Engineering Evaluation/Cost Analysis for Non-Time Critical Removal Action at D-6, 50-Foot Indoor Rifle and Pistol Range – UXO-01, Former Building 451

Marine Corps Base Camp Lejeune

Onslow County, North Carolina

Naval Facilities Engineering Command Mid-Atlantic

Contract Number N62472-03-D-0057

Contract Task Order 163

October 2010

021005/P

FINAL
ENGINEERING EVALUATION/COST ANALYSIS FOR NON-TIME CRITICAL REMOVAL ACTION AT D-6, 50-FOOT INDOOR RIFLE AND PISTOL RANGE- UXO-01, FORMER BUILDING 451

MARINE CORPS BASE CAMP LEJEUNE
ONSLOW COUNTY, NORTH CAROLINA

COMPREHENSIVE LONG-TERM
ENVIRONMENTAL ACTION NAVY (CLEAN) CONTRACT

Submitted to:
Naval Facilities Engineering Command Mid-Atlantic
Marine Corps North Carolina IPT
6506 Hampton Boulevard
Norfolk, Virginia 23508

Submitted by:
Tetra Tech NUS, Inc.
234 Mall Boulevard, Suite 260
King of Prussia, Pennsylvania 19406

CONTRACT NUMBER N62472-03-D-0057
CONTRACT TASK ORDER 163

OCTOBER 2010

PREPARED UNDER DIRECTION OF:

RICK BARRINGER
PROJECT MANAGER
TETRA TECH NUS, INC.
PITTSBURGH, PENNSYLVANIA

APPROVED FOR SUBMISSION BY:

JOHN J. TREPANOWSKI, P.E.
PROGRAM MANAGER
TETRA TECH NUS, INC.
KING OF PRUSSIA, PENNSYLVANIA

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

TABLES

FIGURES

ACRONYMS AND ABBREVIATIONS

ARAR	Applicable or Relevant and Appropriate Requirement
bgs	below ground surface
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CLEAN	Comprehensive Long-Term Environmental Action Navy
CMU	concrete masonry unit
COC	contaminant of concern
COPC	chemical of potential concern
CSF	cancer slope factor
CSM	conceptual site model
CTO	Contract Task Order
DoD	Department of Defense
DOT	Department of Transportation
EE/CA	Engineering Evaluation/Cost Analysis
EEQ	ecological effects quotient
ESL	Ecological Screening Level
FY	Fiscal Year
HMR	Hazardous Materials Regulations
HMTA	Hazardous Material Transportation Act
MC	Munitions Constituents
MCB	Marine Corps Base
MCL	Maximum Contaminant Level
mg/kg	milligram per kilogram
MRP	Munitions Response Program
msl	mean sea level
NC	North Carolina
NCAC	North Carolina Administrative Code
NCGS	North Carolina General Session
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NTCRA	Non-Time-Critical Removal Action
NTU	nephelometric turbidity unit
OSHA	Occupational Safety and Health Administration
OSWER	Office of Solid Waste and Emergency Response

O&M	Operation and Maintenance
PA	Preliminary Assessment
PRG	Preliminary Remediation Goal
RACER	Remedial Action Cost Engineering and Requirements
RAO	Removal Action Objective
RCRA	Resource Conservation and Recovery Act
RfD	reference dose
RSL	Residential Screening Level
SARA	Superfund Amendments and Reauthorization Act
SI	Site Inspection
SRG	Soil Remediation Goal
SSL	Soil Screening Level
TBC	To Be Considered
TSD	treatment, storage, and disposal
TtNUS	Tetra Tech NUS, Inc.
USC	United States Code
µg/L	micrograms per liter
USEPA	United States Environmental Protection Agency
USMC	United States Marine Corps
XRF	X-ray Fluorescence

EXECUTIVE SUMMARY

This Engineering Evaluation/Cost Analysis (EE/CA) report for D-6, 50-Foot Indoor Rifle and Pistol Range, former Building 451 (referred to as D-6, Small Arms Range) at Marine Corps Base (MCB) Camp Lejeune, Onslow County, North Carolina, has been prepared by Tetra Tech NUS, Inc. (TtNUS) to provide the documentation necessary to support a non-time-critical removal action (NTCRA) at the site. The EE/CA and subsequent actions focus on the soil at D-6, Small Arms Range, contaminated with unacceptable concentrations of lead.

The Navy has determined that a NTCRA is necessary at the D-6, Small Arms Range site to remove lead-contaminated soil so that land use restrictions will not be associated with the site. The NTCRA is to be conducted under guidance provided by the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) as amended by the Superfund Amendments and Reauthorization Act (SARA).

The following Removal Action Objective (RAO) has been identified for D-6, Small Arms Range based on the potential risks and conceptual site model:

- Mitigate human health and environmental risks associated with contaminated soil at D-6, Small Arms Range in a manner such that the property is suitable for unrestricted use and unlimited exposure.

Because of the RAO to remediate the D-6, Small Arms Range for unrestricted residential use and because of the contaminant of concern (lead), the following alternatives were developed for evaluation:

- Alternative 1 – No Action
- Alternative 2 – Excavation and Off-Site Disposal
- Alternative 3 – In-Situ Phytoremediation
- Alternative 4 – Ex-Situ Soil Washing

Under Alternative 1, included as a baseline for comparison, no activities to abate the potential risks would be conducted. Under Alternative 2, all of the areas containing unacceptable concentrations of lead would be excavated and transported off site for disposal. Under Alternative 3, all lead-contaminated soil would be excavated and spread over the site at a maximum depth of 6 inches. Plants that hyperaccumulate lead would then be planted on the site. The plants would then be harvested and transported off site for disposal. Under Alternative 4, all of the areas containing unacceptable concentrations of lead would be excavated and treated via soil washing. “Cleaned” soil would be used to backfill the excavated areas.

Wash water from soil washing along with any soil still exceeding applicable criteria would be transported off site for disposal.

The alternatives were compared to each other with respect to their predicted effectiveness in meeting the RAO, implementability, and costs. Alternative 1 would not be effective in meeting the RAO. Alternatives 2 and 4 would be effective in meeting the RAO within a short time period (weeks) of being implemented. Alternative 3 would require years to be effective in achieving the RAO for the site. Alternative 3 would protect human health and the environment in the long term but would require land use controls in the short term. Alternatives 2 and 4 would be protective in both short- and long-term time scales. Alternatives 2 and 4 would quickly remove risks and permanently remove lead from the site. As long as plant biomass was periodically harvested for disposal, Alternative 3 would permanently remove lead and reduce risk over time at the site.

All four alternatives are implementable, with Alternative 2 being the easiest to implement, except Alternate 1, which cannot be chosen. The facilities, equipment, and processes necessary to implement Alternatives 2, 3, and 4 are all readily available. Alternative 2 would be easier to implement than Alternatives 3 or 4, and there are less limitations associated with implementing it. Alternative 3 is more difficult to implement than Alternatives 2 and 4 because it is limited by the rate of biological lead uptake. The successful biological uptake of lead involves more variables than Alternatives 2 and 4 and results in a greater risk of successful implementation. Alternative 4 is more difficult to implement than Alternative 2, but easier than Alternative 3. There are limited risks associated with implementing Alternative 4 although it is a feasible technology for lead removal. A limitation to Alternative 4 is that soil washing typically results in a reduced volume of soil requiring treatment through initial grain size separation. The soil at D-6, Small Arms Range consists of sand that is uniform in size and prevents the volume of contaminated soil requiring treatment from being reduced.

The estimated net present worth costs of the two alternatives are as follows:

- Alternative 1: $0
- Alternative 2: $ 312,000
- Alternative 3: $ 409,000
- Alternative 4: $ 461,000

Of the four alternatives, Alternative 2 is the recommended removal action for D-6, Small Arms Range.

1.0 INTRODUCTION

Tetra Tech NUS, Inc. (TtNUS) has prepared this Engineering Evaluation/Cost Analysis (EE/CA) for the former D-6, 50-Foot Indoor Rifle and Pistol Range, former Building 451 (referred to as D-6, Small Arms Range), located within Marine Corps Base (MCB) Camp Lejeune, Onslow County, North Carolina, for Naval Facilities Engineering Command Mid-Atlantic under the Comprehensive Long-Term Environmental Action Navy (CLEAN) Contract Number N62472-03-D-0057, Contract Task Order (CTO) 163. The Navy has determined that a non-time-critical removal action (NTCRA) is necessary to abate potential unacceptable risk to human health and to eliminate the potential for contaminant migration to surrounding areas. As described in Section 1.2, this EE/CA has been prepared in general accordance with procedures developed under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) as amended by the Superfund Amendments and Reauthorization Act (SARA).

1.1 PURPOSE AND SCOPE

This EE/CA has been prepared to provide the CERCLA documentation necessary to support an NTCRA at D-6, Small Arms Range. This EE/CA focuses on the lead contamination present in surface and subsurface soil at the site and provides a discussion of the results of previous investigations conducted within the limits of D-6, Small Arms Range and the conceptual site model (CSM) that has been developed based on the results of these investigations.

1.2 REGULATORY FRAMEWORK

The Department of Defense (DoD) has established a program to address closed military ranges, known as the Military Munitions Response Program (MRP). For MRP sites, DoD is following the CERCLA process. TtNUS conducted a Preliminary Assessment (PA) for D-6, Small Arms Range in September 2008, and the results of the PA were used to develop the field program for the Site Inspection (SI). TtNUS completed the SI field work and presented the results in an SI Report dated October 2009 (TtNUS, 2009). Based on the results of the SI, the Navy has determined that a NTCRA is appropriate for D-6, Small Arms Range site.

Under the CERCLA program, an EE/CA is prepared to document the decision-making process associated with a NTCRA. This EE/CA has been prepared using United States Environmental Protection Agency's (USEPA's) Guidance on Conducting NTCRAs Under CERCLA (USEPA, 1993).

The term “removal action” does not necessarily imply that the remedy selected will actually involve the physical removal of materials at the site. As listed in the guidance and outlined in Sections 300.415(b)(2)(i) through (viii) of the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), a “removal action” may potentially include the following:

- Prevention or abatement of actual or potential exposure to nearby human populations, animals, or the food chain from hazardous substances, pollutants, or contaminants.

- Minimization or elimination of the effects of weather conditions that may cause hazardous substances, pollutants, or contaminants to migrate or to be released.

- Treatment or elimination of high levels of hazardous substances, pollutants, or contaminants in soil largely at or near the surface that may migrate.

- Prevention or abatement of actual or potential contamination of drinking water supplies or sensitive ecosystems.

- Stabilization or elimination of hazardous substances in drums, barrels, tanks, or other bulk storage containers that may pose a threat of release.

- Elimination of threat of fire or explosion.

- Determination of availability of other appropriate federal or state response mechanisms to respond to the release.

- Mitigation or abatement of other situations or factors that may pose threats to public health, welfare, or the environment.

The first three bulleted items pertain to the conditions associated with D-6, Small Arms Range and are considered in this report.

1.3 ORGANIZATION OF THE EE/CA

The report is organized into five sections and three appendices as follows:

- Section 1.0 is this introduction.

- Section 2.0 presents the facility description and site characterization. The site characterization includes information provided in the SI Report (TtNUS, 2009).

- Section 3.0 identifies the Removal Action Objective (RAO) and identifies chemical- and location-specific Applicable or Relevant and Appropriate Requirements (ARARs).

- Section 4.0 discusses potential removal technologies and alternatives and compares the removal action alternatives with respect to their ability to achieve the objective presented in Section 3.0. Section 4.0 also identifies action-specific ARARs that are associated with each removal action alternative being evaluated.

- Section 5.0 presents the recommended alternative.

- Appendix A contains the 2009 SI Report for the D-6, 50-Foot Indoor Rifle and Pistol Range – UXO-01, Former Building 451.

- Appendix B contains the volume calculations associated with the removal action alternatives.

- Appendix C contains cost estimates for the removal action alternatives.

- Appendix D will contain the responses to public and regulator comments on the draft final EE/CA report.

A list of references is also included in this report.

2.0 FACILITY AND SITE BACKGROUND AND PHYSICAL SETTING

This section describes the physical setting, background, history, and features of MCB Camp Lejeune and D-6, Small Arms Range. This section also summarizes the findings and recommendations of the SI and presents the CSM based on the site information. The summaries provided were excerpted from the SI Report (TtNUS, 2009); more details on these summaries can be found in that report.

