No	No	No	Not Detected
Benzaldehyde	4	5.0714	NA	NA	NA	NA	NA	ND	NA	NA	0/7	No	No	No	Not Detected
Benzo(a)anthracene	4	5.0714	0.025	NA	202.86	NA	NA	ND	NA	NA	0/7	No	Yes	No	Not Detected
Benzo(a)pyrene	4	5.0714	0.014	NA	362.24	NA	NA	ND	NA	NA	0/7	No	Yes	No	Not Detected
Benzo(b)fluoranthene	4	5.0714	9.07	NA	0.56	NA	NA	ND	NA	NA	0/7	No	Yes	No	Mean HQ < 1.0
Benzo(g,h,i)perylene	4	5.0714	7.64	NA	0.66	NA	NA	ND	NA	NA	0/7	No	Yes	No	Mean HQ < 1.0
Benzo(k)fluoranthene	4	5.0714	NA	NA	NA	NA	NA	ND	NA	NA	0/7	No	Yes	No	Not Detected
Caprolactam	4	5.0714	NA	NA	NA	NA	NA	ND	NA	NA	0/7	No	Yes	No	Not Detected
Carbazole	4	5.0714	NA	NA	NA	NA	NA	ND	NA	NA	0/7	No	No	No	Not Detected
Chrysene	4	5.0714	NA	NA	NA	NA	NA	ND	NA	NA	0/7	No	No	No	Not Detected
Di-n-butylphthalate	2	5.0714	9.4	NA	0.54	NA	NA	ND	NA	NA	0/7	No	Yes	No	Not Detected
Di-n-octyl phthalate	2	5.0714	0.3	NA	16.90	NA	NA	ND	NA	NA	0/7	No	No	No	Mean HQ < 1.0
Dibenz(a,h)anthracene	4	5.0714	4	NA	1.27	NA	NA	ND	NA	NA	0/7	No	Yes	No	Not Detected
Dibenzofuran	4	5.0714	3.7	NA	1.37	NA	NA	ND	NA	NA	0/7	No	Yes	No	Not Detected
Fluorene	3	4.4857	19	NA	0.05	NA	NA	0.90 J	NA	NA	1/7	Yes	No	No	Not Detected
Hexachlorobenzene	4	5.0714	0.0003	NA	16904.67	NA	NA	ND	NA	NA	0/7	No	Yes	No	Mean HQ < 1.0
Hexachlorobutadiene	2	5.0714	0.93	NA	5.45	NA	NA	ND	NA	NA	0/7	No	Yes	No	Not Detected
Hexachlorocyclopentadiene	2	5.0714	0.07	NA	72.45	NA	NA	ND	NA	NA	0/7	No	Yes	No	Not Detected
Hexachloroethane	2	5.0714	9.8	NA	0.52	NA	NA	ND	NA	NA	0/7	No	Yes	No	Not Detected
Indeno(1,2,3-cd)pyrene	4	5.0714	4.31	NA	1.18	NA	NA	ND	NA	NA	0/7	No	Yes	No	Mean HQ < 1.0
N-Nitroso-di-n-propylamine	4	5.0714	NA	NA	NA	NA	NA	ND	NA	NA	0/7	No	Yes	No	Not Detected
Pentachlorophenol	2	10.4286	12.79	NA	0.82	NA	NA	ND	NA	NA	0/7	No	Yes	No	Not Detected
Phenanthrene	3	4.3429	3.6	NA	1.11	NA	NA	4.00 J	NA	NA	2/7	Yes	Yes	No	Mean HQ < 1.0
Pyrene	4	5.0714	0.3	NA	16.90	NA	NA	ND	NA	NA	0/7	No	Yes	No	See text
bis(2-Chloroethoxy)methane	4	5.0714	NA	NA	NA	NA	NA	ND	NA	NA	0/7	No	Yes	No	Not Detected
bis(2-Ethylhexyl)phthalate	2	5.0714	0.299	NA	16.96	NA	NA	ND	NA	NA	0/7	No	No	No	Not Detected
<b>PESTICIDES (ug/L)</b>															
4,4-DDD	2	0.1045	0.0064	NA	16.33	NA	NA	ND	NA	NA	0/11	No	Yes	No	Not Detected
4,4-DDT	1, 5	0.1373	0.001	0.001	130.00	110.00	ND	0.11 J	NA	NA	1/11	Yes	Yes	No	See text
Aldrin	5	0.045	0.3	0.002	0.15	22.50	ND	0.14 J	NA	NA	1/11	Yes	Yes	No	Mean HQ < 1.0
alpha-Chlordane	3	0.0562	0.0043	NA	13.07	NA	ND	0.09 J	NA	NA	1/11	Yes	Yes	No	See text
delta-BHC	1	0.0546	0.08	NA	0.68	NA	ND	0.19 J	NA	NA	2/11	Yes	Yes	No	Mean HQ < 1.0
Dieldrin	2, 5	0.0682	0.0019	0.002	35.89	34.10	ND	ND	NA	NA	0/11	No	Yes	No	Not Detected
Endosulfan I	2	0.0528	0.056	NA	0.94	NA	ND	ND	NA	NA	0/11	No	Yes	No	Mean HQ < 1.0
Endosulfan II	2	0.1045	0.056	NA	1.87	NA	ND	ND	NA	NA	0/11	No	Yes	No	Not Detected
Endosulfan Sulfate	4	0.1045	2.22	NA	0.05	NA	ND	ND	NA	NA	0/11	No	No	No	Mean HQ < 1.0
Endrin	2	0.1045	0.0023	NA	45.43	NA	ND	ND	NA	NA	0/11	No	No	No	Mean HQ < 1.0
Endrin aldehyde	4	0.1045	0.15	NA	0.70	NA	ND	ND	NA	NA	0/11	No	Yes	No	Not Detected
Endrin ketone	4	0.2136	NA	NA	NA	NA	ND	ND	NA	NA	0/11	No	No	No	Mean HQ < 1.0
gamma-BHC	1, 5	0.0414	0.08	0.01	0.52	4.14	ND	0.10 J	NA	NA	1/11	No	No	No	Not Detected
gamma-Chlordane	3	0.0414	0.0043	NA	9.63	NA	ND	0.10 J	NA	NA	1/11	Yes	Yes	No	Mean HQ < 1.0