2.1 SITE LOCATION AND PHYSICAL SETTING

MCB Camp Lejeune is a 156,000-acre installation located in the Atlantic Coastal Plain Physiographic Province in Onslow County, North Carolina, approximately 45 miles south of New Bern and 47 miles north of Wilmington (Figure 2-1). The base covers approximately 236 square miles and is bisected by the New River, which flows in a southeasterly direction and forms a large estuary before entering the Atlantic Ocean. The base is bordered by the City of Jacksonville, North Carolina, and State Route 24 to the north, the Atlantic shoreline to the south and east, and U.S. Route 17 to the west (not including the Greater Sandy Run Area of the base west of U.S. Route 17).

The D-6, Small Arms Range site covers an area of approximately 1 acre inside the main cantonment area (Compartment #31) on the eastern side of the New River, downstream of the Hadnot Point area of the base. The D-6, Small Arms Range site (former Building 451) is located just north of the intersection of I Street and Julian C. Smith Road (previously named River Road), as shown on Figure 2-2.

The firing range was entirely enclosed inside Building 451 and was used for small arms training and qualification testing for small-bore weapons from approximately 1953 to mid-1997. Building 451 was formerly located on the northwestern side of I Street between Building 429 and Building 430 (see Figure 2-2). The D-6, Small Arms Range site included 50-foot and 75-foot firing lines inside the building structure. The building was demolished in December 1998. The area disturbed by the building demolition and removal did not extend into the mature forested area surrounding the former building site.

2.2 SITE HISTORY AND BACKGROUND

The United States Marine Corps (USMC) has conducted small-bore weapons training and marksmanship qualification activities at multiple ranges at MCB Camp Lejeune, including the D-6, Small Arms Range, which has since been demolished and removed from the site.

Construction of MCB Camp Lejeune began in 1941, and during World War II, the installation was used as a training area to prepare Marines for combat. MCB Camp Lejeune served as a combat Marine training center during the Korean and Vietnam conflicts as well as the Gulf War and subsequent Middle Eastern activities. Sections 2.2.1 and 2.2.2 describe in detail the construction and eventual destruction of D-6, Small Arms Range, as excerpted from the 2009 SI Report.

2.2.1 Development and Construction of D-6, Small Arms Range

Building 451 consisted of metal sheeting on a steel frame (Butler Building) and was constructed in November 1952. The original design blueprints, dated April 25, 1952, indicate outside dimensions of 120 feet, 6 inches long (oriented southwest to northeast) by 40 feet wide. Photographs and drawing details shown on the building demolition plan dated July 9, 1997, indicate that the building entrance was on the southeastern corner and that the direction of small arms fire was to the northeast. This drawing indicates that the northeastern end of the building and approximately 86 feet along the southeastern and northwestern walls were lined with concrete masonry unit (CMU) walls inside the Butler Building sheet metal exterior wall. The CMU walls inside Building 451 were typical cinder block construction, were 12 feet 10 inches high, and extended from the most distant firing line to behind the targets and bullet trap. The 75-foot firing line is consistent with the outside dimensions of the building and the dimensions of the CMU wall lining the inside of the building along the firing range.

The indoor range was equipped with a bullet trap system that consisted of a series of four angled-steel baffle plates suspended from the building's structural steel roof supports. Approximately 8 to 16 inches of sand were placed over a 4-inch layer of gravel directly overlying the foundation slab; the sand thickened downrange, with the northeastern end of the building behind the targets. The sand would catch the expended bullets after they passed through the targets and were deflected by the final steel baffle plate into the bullet trap (sand pit). No records relating to the handling or management of the expended bullets or bullet fragments in the Building 451 bullet trap sand were recovered during the installation archive record search.

2.2.2 Demolition and Removal of D-6, Small Arms Range

Property records indicate that Building 451 was improved in 1985, and building upgrades are believed to have been completed for the ventilation system, electrical supply, and building acoustics, as detailed in Building 451 improvement plans dated June 20, 1983. The demolition plan, dated July 9, 1997, indicates that building demolition included removal of wood-framed structures on the reinforced concrete foundation and slab, including steel siding, CMU walls, partitions, and steel baffle plates. The plan did not

mention how the sand within the building used to stop bullets was disposed. A note also indicates that the area was to be backfilled, raked, and seeded after building demolition and removal, which indicates that non-native soil may have been brought to the site during this process, and any potential surface soil contamination may now be at depth below clean fill.

Since the building demolition in 1998, the area surrounding the former Building 451 has remained undeveloped. A recently installed 8-foot-high chain-link fence around Building 429 to the southwest bisects the southern end of the former B-451 investigation area.

2.3 PREVIOUS REMOVAL ACTIONS

To date, no removal actions under CERCLA have been conducted at theD-6, Small Arms Range site.

2.4 SUMMARY OF INVESTIGATIONS AND PHYSICAL CHARACTERISTICS

This section presents provides a summary of investigations and discusses the physical characteristics of the site. These summaries support the understanding of the CSM for the purposes of development of the RAO for the EE/CA.

2.4.1 Previous Investigations

This following is a summary of the information collected for D-6, Small Arms Range during the SI. The SI Report is provided as Appendix A for reference.

Munitions constituents (MC) consisting of metals (lead, antimony, arsenic, copper, tin, and zinc) were detected at several locations in the investigation area. Lead was the primary MC metal of concern because it is the primary constituent in spent small arms munitions (typically 85 to 96 percent lead by weight) and because of the documented toxicity of lead to both human and ecological receptors. It was determined that concentrations of the other analyzed metals were spatially correlated with lead concentrations.

Lead was detected in 7 of 20 surface soil samples [0 to 0.5 foot below ground surface (bgs)] and four of nine subsurface soil samples (0 to 2 feet bgs) within the main sample grid at concentrations greater than the North Carolina soil screening level (SSL) for residential soil. Soil sample locations are shown on Figure 2-3. A soil tag map is provided as Figure 2-4 and shows the field x-ray fluorescence (XRF) reading and laboratory lead concentrations. The maximum laboratory lead concentration detected was 60,400 milligrams per kilogram (mg/kg) at location SB007. Lead concentrations were greater than the

North Carolina SSL at depths of 2 to 4 feet bgs at sample locations SB005 (1,140 mg/kg) and SB007 (793 mg/kg). No lead concentrations greater than the North Carolina SSL were detected in soil samples at depths greater than 4 feet bgs. Antimony was detected at sample locations SB007 and SB010 at concentrations greater than the North Carolina SSL. Antimony is typically co-located in sample locations with elevated lead concentrations. Sample locations SB007 and SB010 were located in the general area of the bullet trap within the footprint of the former Building 451.

Lead was detected in unfiltered groundwater samples collected from four temporary monitoring wells at concentrations greater than the North Carolina Groundwater Standard of 15 µg/L (see Figure 2-5). Arsenic was detected in one unfiltered groundwater sample (at location TW004) at a concentration greater than the North Carolina SSL. Due to high turbidity in the samples from locations TW004, TW012, and TW019, filtered samples were also collected, and filtered lead concentrations were less than the North Carolina Groundwater Standard. Arsenic concentrations in filtered groundwater samples were less than the North Carolina Groundwater Standard, including the filtered sample at TW004. Differences between filtered and unfiltered lead results in groundwater samples suggest that lead is absorbed to fine silt particles in the groundwater rather than in a dissolved phase.

The human health risk assessment conducted during the SI identified lead, antimony, and arsenic as contaminants of potential concern (COPCs) in surface and subsurface soil and lead and arsenic as COPCs in groundwater. The arithmetic mean concentrations of lead in surface soil, subsurface soil, and unfiltered groundwater exceeded USEPA and North Carolina screening levels. Adverse health effects could be anticipated from exposures to lead in soil and groundwater. Lead, antimony, and zinc were initially selected as surface soil ecological COPCs because maximum detected concentrations exceeded ecological screening levels (ESLs). Lead and antimony were retained as ecological COPCs following further refinement based on specific receptor classes, spatial distribution of chemical concentrations, and average concentrations.

2.4.2 Physical Characteristics

The physical characteristics of MCB Camp Lejeune and D-6, Small Arms Range including topography, geology, hydrology, hydrogeology, ecology, and protected species and lands, is presented in greater detail in Sections 2.3 (Physical Characteristics) and 2.4 (Regional Ecology Summary) of the SI Report (TtNUS,2009) (provided as Appendix A). A summary of this information is provided in the following paragraph.

The site is relatively flat with elevations varying between 11 and 13 feet above mean sea level (msl). Surface soil at the site is primarily fine sand, with loamy sand becoming more prevalent in subsurface soil (to 80 inches bgs). The uppermost undifferentiated formation consists of mostly fine loose to medium dense sands with a lesser amount of silt and clay and is present from land surface to depths of 20 to 30 feet bgs. Surface water runoff at the site is controlled by a drainage ditch along the northwestern side of I Street. Groundwater was encountered at 8 to 10 feet bgs during the SI but has been reported as shallow as 4 to 5 feet bgs.

Vegetation in the site area consists of a mature stand of mixed conifer and deciduous trees, with more recent understory vegetation including pines within the footprint of the former building foundation slab.

2.4.3 Nature and Extent of Contamination

Soil

Lead was detected in 7 of 20 surface soil samples (0 to 0.5 foot bgs) and four of nine subsurface soil samples (0 to 2 feet bgs) within the main sample grid at concentrations greater than the North Carolina SSL for residential soil. The maximum concentration was 60,400 mg/kg. Lead concentrations were greater than the North Carolina SSL at depths of 2 to 4 feet bgs at sample locations SB005 (1,140 mg/kg) and SB007 (793 mg/kg). No lead concentrations exceeding the North Carolina SSL were detected in soil samples at depths greater than 4 feet bgs. Lead concentrations from the three surface soil samples collected within the drainage channel immediately northeast of the site were all less than the North Carolina SSL of 270 mg/kg. Antimony was detected at sample locations SB007 and SB010 at concentrations greater than the North Carolina SSL. Antimony is typically co-located at sample locations where excessive lead concentrations are detected. Sample locations SB007 and SB010 were located in the general area of the bullet trap within the former Building 451.

Groundwater

Lead was detected in all unfiltered samples collected from the temporary groundwater monitoring wells at concentrations greater than the North Carolina Groundwater Standard. Arsenic was detected in one unfiltered groundwater sample (at location TW004) at a concentration greater than the North Carolina SSL. Due to high turbidity in samples from locations TW004, TW012, and TW019, filtered samples were also collected, and the lead concentrations in these samples were less than the North Carolina Groundwater Standard for lead. The arsenic concentration in the filtered sample from TW004 was also less than the North Carolina Groundwater Standard.

2.5 CONCEPTUAL SITE MODEL

The CSM for D-6, Small Arms Range at MCB Camp Lejeune is presented in detail in the SI Report (TtNUS, 2009) and is summarized as follows:

- Lead was the primary MC metal of concern because it is the primary constituent in spent small arms munitions (typically 85 to 96 percent lead by weight) and because of the documented toxicity of lead to human and ecological receptors.

- MC consisting of metals (primarily lead and to a lesser extent antimony, arsenic, copper, tin, and zinc) were detected at several locations in the investigation area. It was determined that the other analyzed metals concentrations were spatially correlated with lead concentrations.

- Maximum lead concentrations were detected primarily in the 0- to 0.5 foot interval of soil. MC (i.e., lead) was detected at concentrations greater than the preliminary remediation goal (PRG) at 7 of the 20 sample locations, and only at two sample locations (SB005 and SB007) were lead concentrations greater than the PRG in soil deeper than 2 feet bgs.

- A drainage ditch is located in the northeastern perimeter of the site. During SI sampling activities there was no water in the drainage ditch, so no surface water samples were collected. However, lead concentrations in the three soil samples collected from the drainage ditch were less than the PRG.

- It has not been completely determined if lead in soil subsequently infiltrated to underlying groundwater. Fixed-base laboratory lead concentrations in groundwater were greater than the 15 µg/L PRG in all four unfiltered groundwater samples; however, lead concentrations in the three groundwater samples filtered through a 0.45-micron filter were less than the PRG. This typically indicates that the lead is adhering to soil particles rather than being in the groundwater. Turbidity levels in the three unfiltered samples were elevated and remained elevated [greater than 300 neuphelometric turbidity units (NTUs)] even after efforts to purge multiple well volumes from the wells. The lead concentration in the unfiltered groundwater sample with a turbidity of 9.7 NTU was 22.2 µg/L (greater than the 15 µg/L PRG).

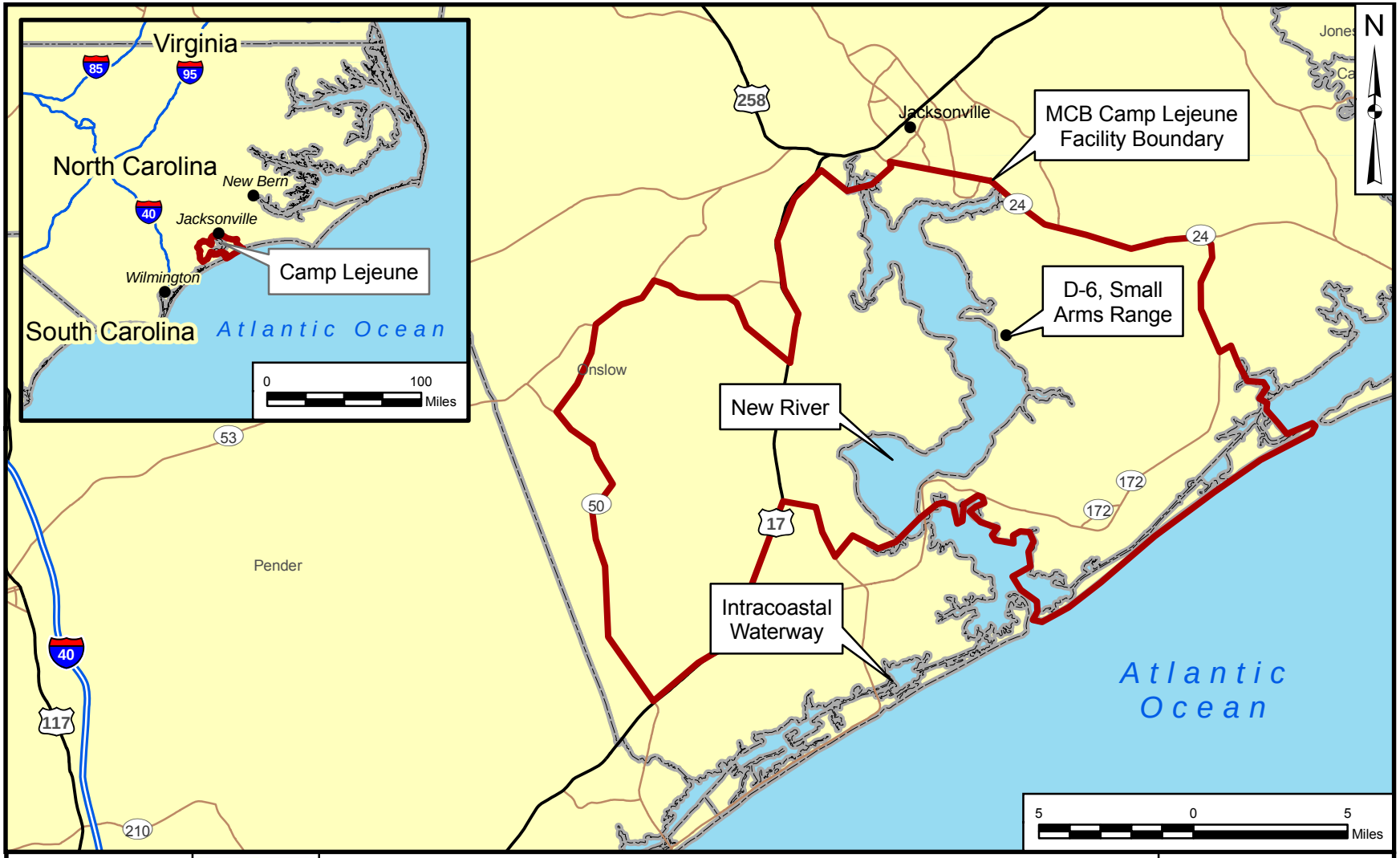
- The CSM indicates that potentially complete exposure pathways for MC exist for human receptors under both current and hypothetical future land uses.

- The human health risk screening identified lead, antimony, and arsenic as COPCs in surface and subsurface soil and lead and arsenic as COPCs in groundwater.

- Comparison to ecological screening levels (ESLs) resulted in lead and antimony being retained as ecological COPCs. Antimony and arsenic detections were determined to be co-located with lead detections.

- Food-chain model ecological effects quotients (EEQs) using average concentrations and average exposure parameters were greater than 1.0 for lead for all ecological receptors (vole, quail, shrew, and woodcock). Similar model EEQs were greater than 1.0 for antimony in only the vole and shrew.

P:\GIS\CAMP_LEJEUNE\MXD\LOCATION_MAP_NF.MXD 03/03/10 JEE



DRAWN BY: J. ENGLISH	DATE: 03/02/10	GENERAL LOCATION MAP D-6, SMALL ARMS RANGE MCB CAMP LEJEUNE ONSLOW COUNTY, NORTH CAROLINA
CHECKED BY: C. METZ	DATE: 03/03/10	CONTRACT NUMBER: CTO 0163
REVISED BY: —	DATE: —	APPROVED BY: — DATE: —
SCALE: AS NOTED	NAVFAC	APPROVED BY: — DATE: —
		FIGURE NO.: FIGURE 2-1 REV: 0

P:\GIS\CAMP_LEJEUNE\MXD\SITE_MAP_2004_NF.MXD 03/03/10 JEE

NOTE: Digital image provided by Camp Lejeune Installation Geospatial and Information Service (IGI&S), East Coast Regional GEOFidelis (Geospatial) Center.

Legend

Topographic Contour (4-ft interval)

DRAWN BY	DATE	
J. ENGLISH	03/03/10	
CHECKED BY	DATE	
C. METZ	03/03/10	
REVISED BY	DATE	
___	___	
SCALE		
AS NOTED		

NAVFAC

SITE LOCATION
D-6, SMALL ARMS RANGE
MCB CAMP LEJEUNE
ONSLOW COUNTY, NORTH CAROLINA

CONTRACT NUMBER	
CTO 0163	
APPROVED BY	DATE
___	___
APPROVED BY	DATE
___	___
FIGURE NO.	REV
FIGURE 2-2	0

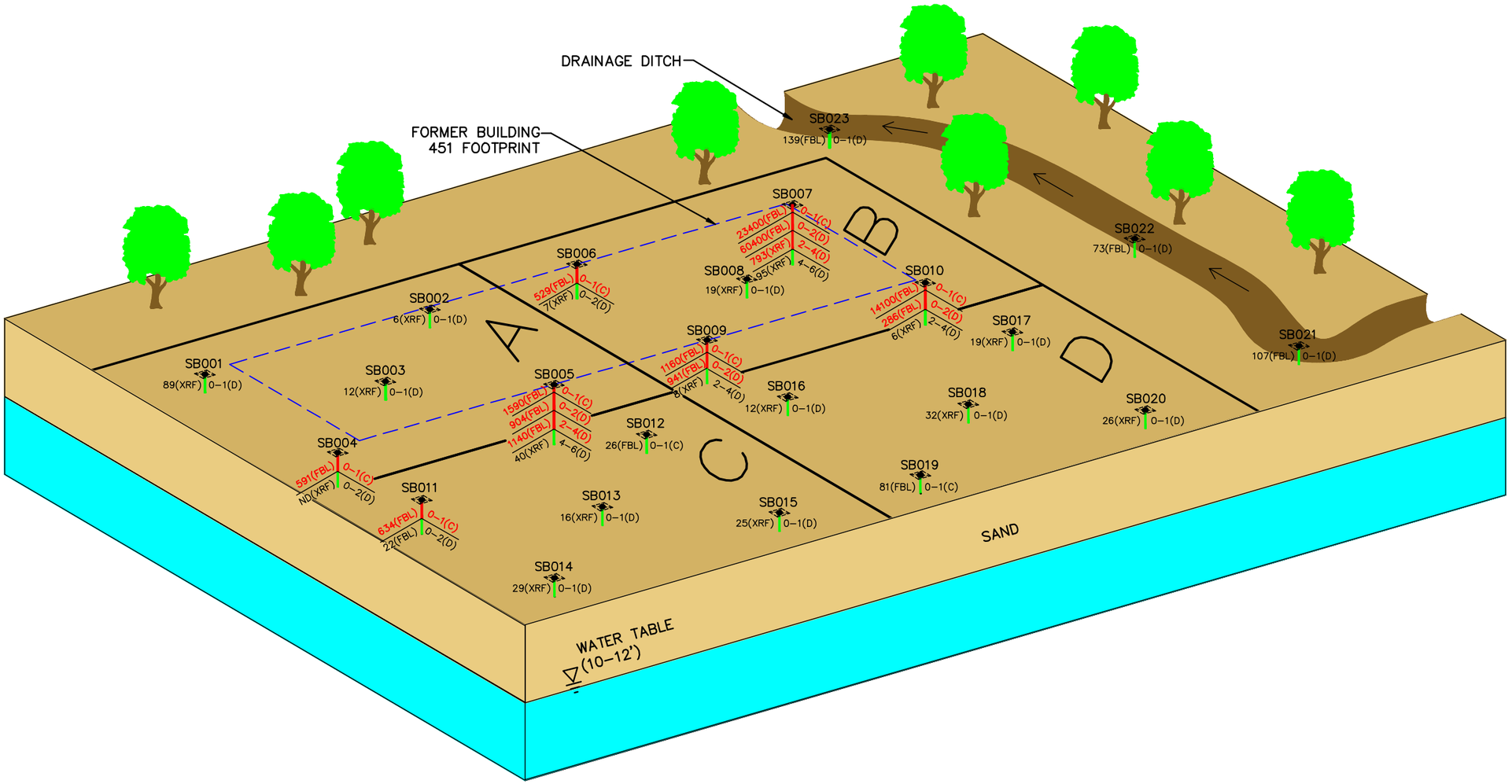
P:\GIS\CAMP_LEJEUNE\MXD\INDOOR_FIRING_RANGE_SAMPLES_NF.MXD 03/03/10 JEE

DRAWN BY / DATE	J, ENGLISH / 03/02/10
CHECKED BY / DATE	C. METZ / 03/03/10
REVISED BY / DATE	___ / ___
SCALE	AS NOTED

NAVFAC

SAMPLE LOCATION MAP
D-6, SMALL ARMS RANGE
MCB CAMP LEJEUNE
ONSLOW COUNTY, NORTH CAROLINA

CONTRACT NUMBER	CTO 0163
APPROVED BY / DATE	___ / ___
APPROVED BY / DATE	___ / ___
FIGURE NO.	FIGURE 2-3
REV	0



LEGEND

ND	NON–DETECT
(D)	DISCRETE SAMPLE
(C)	COMPOSITE SAMPLE
(XRF)	X–RAY FLUORESCENCE RESULT (FIELD READING)
(FBL)	FIXED–BASE LABORATORY RESULT

NOTES:

1.) CONCENTRATIONS ARE IN MG/KG.

2.) SAMPLE DEPTH (I.E. 0–1) IS IN FEET BELOW GROUND SURFACE.

3.) SOIL LEAD CONCENTRATIONS AND BORING SEGMENTS SHOWN IN RED INDICATE LEVELS ABOVE PROJECT ACTION LIMITS.

4.) BORING SEGMENTS SHOWN IN GREEN CONTAINED LEAD AT CONCENTRATIONS BELOW PROJECT ACTION LIMITS.