TABLE 7-5  
 REFINED ASSESSMENT OF ECOLOGICAL CONTAMINANTS OF POTENTIAL CONCERN IN GROUNDWATER  
 SWMU 360  
 RCRA FACILITY INVESTIGATION (CTO-0143)  
 MCB CAMP LEJEUNE, NORTH CAROLINA

Ecological Contaminant of Potential Concern based on Steps 1 and 2	Contaminant Category <sup>(1)</sup>	Refined Risk Screening					Maximum Concentration in Upgradient Monitoring Wells	Base Background Comparison			Frequency of Detection		Important Bio-accumulative Chemical? <sup>(5)</sup>	Further Evaluation Recommended based on Step 3A?	Comments
		Arithmetic Mean (Half Non-Detects)	Refined Surface Water Screening Value (SWSV) <sup>(2)</sup>	North Carolina Freshwater Surface Water Quality Standard	Refined SWSV Mean HQ <sup>(3)</sup>	NCWQS Mean HQ <sup>(3)</sup>		Maximum Site Concentration	2 X Mean Background <sup>(4)</sup>	Maximum Site Concentration Less than 2X Mean Background?	Frequency of Detection	Contaminant Detected?			
<b>PESTICIDES (ug/L)(Cont.)</b>															
Heptachlor	1	0.0403	0.0038	NA	10.61	NA	ND	0.09 J	NA	NA	1/11	Yes	Yes	No	See text
Heptachlor epoxide	1	0.0737	0.0038	NA	19.39	NA	ND	0.45 J	NA	NA	2/11	Yes	Yes	No	See text
Methoxychlor	2, 5	0.3457	0.03	0.03	11.52	11.52	ND	ND	NA	NA	0/11	No	Yes	No	Not Detected
Toxaphene	2, 5	3.4568	0.0002	0.0002	17284.00	17284.00	ND	ND	NA	NA	0/11	No	Yes	No	Not Detected
<b>TOTAL METALS (ug/L)</b>															
Barium	3	52.1545	220	NA	0.24	NA	35.80 J	145.00 J	NA	NA	11/11	Yes	No	No	Mean HQ < 1.0
Cadmium	2, 5	0.3909	0.16	0.4	2.41	0.98	ND	ND	NA	NA	0/11	No	Yes	No	Not Detected
Chromium	3	1.1091	11.00	50	0.10	0.02	ND	7.60	NA	NA	2/11	Yes	Yes	No	Mean HQ < 1.0
Lead	2	0.8045	1.32	25	0.61	0.03	2.10 J	ND	NA	NA	0/11	No	Yes	No	Mean HQ < 1.0
Mercury	2, 5	0.0818	0.012	0.012	6.82	6.82	ND	ND	NA	NA	0/11	No	Yes	No	Not Detected
Selenium	1, 5	2.2773	5	5	0.46	0.46	ND	5.70	NA	NA	4/11	Yes	Yes	No	Mean HQ < 1.0
Silver	2, 5	0.6318	0.012	0.06	52.65	10.53	ND	ND	NA	NA	0/11	No	Yes	No	Not Detected

**Notes:**

HQ = Hazard Quotient

COPC = Ecological Contaminant of Potential Concern

ug/L = microgram per liter

NA = Not Applicable

NE = Note Established

<sup>(1)</sup> See Table 7-3 and text for definitions of contaminant categories.

<sup>(2)</sup> References for alternative screening values are provided on Table 7-4.

<sup>(3)</sup> The mean HQ represents the mean (half non-detect) concentration divided by the screening value. In cases where the mean exceeds the maximum the maximum value is used.

<sup>(4)</sup> The background concentration presented is for shallow portions of the surficial aquifer (Base Background Groundwater Investigation [Baker 2002]).

<sup>(5)</sup> Compound is identified as an "important bioaccumulative chemical" in the USEPA document *Bioaccumulation Testing and Interpretation for the Purpose of Sediment Quality Assessment, Status and Needs* (EPA-823-R-00-001, February 2000).



**Baker**

*Baker Environmental, Inc.*

**SECTION 7.0**

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*FIGURES*



**FIGURE 7-1**  
**RCRA FACILITY INVESTIGATION**  
**AERIAL VIEW**  
**SWMU 360, CTO-143**  
**MARINE CORPS BASE, CAMP LEJEUNE**  
**NORTH CAROLINA**

**LEGEND**

- - SWMU LOCATION

SOURCE: MCB CAMP LEJEUNE MARCH 2000