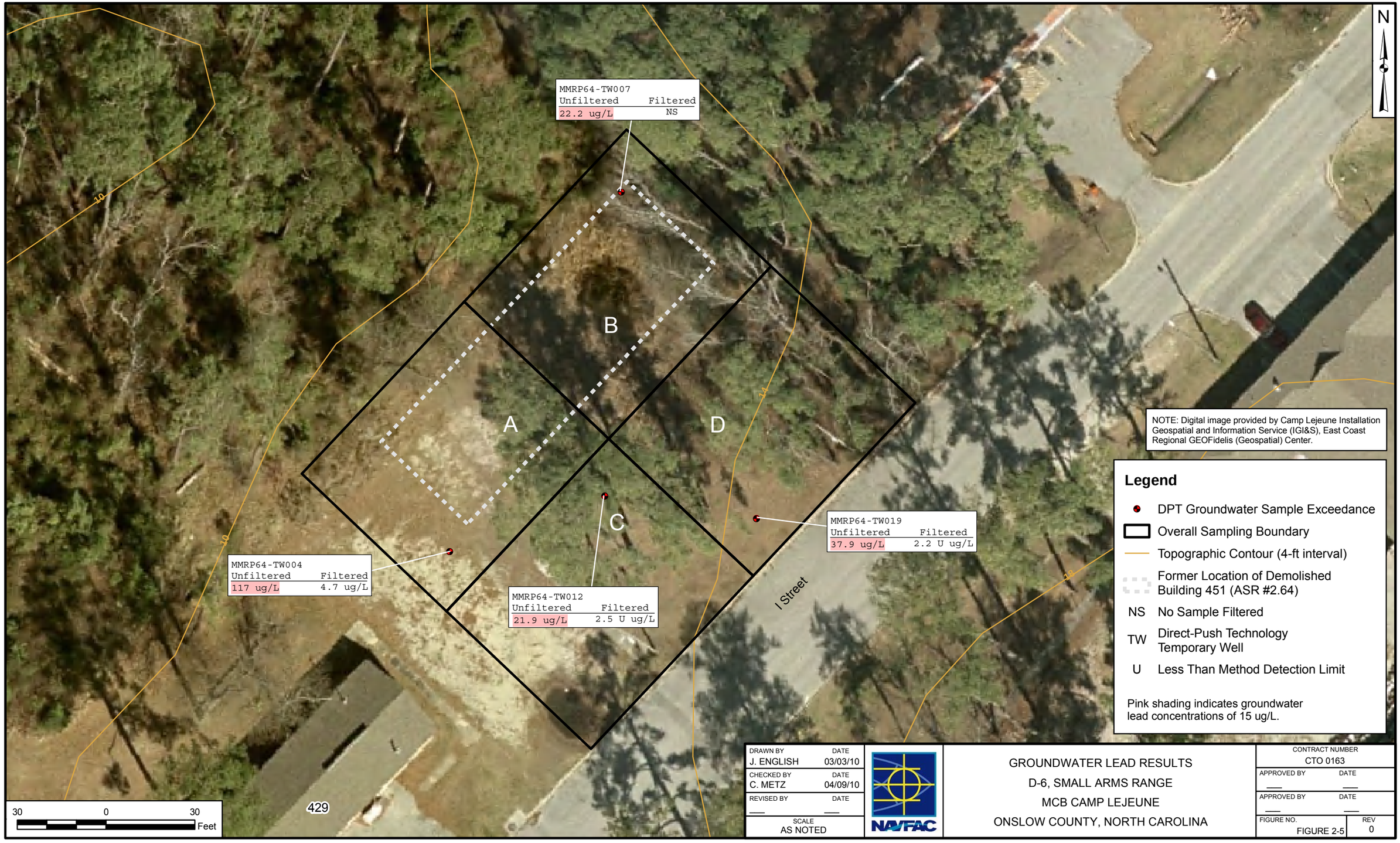
DRAWN BY CK	DATE 2–17–10	SOIL LEAD CONCENTRATIONS D–6, SMALL ARMS RANGE (FORMER BUILDING 451) MCB CAMP LEJEUNE ONSLOW COUNTY, NORTH CAROLINA
CHECKED BY	DATE	
REVISED BY	DATE	
SCALE NTS		

NAVFAC

CONTRACT NO.	1716
OWNER NO.	
APPROVED BY	DATE
DRAWING NO.	FIGURE 2–4
REV.	0

R:\1716\Figures\1716FG05.dwg PIT CARLY.KRAMER 2/17/2010 11:35:53 AM

P:\GIS\CAMP_LEJEUNE\MXD\INDOOR_RANGE_GW_RESULTS_NF.MXD 04/09/10 JEE



NOTE: Digital image provided by Camp Lejeune Installation Geospatial and Information Service (IGI&S), East Coast Regional GEOFidelis (Geospatial) Center.

Legend

- DPT Groundwater Sample Exceedance
- Overall Sampling Boundary
- Topographic Contour (4-ft interval)
- Former Location of Demolished Building 451 (ASR #2.64)
- NS — No Sample Filtered
- TW — Direct-Push Technology Temporary Well
- U — Less Than Method Detection Limit

Pink shading indicates groundwater lead concentrations of 15 ug/L.

DRAWN BY	J. ENGLISH
DATE	03/03/10
CHECKED BY	C. METZ
DATE	04/09/10
REVISED BY	___
DATE	___
SCALE	AS NOTED

NAVFAC

GROUNDWATER LEAD RESULTS
D-6, SMALL ARMS RANGE
MCB CAMP LEJEUNE
ONSLOW COUNTY, NORTH CAROLINA

CONTRACT NUMBER	CTO 0163
APPROVED BY	___
DATE	___
APPROVED BY	___
DATE	___
FIGURE NO.	FIGURE 2-5
REV	0

3.0 IDENTIFICATION OF REMOVAL ACTION OBJECTIVES

RAOs are developed to determine guidance for the removal action and to ensure that the action complies with regulatory requirements. This section provides identification of ARARs, identification of the RAOs, discussion of the removal action scope, and the proposed schedule.

3.1 APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

ARARs are regulatory requirements that may potentially govern remedial activities and are defined as follows:

- Any standard, requirement, criterion, or limitation under federal environmental law.
- Any promulgated standard, requirement, criterion, or limitation under a state environmental or facility-siting law that is more stringent than the associated federal standard, requirement, criterion, or limitation, that either is legally applicable to the CERCLA hazardous substance(s) at the site or is relevant and appropriate under the circumstances of the hazardous substance release.

One of the primary concerns during the development of RAOs for hazardous waste sites under CERCLA is the degree of human health and environmental protection afforded by a given remedy. Section 121 of CERCLA requires that primary consideration be given to remedial alternatives that attain or exceed ARARs. The purpose of this requirement is to ensure that CERCLA response actions are consistent with other pertinent federal and state environmental requirements.

Definitions of the two types of ARARs, as well as To Be Considered (TBC) criteria, are as follows:

- Applicable requirements are those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal or state law that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site.

- Relevant and appropriate requirements are those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal or state law that, although not "applicable," address problems or situations sufficiently similar (relevant) to those encountered at the CERCLA site that their use is well suited (appropriate) to the particular site.

- TBC criteria are non-promulgated non-enforceable guidelines or criteria that may be useful for developing remedial action alternatives and for determining action levels that are protective of human health and/or the environment. Examples of TBC criteria include USEPA Drinking Water Health Advisories, carcinogenic slope factors (CSFs), and reference doses (RfDs).

ARARs and TBCs can be divided into the following three categories, although many requirements are combinations of the three types of ARARs and TBCs:

- Chemical-specific: Health- or risk-based numerical values or methodologies that establish concentration or discharge limits for particular contaminants. In the absence of ARARs, site-based criteria may be developed using guidance provided under USEPA Risk RfDs guidance or USEPA Human Health Assessment Group CSFs.

- Location-specific: Restrictions based on the concentrations of hazardous substances or the conduct of activities in specific locations. These may restrict or preclude certain remedial actions or may apply only to certain portions of sites. Examples of location-specific ARARs are floodplain and wetland management requirements. Location-specific ARARs pertain to special site features.

- Action-specific: Technology- or activity-based controls or restrictions on activities related to management of hazardous substances. Action-specific ARARs pertain to implementing a given remedy.

Chemical- and location-specific ARARs and TBCs for D-6, Small Arms Range are presented in Tables 3-1 and 3-2, respectively. Action-specific ARARs are discussed with the removal action alternative descriptions presented in Section 4.0.

3.2 REMOVAL ACTION OBJECTIVE

The RAO for D-6, Small Arms Range was identified based on the site contaminants and CSM as discussed in Section 2.5. The following RAO has been developed for D-6, Small Arms Range removal action:

- Mitigate human health and environmental risks associated with contaminated soil at D-6, Small Arms Range in a manner such that the property is suitable for unrestricted use and unlimited exposure.

3.3 PRELIMINARY REMEDIATION GOALS DEVELOPMENT

A human health risk assessment (HHRA) and ecological risk assessment (ERA) were conducted during the SI to evaluate risks using North Carolina residential screening levels (RSLs) and USEPA SSLs and RSLs for residential and industrial/commercial land use scenarios. Antimony, arsenic, and lead were identified as COPCs for surface and subsurface soil based on comparison of maximum concentrations to residential screening criteria. Antimony and arsenic detections were co-located with lead detections, which is typical for sites with MC. Therefore, removal of lead-contaminated soil will result in the incidental removal of antimony and arsenic contamination.

Arsenic and lead were identified as COPCs for groundwater in the SI. However, lead and arsenic concentrations appeared to be associated with sample turbidity and not dissolved concentrations. This assumption was supported by the collection of filtered samples, which did not contain concentrations of lead and arsenic in excess of criteria. Remediation of groundwater is not warranted because no groundwater COPCs were selected in the SI. However, the USEPA (Gena Townsend, Remedial Project Manager) provided the following comment, dated December 7, 2009, to the SI report:

> *However, as documented in the subject report, there are groundwater samples that contain concentrations of lead and arsenic above the US EPA and North Carolina screening levels. The report further states "that high total arsenic and lead concentrations are largely associated with the particulates in the groundwater samples." The non time critical removal action should include the collection of groundwater samples after the soils have been removed to substantiate this statement.*

Therefore, post-excavation groundwater monitoring will be included to verify the conclusions of the SI report and to address USEPA concerns.

3.3.1 Cleanup Goals

Cleanup goals are concentrations of contaminants in environmental media that, when attained, should achieve RAOs. In general, cleanup goals are established with consideration to the following:

- Protection of human receptors from adverse health effects
- Protection of the environment from detrimental impacts from site-related contamination
- Compliance with federal and state ARARs

3.3.1.1 Soil Cleanup Goals

North Carolina Soil Remediation Goals (SRGs) were chosen as surface soil and subsurface soil cleanup goals for the COPCs identified in Section 3.3 above. The North Carolina SRGs will be used as the preliminary remediation goals (PRGs).

The soil PRGs are presented below:

- Antimony - 6.3 mg/kg
- Arsenic - 4.4 mg/kg
- Lead - 400 mg/kg

3.4 REMOVAL ACTION SCOPE

The focus of this EE/CA and subsequent removal action is the contaminated soil at D-6, Small Arms Range and the potential risk posed by this contaminated material. To reduce the potential risk associated with D-6, Small Arms Range contaminated soil and to achieve the RAO, the removal action must address soil with concentrations of lead greater than the PRG. For this removal action, the PRG or cleanup goal for lead is 400 mg/kg.

Using this PRG, the areas of soil with concentrations of lead greater than 400 mg/kg are identified on Figure 4-1. The volume of contaminated soil has been estimated based on the areas and approximate thicknesses of contaminated surface soil at the site as 253 cubic yards over a 4,966-square-foot area. Details of the volume and area estimates are presented in Appendix B.

3.5 REMOVAL ACTION SCHEDULE

There are currently no buildings or activities within the former D-6, Small Arms Range site. It would be beneficial to implement the selected removal action alternative while this site remains empty and unused. It is anticipated that this EE/CA will be completed in mid-summer 2010 and that the Action Memorandum will be submitted by fall 2010. Completion of the removal action will occur when funding becomes available for allocation. It is estimated that funding will not become available until approximately Fiscal Year 2011 (FY11) or FY12.

TABLE 3-1

CHEMICAL-SPECIFIC ARARs
D-6, SMALL ARMS RANGE EE/CA
MCB CAMP LEJEUNE, ONSLOW COUNTY, NORTH CAROLINA

Medium/Activity	Requirement/ Citation	Status	Synopsis	Evaluation/Action To Be Taken
State				
Soil/Risk Assessment	Soil Remediation Goals (SRGs)/15A NCAC 02L.0411	Applicable	Establishes maximum soil contaminant concentrations that are protective of human health. Antimony (6.3 mg/kg) Arsenic (4.4 mg/kg) Lead (400 mg/kg)	Preliminary Remediation Goals were selected based on SRGs, which are at a minimum as stringent as USEPA criteria. These values will be used to determine when soil remediation is complete.
Groundwater/Risk Assessment	Groundwater Quality Standards/15A NCAC 02L.0202	Applicable	Establishes maximum groundwater contaminant concentrations that are protective of human health Arsenic (10 µg/L) Lead (15 µg/L)	Contaminant concentrations in post-excavation groundwater samples will be compared to these criteria, which are equal to or more stringent than USEPA Maximum Contaminant Levels (MCLs).

MCLs – Maximum Contaminant Levels
NCAC – North Carolina Administrative Code
SRG – Soil Remediation Goal
USEPA – United States Environmental Protection Agency

TABLE 3-2

LOCATION-SPECIFIC ARARs AND TBCs
D-6, SMALL ARMS RANGE EE/CA
MCB CAMP LEJEUNE, ONSLOW COUNTY, NORTH CAROLINA
PAGE 1 OF 2

Requirement	Citation	Status	Synopsis	Evaluation/Action To Be Taken
Federal				
Other Natural Resources	The Endangered Species Act of 1973 (16 USC 1531, 50 CFR 200, and 50 CFR 402)	Applicable	Provides for consideration of impacts to endangered and threatened species and their critical habitats. Requires federal agencies to ensure that any action carried out by the agency is not likely to jeopardize the continued existence of any endangered or threatened species or adversely affect its critical habitat.	No known endangered or threatened species or critical habitats are known to exist on this site. For this reason, the Endangered Species Act is not considered relevant and appropriate. However, it could become potentially applicable if pre-excavation sampling indicated that the mature forest to the north and west of the site would need to be disturbed.

TABLE 3-2

LOCATION-SPECIFIC ARARs AND TBCs
D-6, SMALL ARMS RANGE EE/CA
MCB CAMP LEJEUNE, ONSLOW COUNTY, NORTH CAROLINA

Requirement	Citation	Status	Synopsis	Evaluation / Action To Be Taken
State				
Other Natural Resources	North Carolina Endangered Species Act – per the North Carolina Wildlife Resources Commission (NCGS 113-331 to 113-337)	Relevant and Appropriate	Similar to the Federal Endangered Species Act but also includes state special concern species, state significantly rare species, and the state watch list.	Should the planned excavation area expand beyond the currently planned boundaries, steps should be taken to ensure that state protected species and habitat are not damaged or destroyed.
	NC Hazardous Waste Management Rules (15A NCAC 13A)	Applicable	Location requirements and land disposal restrictions for hazardous waste excavated, stored, or treated on site.	Should any removed soil classified as hazardous following analytical sampling, state-specific rules would be followed if they are more strict than Federal rules.
	NC Recordation of Inactive Hazardous Substances or Waste Disposal Sites (NCGS 130A-310.8)	Applicable	State requirement for recordation of inactive hazardous waste sites.	Should any soil be deemed hazardous, the site would need to be recorded in the inactive hazardous waste sites list.

Notes:
CFR - Code of Federal Regulations
NCGS – North Carolina General Session
NCAC – North Carolina Administrative code
USC - United States Code

4.0 IDENTIFICATION AND ANALYSIS OF REMOVAL ACTION ALTERNATIVES

4.1 DEVELOPMENT OF ALTERNATIVES

Several technologies and process options were evaluated to achieve the RAO for D-6, Small Arms Range. Table 4-1 summarizes the technology screening process. The following technologies were retained from the technology screening process for development into removal action alternatives:

- **No Action** – The no action response, retained as required by the NCP, provides a comparative baseline against which other alternatives are evaluated. Under this response, no remedial action is taken. The contaminated medium is left "as is" without the implementation of any monitoring, land use controls, containment, removal, treatment, or other mitigating actions.

- **Removal (Excavation)** – Removal is used to remove a contaminated medium from its current location for treatment and return to the site, for treatment and disposal elsewhere, or for disposal elsewhere without treatment. Removal actions are combined with other technologies such as treatment or disposal to develop remedial alternatives.

- **Disposal (Off-Site Landfilling/Recycling)** – Disposal actions include placement of excavated materials within a permanent, approved, and permitted disposal facility. Disposal actions are combined with removal actions and could be combined with treatment actions to develop alternatives. Although the location of the contaminant may change, the toxicity, mobility, and volume of the contaminants are not reduced through the implementation of disposal without a treatment process.

- **In-Situ Bioremediation via Phytoremediation** – Phytoremediation is used to physically remove contaminants from soil using plants. The plants hyperaccumulate contaminants in their biomass, which is then harvested and removed (disposal) from the site. Depending on the concentration of contaminants in the plant biomass, disposal can involve special handling requirements (hazardous or non-hazardous). Phytoremediation is typically combined with disposal to develop a remedial alternative.

- **Ex-Situ Soil Washing** – Soil washing uses a solvent or solvents to physically solubilize the contaminant(s) from soil. This significantly reduces the volume of remaining material that requires disposal. In addition, the "washed" soil can be used to restore the site to its original physical

condition. Ex-situ soil washing actions are combined with other technologies such as removal and disposal to develop alternatives.

These technologies were used to develop four removal action alternatives for D-6, Small Arms Range which are discussed in the following sections. Because of the RAO to remediate D-6, Small Arms Range for unrestricted residential use and because of the COC (lead), there is a limited list of available technologies to develop into remedial alternatives. Table 4-1 presented a screening of all potentially applicable technologies and rationale for either eliminating them or retaining them for evaluation.

4.1.1 Alternative 1 – No Action

No action consists of implementing no activities to address contamination. The no action response is retained throughout the removal action evaluation process, as required by the NCP, to provide a comparative baseline against which other alternatives are evaluated. Under this response, no removal action is taken. The contaminated surface soil is left "as is," without implementation of any administrative or institutional controls, containment, removal, treatment, or other mitigating actions. Because no action would be taken, there are no action-specific ARARs associated with Alternative 1.

4.1.2 Alternative 2 – Excavation and Off-Site Disposal

This alternative would involve the excavation and off-site disposal of D-6, Small Arms Range contaminated soil from the areas identified on Figure 4-1. Following excavation, the site would be backfilled and restored to the desired use or pre-removal action conditions. Quantity calculations (excavation/backfill volume estimates, site restoration area, etc.) and excavation areas assumed for the costing of this alternative are provided in Appendix B. Specific design considerations would be provided in the removal action design or removal action work plan.

The main construction tasks used to implement Alternative 2 would consist of the following:

- Pre-excavation soil lead sampling will be conducted to refine the limits of excavation currently detailed on Figure 4-1.

- Characterization sampling for waste disposal. This will be used to determine whether excavated soil will require stabilization. It is currently assumed that the soil will be non-hazardous. If results indicate that soil is hazardous, stabilization would be required prior to disposal.

- Following pre-excavation sampling, surface soil would be excavated to the limits and depths identified during pre-excavation sampling. Excavated soil would be stockpiled or directly loaded for off-site transportation.

- Following excavation, verification samples would be collected to confirm the removal of all soil with lead concentrations greater than the PRG.

- Following removal, verification of contamination removal and with appropriate disposal characterization and manifesting, the excavated soil would then be transported to an approved off-site disposal facility for proper disposal.

- Excavation areas would then be backfilled with certified clean backfill material. Following backfilling, D-6, Small Arms Range would be graded and restored to the desired use or pre-excavation site conditions. Excavation areas would be backfilled with common fill to a depth of 6 inches below final grade and 6 inches of topsoil to achieve final grade.

- Following backfilling, the disturbed area would be vegetated using a permanent seed mixture.

- Shallow monitoring wells would be installed at up to five locations to verify that dissolved lead concentrations previously detected in groundwater do not increase to greater than the PRG (15 µg/L). The wells would likely be installed using direct-push technology and pre-packed screens. Post-excavation groundwater monitoring (lead only) would be conducted quarterly for one year to potentially support a no further action determination for groundwater.

4.1.3 Alternative 3 – Excavation, Phytoremediation, and Off-Site Disposal

This alternative would involve the phytoremediation of D-6, Small Arms Range contaminated soil identified on Figure 4-1. Site preparation would require a limited amount of excavation because phytoremediation is limited by plant root depth (assumed to be 6 inches). Therefore, the maximum depth of lead-contaminated soil would need to be adjusted to 6 inches across the site. Lead-contaminated soil in the areas depicted on Figure 4-1 would be excavated and spread over the site to allow for plant root interaction. It is assumed that the most of the site would be used to implement phytoremediation. Following excavation, an irrigation system would be installed followed by the planting of species (e.g., Indian mustard) known to hyperaccumulate lead. The plant biomass would be periodically harvested for off-site disposal. Soil monitoring would occur to document the removal of lead from the soil and to determine when the RAO had been met. Costs for Alternative 3 were calculated using the 2010

Remedial Action Cost Engineering and Requirements (RACER) software. Estimates and assumptions used for the costing of this alternative are provided in Appendix C. Specific design considerations would be provided in the removal action design or removal action work plan.

The main construction tasks used to implement Alternative 3 consist of the following:

- Pre-excavation sampling to further delineate the horizontal and vertical extent of excavation currently detailed on Figure 4-1.

- Following pre-excavation sampling, any areas with lead-contaminated soil extending greater than 6 inches bgs would be excavated and temporarily stockpiled. The excavated areas would be backfilled to within 6 inches of grade with soil obtained from clean areas of the site. The stockpiled lead-contaminated soil would then be spread across the site to achieve a maximum thickness of 6 inches to allow plant root interaction with the lead-contaminated soil.

- Shallow monitoring wells would be installed at up to five locations to verify that dissolved lead concentrations previously detected in groundwater do not increase to greater than the groundwater PRG (15 µg/L). The wells would likely be installed using direct-push technology and pre-packed screens. Post-excavation groundwater monitoring (lead only) would be conducted quarterly for one year to potentially support a no further action determination for groundwater.

- Following excavation to obtain a uniform contaminated soil thickness, an irrigation system would be installed along with a site fence to prevent trespassing.

- Select species of plants documented to hyperaccumulate lead in their biomass would be planted.

- Monitoring and system maintenance would be required after planting. Soil would be periodically monitored to document soil lead concentrations, and groundwater monitoring would be performed to verify that lead in soil does not leach into the groundwater. System maintenance would involve watering and addition of fertilizers and/or pesticides to support and maintain plant growth. In addition, the use of synthetic chelates would be required to help solubilize the lead and make it available for plant uptake.

- Following harvesting of the plant biomass, verification of lead concentrations in the biomass, and with appropriate disposal characterization and manifesting, the harvested biomass would then be transported to an approved off-site disposal facility for proper disposal.

- After the site RAO has been achieved and phytoremediation is no longer required, the site fence and irrigation system would be removed to allow for unrestricted site use.

4.1.4 Alternative 4 – Excavation, Soil Washing, and Off-Site Disposal

This alternative would involve the excavation and treatment (soil washing) of D-6, Small Arms Range contaminated soil in the areas identified on Figure 4-1. Following excavation, treated soil would be returned to the site to restore it to the desired use or pre-removal conditions. Lead removed from the soil and captured in the wash water would be disposed of off site. Quantity calculations (excavation volume estimates, site restoration area, etc.) and excavation areas assumed for the costing of this alternative are provided in Appendix B. Specific design considerations would be provided in the removal action design or removal action work plan.

The main construction tasks used to implement Alternative 4 consist of the following:

- Pre-excavation sampling to further delineate the horizontal and vertical extent of excavation currently detailed on Figure 4-1.

- Following pre-excavation sampling, surface soil would be excavated to the limits and depths identified during pre-excavation sampling. Excavated soil would be stockpiled prior to soil washing.

- Soil washing would involve the use of a solvent to solubilize the lead. The solubilized lead would then be captured in the wash water for physical removal.

- Following excavation, verification samples would be collected to confirm the removal of all soil with lead concentrations greater than the PRG. Verification samples would be collected from areas where existing data do not delineate the extent of excavation.

- Following soil washing, verification of contamination removal from the washed soil would be obtained prior to backfilling with washed soil.

- Wash water and any soils that were unable to attain PRGs through soil washing would be transported to an approved off-site disposal facility for proper disposal.

- Excavation areas would then be backfilled with the "clean" washed soil. Following backfilling, D-6, Small Arms Range would be graded and restored to the desired use or pre-excavation site conditions.

- Following backfilling, the disturbed area would be vegetated using a permanent seed mixture.

- Shallow monitoring wells would be installed at up to five locations to verify that dissolved lead concentrations previously detected in groundwater were no longer present. The wells would likely be installed using direct-push technology and utilize pre-packed screens. Post-excavation groundwater monitoring (lead only) would be conducted quarterly for one year to potentially support a no further action determination for groundwater.

The action-specific ARARs associated with these alternatives are presented in Table 4-2.

4.2 EVALUATION CRITERIA

The following criteria were used to evaluate the removal action alternatives:

- Effectiveness: Short-term and long-term protection of human health and the environment, degree of protection achieved, degree of destruction or immobility achieved, and reliability of the alternative.

- Implementability: The degree of difficulty of implementation, associated risks and limitations, feasibility, and limitations of the technology process.

- Cost: Removal action costs including capital cost and maintenance cost.

4.3 EVALUATION OF ALTERNATIVES

4.3.1 Alternative 1 – No Action Evaluation

Effectiveness

The no action alternative would not meet the RAO for the site. The contaminated soil would not be removed or treated; therefore, human and environmental receptors could be exposed to the

contaminants, thereby resulting in a potential risk to these receptors. Additionally, D-6, Small Arms Range would not be suitable for unrestricted use because contaminants at concentrations greater than PRGs would remain.

Implementability

The no action alternative is immediately implementable. No implementability concerns exist.

Cost

No cost is associated with this alternative.

4.3.2 Alternative 2 – Excavation and Off-Site Disposal Evaluation

Effectiveness

Alternative 2 would be effective in removing the contaminated soil and thereby attaining the RAO for the site. The disposal of contaminated soil at an off-site disposal facility would be an environmentally suitable method for disposal of the contaminated soil.

Implementability

Excavation of contaminated media is performed extensively for site remediation, and excavation is applicable to almost all site conditions. Excavation equipment would be selected considering limited site access and depth of contaminated material. Excavation of soil (maximum depth of 4 feet bgs) from the unsaturated zone can be performed with common equipment. There are no major implementability concerns with off-site disposal. Several permitted landfills in the general vicinity of the base would be able to accept and dispose of D-6, Small Arms Range soil.

Because of the limited volume and location of the contaminated soil, implementation of this alternative would not disrupt MCB Camp Lejeune activities other than adding truck traffic on the base. Potential health and safety concerns associated with the removal action may require additional activities such as dust suppression during excavation and transportation.

Cost

The estimated costs for Alternative 2 would be as follows:

Capital Cost: $277,000
Operation and Maintenance (O&M) Cost (1 year): $37,000
Present Worth Cost (1 year): $312,000

Details of the cost estimates are provided in Appendix C.

4.3.3 Alternative 3 – Excavation, Phytoremediation, and Off-Site Disposal

Effectiveness

Alternative 3 would be effective in removing the contaminated soil and thereby attaining the RAO for the site. The disposal of contaminated biomass at an off-site disposal facility would be an environmentally suitable method for disposal.

Implementability

Excavation is applicable to almost all site conditions. Excavation equipment would be selected considering limited site access and depth of contaminated material. Soil excavation (maximum depth of 4 feet bgs) from the unsaturated zone can be performed with common equipment. Installation of a phytoremediation system would require no special equipment, but a site-specific phytoremediation system design would need to identify the best plant species for the uptake of lead in soil, specify planting densities and configurations for planting areas, installation of area irrigation systems, and characterize the soil conditions necessary for successful plant growth and optimized lead removal conditions at the site. The design process from initial conceptual design to actual field construction would likely require limited bench-scale and pilot-scale testing to evaluate the lead-accumulating plant species and to identify optimum conditions for productive plant growth. The required plant species and associated maintenance items (water, fertilizer, pesticides, synthetic chelates) should be easy to obtain and implement after a successful design is completed. The phytoremediation alternative would also include increased field implementation requirements because of the typical need for multiple growing seasons to support the bioaccumulation process, the need for seasonal fertilizing and regular plant irrigation, and seasonal plant harvesting and replanting. Regular monitoring of soil lead concentrations, plant lead concentrations, and groundwater lead concentrations would be required to confirm that the phytoremediation system is functioning as designed and to verify that lead in soil is not mobilized into the shallow groundwater aquifer

at the site by operation of the plant area irrigation system. There are no major implementability concerns anticipated for off-site disposal of plant biomass. Permitted landfills in the general vicinity of the base would be able to accept and dispose of D-6, Small Arms Range plant biomass.

Because of the limited volume and area of contaminated soil, implementation of this alternative would not disrupt MCB Camp Lejeune activities. Potential health and safety concerns associated with the removal action may require additional activities such as dust suppression during excavation and installation of a site fence to prevent trespassing.

Cost

The estimated costs for Alternative 3 would be as follows:

Capital Cost: $169,000
O&M Cost (over 9 years): $307,000
Present-Worth Cost (over 10 years): $409,000

Details of the cost estimates are provided in Appendix C.

4.3.4 Alternative 4 – Excavation, Soil Washing, and Off-Site Disposal Evaluation

Effectiveness

Alternative 4 would be effective in removing the contaminated soil and thereby attaining the RAO for the site. The disposal of lead-contaminated soil and wash water at an off-site disposal facility would be an environmentally suitable method for disposal.

Implementability

Excavation is applicable to almost all site conditions. Excavation equipment would be selected considering limited site access and depth of contaminated material. Excavation of soil (maximum depth of 4 feet bgs) from the unsaturated zone can be performed with common equipment. Mobile soil washing units can be rented and assembled on or near the site. There are no major implementability concerns with off-site disposal of the lead-contaminated soil and wash water. Permitted treatment facilities would be able to accept and dispose of D-6, Small Arms Range soil and wash water.

Because of the limited volume and location of the contaminated soil, implementation of this alternative would not disrupt MCB Camp Lejeune activities other than adding truck traffic on the base during mobilization and demobilization. Potential health and safety concerns associated with the removal action may require additional activities such as dust suppression during excavation.

Cost

The estimated costs for Alternative 4 would be as follows:

Capital Cost: $426,000
O&M Cost (1 year): $37,000
Present-Worth Cost (over 1 year): $461,000

Details of the cost estimates are provided in Appendix C.

4.4 COMPARATIVE ANALYSIS OF ALTERNATIVES

The removal action alternatives were compared to each other using the same criteria used in the evaluation of each alternative in the previous section (i.e., effectiveness, implementability, and cost).

4.4.1 Effectiveness

Alternative 1 would not meet the RAO. Alternatives 2, 3, and 4 would meet the RAO.

Alternatives 2 and 4 would be effective in meeting the RAO within a short time period (weeks) of being implemented. Alternative 3 would require years to be effective in meeting the RAO for the site. Alternative 3 would protect human health and the environment in the long term but would require land use controls in the short term. Alternatives 2 and 4 would be protective in both short and long term time frames. Alternatives 2 and 4 would quickly remove risks and permanently remove lead from the site. As long as plant biomass was periodically harvested for disposal, Alternative 3 would permanently remove lead and reduce risk over time from the site. Alternatives 2 and 4 are reliable alternatives that have been proven at many sites. Alternative 3 would be the least reliable because its effectiveness at achieving the RAO (unrestricted use) is not as well-documented even though it is a well documented technology.

4.4.2 Implementability

Alternative 1 would not require any implementation and would therefore be the easiest to implement. Alternative 2 would be more difficult to implement than Alternative 1 but easier than Alternatives 3 and 4. Alternative 2 would result in a limited increase in truck traffic through MCB Camp Lejeune during implementation but should not disturb ongoing facility activities. Alternative 4 would be more technically difficult to implement than Alternatives 1 and 2 but less difficult than Alternative 3. Implementation of the soil washing component in Alternative 4 would required specialized equipment, but this equipment is readily available. Alternative 3 would be the most difficult to implement due to its duration (requires multiple years) and technical maintenance (monitoring and application of soil additives) required over that time. The facilities, equipment, and procedures required to implement Alternative 2, 3, and 4 are readily available.

4.4.3 Cost

The following table compares the costs of Alternatives 1 through 4.

Cost Item	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Capital	$0	$277,000	$169,000	$426,000
O&M[1]	$0	$37,000	$307,000	$37,000
Net Present Worth[2]	$0	$312,000	$409,000	$461,000

1 - O&M costs are for the total duration of the alternative.
2 - Net present worth is the discounted rate for O&M costs over the duration of the project.

TABLE 4-1

PRELIMINARY SCREENING OF SOIL REMEDIATION TECHNOLOGIES AND PROCESS OPTIONS
D-6, SMALL ARMS RANGE EE/CA
MCB CAMP LEJEUNE, ONSLOW COUNTY, NORTH CAROLINA

General Response Action	Remedial Technology	Process Option	Description	Screening Comment
No Action	None	Not applicable	No activities conducted at the site to address contamination.	**Required by NCP. Retain for baseline comparison to other technologies.**
Limited Action	Land Use Controls	Active Controls: Physical Barriers/ Security Guards	Fencing, markers, warning signs, and monitoring to restrict site access.	Eliminate because land use controls will not allow D-6, Small Arms Range site to be zoned for unrestricted use.
		Passive Controls: Deed or Land Use Restrictions	Administrative action using property deeds or other land use prohibitions to restrict future site activities.	Eliminate because deed or land use restrictions will not allow D-6, Small Arms Range site to be zoned for unrestricted use.
	Monitoring	Sampling and Analysis	Sampling and analysis of soil and groundwater to evaluate migration of chemical constituents in the environment.	Eliminate because sampling will not reduce the potential of exposure to contaminated soils and will not allow D-6, Small Arms Range site to be zoned for unrestricted use.
Containment	Surface Protection	Asphalt/Multimedia Cover	Installation of an asphalt or multimedia cover to prevent direct exposure to contaminated soil and off-site migration of soil through erosion.	Eliminate because cover systems will leave the contaminated soil in place and will not allow D-6, Small Arms Range site to be zoned for unrestricted use.
Removal	Bulk Excavation	Excavation	Use of construction equipment such as a backhoe, front-end loader, gradall, etc. to remove contaminated soil.	**Retain. Excavation would effectively remove contaminated soil from the site and would allow D-6, Small Arms Range site to be zoned for unrestricted use.**
In-Situ Treatment	Biological	Anaerobic/Aerobic Treatment	Innoculation of microorganisms and nutrients to enhance naturally occurring biodegradation of COCs.	Eliminate because biodegradation is ineffective for lead contamination.

TABLE 4-1

PRELIMINARY SCREENING OF SOIL REMEDIATION TECHNOLOGIES AND PROCESS OPTIONS
D-6, SMALL ARMS RANGE EE/CA
MCB CAMP LEJEUNE, ONSLOW COUNTY, NORTH CAROLINA

General Response Action	Remedial Technology	Process Option	Description	Screening Comment
In-Situ Treatment (continued)	Physical/ Chemical	Soil Flushing	Use of water or other solvents to remove COCs by flushing and collecting and treating or disposing of the contaminated fluids.	Eliminate because this process would be very difficult to control in situ due to the distribution of contamination within D-6, Small Arms Range site.
		Dynamic Underground Stripping	Injection of steam at the periphery of the contaminated area to volatilize COCs and removal of these COCs through a centrally located extraction well.	Eliminate because lead is not volatile.
		Soil Vapor Extraction	Use of vacuum and possibly air sparging to volatilize COCs.	Eliminate because soil vapor extraction is not practical for lead contamination.
		Chemical Fixation/ Solidification	Mixing of pozzolanic agents in the vadose zone to chemically fix COCs and solidify the matrix. This technology is primarily used to reduce the mobility of contaminants.	Eliminate because reduction in mobility of COCs is not an RAO. The use of this technology to prepare a surface barrier by in-situ application would be difficult to control due to the very heterogeneous nature of the soil. Mechanical property of solidified soil may affect site reuse.
	Thermal	Vitrification/ Radiofrequency Heating	Use of moderate to high temperature to either volatilize COCs or to fuse them into a glass matrix.	Eliminate because lead is not volatile. Solidified matrix would limit site reuse. Usually only considered for highly contaminated soils.
Ex-Situ Treatment	Physical/ Chemical	Soil Washing/Solvent Extraction	Use of water or other solvents to remove COCs by solubilizing and/or gravity-based separation of contaminated soil particles.	Eliminate from consideration because the grain size distribution of surface soil will not allow for effective soil washing to reduce contaminant volume.

TABLE 4-1

PRELIMINARY SCREENING OF SOIL REMEDIATION TECHNOLOGIES AND PROCESS OPTIONS
D-6, SMALL ARMS RANGE EE/CA
MCB CAMP LEJEUNE, ONSLOW COUNTY, NORTH CAROLINA

General Response Action	Remedial Technology	Process Option	Description	Screening Comment
Ex-Situ Treatment (Continued)	Physical/ Chemical (Continued)	Chemical Fixation/ Stabilization	Mixing of pozzolanic agents to chemically fix COCs and stabilize the soil matrix.	Eliminate from consideration because there is no evidence that the soil of concern is hazardous. In addition, stabilization of lead would not be RAO for removal.
	Biological	On-site Landfarming	Spreading and tilling of contaminated soil into layers of clean surface soil to aerate and biodegrade organic COCs.	Eliminate because lead is not organic and would not biodegrade.
		Bioslurry Reactor/Biopile	Treatment of soil in a bioslurry reactor or biopile under controlled conditions using natural or cultured microorganisms to biodegrade organic COCs.	Eliminate because it would not be effective for the removal of an inorganic COC (lead).
	Thermal	Incineration	Use of high temperatures to destroy COCs.	Eliminate because it would be ineffective for destroying the inorganic COCs.
		Low-Temperature Thermal Desorption	Use of low to moderate temperatures to evaporate COCs and remove them from soil.	Eliminate because it would not be effective in removing inorganic COCs.
	Solids Processing	Screening	Removal/segregation of material based on size either as a means to remove associated COCs or as a preliminary process to aid in downstream treatment.	Eliminate because the surface soil at D-6, Small Arms Range site is poorly graded [soil grains are of similar size (sand)].
		Crushing/Grinding	Size reduction of wastes as a preliminary process to aid in downstream treatment.	Eliminate because the surface soil at D-6, Small Arms Range site contains minimal amounts of material that can be crushed or ground.

TABLE 4-1

PRELIMINARY SCREENING OF SOIL REMEDIATION TECHNOLOGIES AND PROCESS OPTIONS
D-6, SMALL ARMS RANGE EE/CA
MCB CAMP LEJEUNE, ONSLOW COUNTY, NORTH CAROLINA

General Response Action	Remedial Technology	Process Option	Description	Screening Comment
Disposal	Landfill/Recycling	On-Site Landfilling	Disposal of excavated soil and treatment residues in an on-yard landfill.	Eliminate because of lack of space on the yard.
		Off-site Landfilling/Recycling	Disposal of excavated soil and treatment residues in an off yard permitted disposal facility. Disposal of recovered material such as metallic lead pieces.	**Retain landfilling and recycling.**

COC Chemical of concern
NCP National Oil and Hazardous Substances Pollution Contingency Plan
TSDF Treatment, storage, and disposal facility

TABLE 4-2

ALTERNATIVE 2: EXCAVATION AND OFF-SITE DISPOSAL
ACTION-SPECIFIC ARARS
D-6, SMALL ARMS RANGE EE/CA
MCB CAMP LEJEUNE, ONSLOW COUNTY, NORTH CAROLINA

Requirement	Citation	Status	Synopsis	Evaluation/Action To Be Taken
Federal Action-Specific ARARs and TBCs				
Waste Characterization	RCRA Standards [40 CFR 262.11(a)]	Applicable	Applies to the generation of solid waste as defined in 40 CFR 261.2 and which is not excluded under 40 CFR 261,4(a)	Must determine if solid waste is hazardous waste or if waste is excluded under 40 CFR 261.4(b); and
	RCRA Standards [40 CFR 262.11(b)]	Applicable	Applies to the generation of solid waste which is not excluded under 40 CFR 261,4(a)	Must determine if waste is listed as hazardous waste under subpart D 40 CFR Part 261; or
	RCRA Standards [40 CFR 262.11(c)]	Applicable		Must characterize waste by using prescribed testing methods or applying generator knowledge based on information regarding material or processes used.
	RCRA Standards [40 CFR 262,11(d)]	Applicable	Applies to the generation of solid waste which is determined to be hazardous	Must refer to Parts 261, 262, 264, 265, 266, 268, and 273 of Chapter 40 for possible exclusions or restrictions pertaining to management of the specific waste.
	RCRA Standards [40 CFR 264.13(a)(1)]	Applicable	Applies to the generation of RCRA-hazardous waste for storage, treatment or disposal	Must obtain a detailed chemical and physical analysis on a representative sample of the waste, which at a minimum contains all the information that must be known to treat, store, or dispose of the waste in accordance with pertinent sections of 40 CFR 264 and 268.
Temporary Waste Storage	RCRA Standards (40 CFR 264, Subpart S)	Relevant and Appropriate	Provides special standards for cleanup using Corrective Action Management Units, temporary units, and staging piles.	This requirement is relevant and appropriate for management of remediation wastes (e.g., staging piles) if remedial action involves excavation and staging of hazardous wastes.

TABLE 4-2

ALTERNATIVE 2: EXCAVATION AND OFF-SITE DISPOSAL
ACTION-SPECIFIC ARARS
D-6, SMALL ARMS RANGE EE/CA
MCB CAMP LEJEUNE, ONSLOW COUNTY, NORTH CAROLINA

Requirement	Citation	Status	Synopsis	Evaluation/Action To Be Taken
Transportation of Hazardous Wastes	RCRA Standards [40 CFR 171.1(c)]	Applicable	Shall be subject to and must comply with all applicable provisions of the HMTA and DOT HMR at 49 CFR 171-180	Any person who, under contract with a department or agency of the federal government, transports "in commerce," or causes to be transported or shipped, a hazardous material will comply with this rule.
	RCRA Standards [40 CFR 262.10(h)]	Applicable	Off-site transportation of RCRA-hazardous waste	Must comply with the generator requirements of 40 CFR 262.20 through 23 for manifesting, Sect. 262.30 for packaging, Sect. 262.31 for labeling, Sect 262.32 for marking, Sect. 262.33 for placarding, Sect. 262.40, 262.41(a) for record keeping requirements, and Sect. 262.12 to obtain EPA ID number.
	RCRA Standards [40 CFR 263.10(a)	Applicable	Transportation of hazardous waste within the Unites States requiring a manifest	Must comply with the requirements of 40 CFR 263.22 through 263.31.
		Applicable		A transporter who meets all applicable requirements of 49 CFR 171 through 179 and the requirements of 40 CFR 263.11 and 263.31 will be deemed in compliance with 40 CFR 263.
Hazardous Waste Disposal	RCRA Subtitle C – Standards for Hazardous Waste TSD Facilities (40 CFR 264)	Applicable	Establishes standards for acceptable management of hazardous waste.	These standards would pertain to off-site waste disposal facilities. Wastes generated during remedial actions would be disposed at appropriately licensed and permitted facilities. This would only be applicable if lead concentrations were high enough to require hazardous disposal

TABLE 4-2

ALTERNATIVE 2: EXCAVATION AND OFF-SITE DISPOSAL
ACTION-SPECIFIC ARARS
D-6, SMALL ARMS RANGE EE/CA
MCB CAMP LEJEUNE, ONSLOW COUNTY, NORTH CAROLINA

Requirement	Citation	Status	Synopsis	Evaluation/Action To Be Taken
	Land Disposal Restrictions (40 CFR 268)	Applicable	Applicable to alternatives involving land disposal of hazardous wastes and requires treatment to diminish a waste's toxicity and/or minimize contaminant migration. Treatment standards are provided.	Pertains to off-site waste disposal facilities. Wastes generated during remedial actions would be disposed at appropriately licensed and permitted facilities.
State Action-Specific ARARs and TBCs				
General Management Standards – All Land-disturbing Activities	N.C.G.S. Ch.113A-157(3)	Relevant and Appropriate	Applies to land-disturbing activities (as defined in N.C.G.S. Ch. 113A-53) of more than 1 acre of land.	Shall install erosion and sedimentation control devices and practices sufficient to retain the sediment generated by the land-disturbing activity within the boundaries of the tract during construction.
	N.C.G.S. Ch.113A-157(3)	Relevant and Appropriate	Applies to land-disturbing activities (as defined in N.C.G.S. Ch. 113A-53) of more than 1 acre of land.	Shall plant or otherwise provide permanent ground cover sufficient to restrain erosion after completion of construction.
	15A NCAC 4B.0105	Relevant and Appropriate	Applies to land-disturbing activities (as defined in N.C.G.S. Ch. 113A-53) of more than 1 acre of land.	Shall take all reasonable measures to protect all public and private property from damage caused by such activities.

TABLE 4-2

ALTERNATIVE 2: EXCAVATION AND OFF-SITE DISPOSAL
ACTION-SPECIFIC ARARS
D-6, SMALL ARMS RANGE EE/CA
MCB CAMP LEJEUNE, ONSLOW COUNTY, NORTH CAROLINA

Requirement	Citation	Status	Synopsis	Evaluation/Action To Be Taken
	15A NCAC 4B.0106	Relevant and Appropriate	Applies to land-disturbing activities (as defined in N.C.G.S. Ch. 113A-53) of more than 1 acre of land.	Erosion and sedimentation control plan must address the following basic control objectives: (1) Identify areas subject to severe erosion, and off-site area especially vulnerable to damage from erosion and sedimentation. (2) Limit the size of the area exposed at any one time. (3) Limit exposure to the shortest feasible time. (4) Control surface water run-off originating upgrade of exposed areas. (5) Plan and conduct land-disturbing activity so as to prevent off-site sedimentation damage. (6) Include measures to control velocity of storm water run-off to the point of discharge.
	15A NCAC 4B.0108	Relevant and Appropriate	Applies to land-disturbing activities (as defined in N.C.G.S. Ch. 113A-53) of more than 1 acre of land.	Erosion and sedimentation control measures, structures, and devices shall be planned, designed, and constructed to provide protection from the run-off of a 10-year storm.
	15A NCAC 4B.0109	Relevant and Appropriate	Applies to land-disturbing activities (as defined in N.C.G.S. Ch. 113A-53) of more than 1 acre of land.	Shall conduct activity so that the post-construction velocity of the ten year storm run-off in the receiving watercourse to the discharge point does not exceed the parameters provided in this Rule.

TABLE 4-2

ALTERNATIVE 2: EXCAVATION AND OFF-SITE DISPOSAL
ACTION-SPECIFIC ARARS
D-6, SMALL ARMS RANGE EE/CA
MCB CAMP LEJEUNE, ONSLOW COUNTY, NORTH CAROLINA

Requirement	Citation	Status	Synopsis	Evaluation/Action To Be Taken
Managing Fugitive Dust Emissions	15A NCAC 02D.0540(c)	Relevant and Appropriate	Applies to activities within facility boundary that will generate fugitive dust emissions	Shall not cause or allow fugitive dust emissions to cause or contribute to substantive complaints, or visible emissions in excess of that allowed under paragraph 9e) of this Rule.
	15A NCAC 02D.0540(g)	Relevant and Appropriate	Applies to activities within facility boundary that will generate fugitive dust emissions	Implement methods (e.g. wetting dry soils) to control dust emissions that could travel beyond the facility boundary.
Waste Storage	15A NCAC 13B.0104(f)	Relevant and Appropriate	Applies to the generation of solid waste which is determined not to be hazardous.	All solid waste shall be stored in such a manner as to prevent the creation of a nuisance, insanitary conditions, or a potential public health hazard.
	15A NCAC 13B.0104(e)	Relevant and Appropriate	Applies to the generation of solid waste which is determined not to be hazardous.	Containers that are broken or that otherwise fail to meet this rule shall be replaced with acceptable containers.
Waste Treatment and Disposal	15A NCAC 13B.0106(b)	Relevant and Appropriate	Applies to the generation of solid waste intended for off-site disposal.	Shall ensure that waste is disposed of at a site or facility which is permitted to receive the waste.
Monitoring Well Installation	15A NCAC 13B.0108(a)	Applicable	Applies to the installation of groundwater monitoring wells.	No well shall be located, constructed, operated, or repaired, in any manner that may adversely impact the quality of groundwater.

TABLE 4-2

ALTERNATIVE 2: EXCAVATION AND OFF-SITE DISPOSAL
ACTION-SPECIFIC ARARS
D-6, SMALL ARMS RANGE EE/CA
MCB CAMP LEJEUNE, ONSLOW COUNTY, NORTH CAROLINA

Requirement	Citation	Status	Synopsis	Evaluation/Action To Be Taken
	15A NCAC 13B.0108(c)	Applicable	Applies to the installation of groundwater monitoring wells.	Shall be located, designed, constructed, operated and abandoned with materials and by methods which are compatible with the chemical and physical properties of the contaminants involved, specific site conditions, and specific subsurface conditions.
	15A NCAC 13B.0108(c)	Applicable	Applies to the installation of groundwater monitoring wells.	Must comply with general requirements for construction of a well as provided in 15A NCAC 02C.0108(c)(1) through (12).
	15A NCAC 13B.0108(f)	Applicable	Applies to the installation of groundwater monitoring wells.	Shall be constructed in such a manner as to preclude the vertical migration of contaminants with and along borehole channel.
Monitoring Well Maintenance	15A NCAC 13B.0112(a)	Applicable	Applies to the general maintenance of groundwater monitoring wells.	Every well shall be maintained by the owner in a condition whereby it will conserve and protect groundwater resources, and whereby it will not be a source of channel contamination or pollution to the water supply or any aquifer.
	15A NCAC 13B.0112(b)	Applicable	Applies to the general maintenance of groundwater monitoring wells.	Broken, punctured, or otherwise defective or unserviceable casing, screens, fixtures, seals, or any part of the well head shall be repaired or replaced, or the well shall be abandoned pursuant to 15A NCAC 02C.0113.

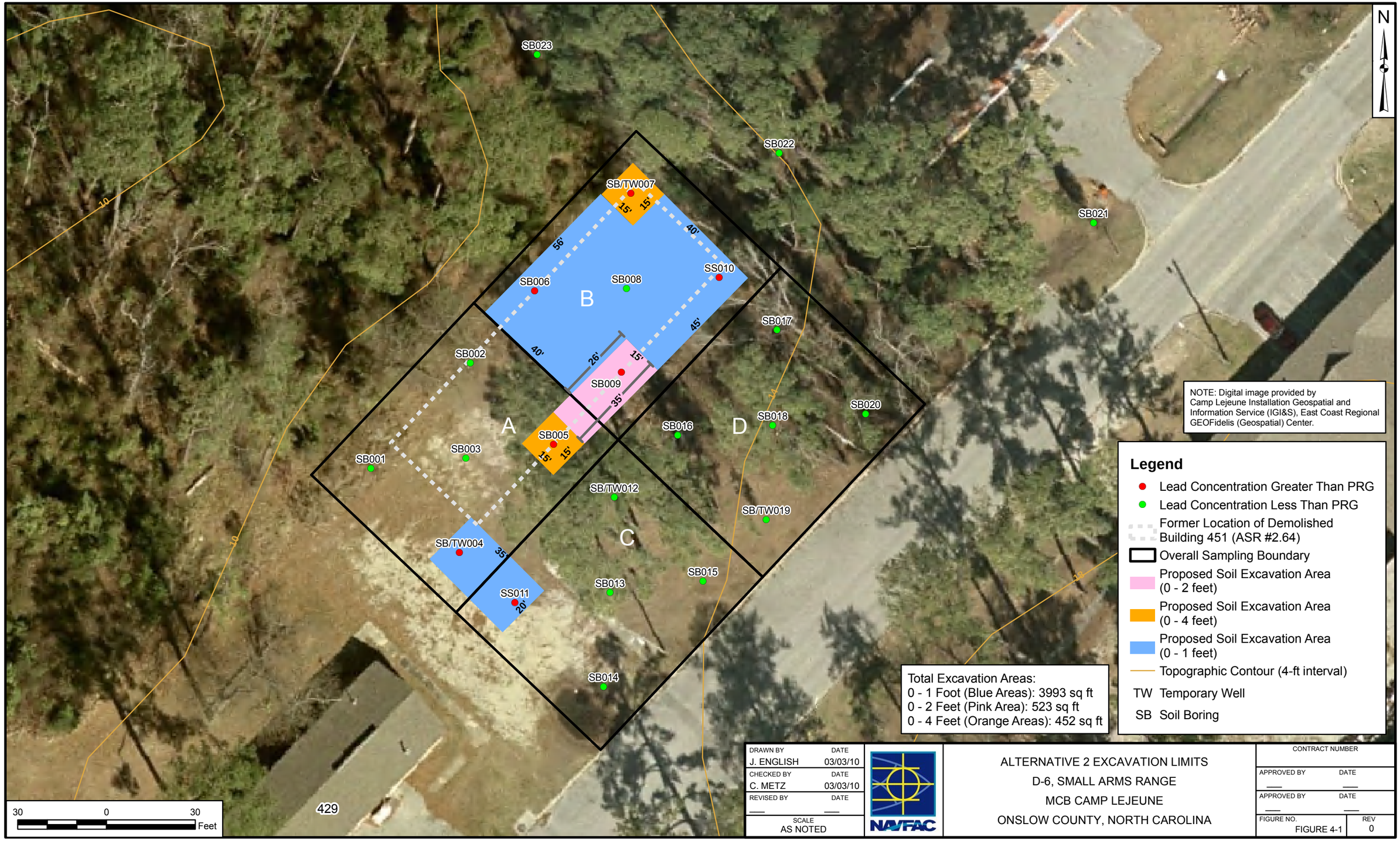
TABLE 4-2

ALTERNATIVE 2: EXCAVATION AND OFF-SITE DISPOSAL
ACTION-SPECIFIC ARARS
D-6, SMALL ARMS RANGE EE/CA
MCB CAMP LEJEUNE, ONSLOW COUNTY, NORTH CAROLINA

Requirement	Citation	Status	Synopsis	Evaluation/Action To Be Taken
	15A NCAC 13B.0112(c)	Applicable	Applies to the general maintenance of groundwater monitoring wells.	All material used in the maintenance, replacement, or repair of any well shall meet the requirements for new installation.

CAA – Clean Air Act
Ch. – Chapter
CFR – Code of Federal Regulations
DOT – Department of Transportation
HMR – Hazardous Materials Regulations
HMTA – Hazardous Materials Transportation Act
NAAQSs – National Ambient Air Quality Standards
N.C.G.S. – North Carolina General Session
NCAC – North Carolina Administrative Code
OSHA – Occupational Safety and Health Act
RCRA – Resource Conservation and Recovery Act
TBC – to be considered
TSD – Treatment, storage, and disposal
USC – United State Code
USEPA – United States Environmental Protection Agency

P:\GIS\CAMP_LEJEUNE\MXD\INDOOR_FIRING_RANGE_EXCAVATION_REV1_NF.MXD 03/03/10 JEE



DRAWN BY	DATE
J. ENGLISH	03/03/10
CHECKED BY	DATE
C. METZ	03/03/10
REVISED BY	DATE
___	___
SCALE	
AS NOTED	

NAVFAC

ALTERNATIVE 2 EXCAVATION LIMITS
D-6, SMALL ARMS RANGE
MCB CAMP LEJEUNE
ONSLOW COUNTY, NORTH CAROLINA

CONTRACT NUMBER	
APPROVED BY	DATE
___	___
APPROVED BY	DATE
___	___
FIGURE NO.	REV
FIGURE 4-1	0

5.0 RECOMMENDED REMOVAL ACTION ALTERNATIVE

Alternative 2, Excavation and Off-Site Disposal, is the recommended removal action alternative for implementation at D-6, Small Arms Range. As outlined in Section 4.0, the main components of this alternative would consist of the following to remove contaminated soil from the site:

- Pre-excavation samples will be collected to further delineate the horizontal and vertical extent of excavation currently detailed on Figure 4-1.

- Characterization sampling for waste disposal will be conducted to determine whether excavated soil will require stabilization. It is currently assumed that the soil will be non-hazardous. If results indicate that soil is hazardous, stabilization would be required prior to disposal.

- Following pre-excavation sampling, surface soil will be excavated to the limits and depths identified during pre-excavation sampling. Excavated soil will be stockpiled or directly loaded for off-site transportation.

- Following excavation, verification samples will be collected to confirm the removal of all soil with lead concentrations greater than the PRG.

- Following removal, verification of contamination removal, and with appropriate disposal characterization and manifesting, the excavated soil will then be transported to an approved off-site disposal facility for proper disposal.

- Excavation areas will then be backfilled with certified clean backfill material. Following backfilling, D-6, Small Arms Range will be graded and restored to the desired use or pre-excavation site conditions. Excavation areas will be backfilled with common fill to a depth of 6 inches below final grade and 6 inches of topsoil to achieve final grade.

- Following backfilling, the disturbed area will be vegetated using a permanent seed mixture.

- Shallow monitoring wells will be installed at up to five locations to verify that dissolved lead concentrations previously detected in groundwater do not increase to greater than the groundwater PRG (15 µg/L). The wells will likely be installed using direct-push technology and pre-packed screens. Post-excavation groundwater monitoring (lead only) will be conducted quarterly for

one year. If lead concentrations do not exceed the PRG in an individual well for four consecutive quarters, that well will be removed from the monitoring program. Wells removed from the monitoring program will not be abandoned until a No Further Action is granted for the site.

REFERENCES

TtNUS (Tetra Tech NUS, Inc.), 2009. Site Inspection Report for D-6, 50-Foot Indoor Rifle and Pistol Range – Former Building 451. October.

North Carolina Department of Environment and Natural Resources, 2009. Soil Remediation Goals (SRGs). October.

USEPA (United States Environmental Protection Agency), 1993. Guidance on Conducting Non-Time-Critical Removal Actions Under CERCLA. August.

USEPA, 1994. Revised Interim Soil Lead Guidance for CERCLA Sites and RCRA Corrective Action Facilities, OSWER Directive 9355.4-12, EP 540-F-94-043. August.

USEPA, 2003. Recommendations of the Technical Review Workgroup for Lead for an Approach to Assessing Risks Associated with Adult Exposures to Lead in Soil, OSWER Dir #9285.7-54, EPA-540-R-03-001. January.

USEPA, 2008. USEPA Regional Screening Levels (RSLs) for Chemical Contaminants at Superfund Sites, RSL Table Update. September.

APPENDIX A

2009 SI REPORT FOR THE D-6, 50-FOOT INDOOR RIFLE AND PISTOL RANGE – UX0 01, FORMER BUILIDNG 451

Site Inspection Report
for
D-6, 50-Foot Indoor Rifle and Pistol Range Former Building 451

Marine Corps Base Camp Lejeune
Onslow County, North Carolina

Naval Facilities Engineering Command Mid-Atlantic

Contract Number N62472-03-D-0057
Contract Task Order 163

October 2009

SITE INSPECTION REPORT
FOR
D-6, 50-FOOT INDOOR RIFLE AND PISTOL RANGE
FORMER BUILDING 451

MARINE CORPS BASE CAMP LEJEUNE
ONSLOW COUNTY, NORTH CAROLINA

COMPREHENSIVE LONG-TERM
ENVIRONMENTAL ACTION NAVY (CLEAN) CONTRACT

Submitted to:
Naval Facilities Engineering Command Mid-Atlantic
Marine Corps North Carolina IPT
6506 Hampton Boulevard
Norfolk, Virginia 23508

Submitted by:
Tetra Tech NUS, Inc.
234 Mall Boulevard, Suite 260
King of Prussia, Pennsylvania 19406

CONTRACT NUMBER N62472-03-D-0057
CONTRACT TASK ORDER 163

OCTOBER 2009

PREPARED UNDER THE DIRECTION OF:

Richard Barringer

RICK BARRINGER
PROJECT MANAGER
TETRA TECH NUS
PITTSBURGH, PENNSYLVANIA

APPROVED FOR SUBMISSION BY:

John J. Trepanowski

JOHN J. TREPANOWSKI, P.E.
PROGRAM MANAGER
TETRA TECH NUS
KING OF PRUSSIA, PENNSYLVANIA

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

APPENDICES

TABLES

NUMBER

FIGURES

NUMBER

ACRONYMS

AEC	Area of Environmental Concern
BAF	Bioaccumulation Factors
bgs	below ground surface
BSAF	Biota Sediment Accumulation Factor
B-451	Building 451
CAMA	Coastal Area Management Act
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CLEAN	Comprehensive Long-Term Environmental Action Navy
CMU	concrete masonry unit
CS	Confirmatory Sampling
CSF	Cancer Slope Factor
CSM	Conceptual Site Model
COPC	chemical of potential concern
CTO	Contract Task Order
DAF	Dilution Attenuation Factor
DI	deionized
DO	dissolved oxygen
DoD	Department of Defense
DPT	direct-push technology
DQI	data quality indicator
Eco-SSL	Ecological Soil Screening Level
EEQ	Ecological Effect Quotients
EPC	Exposure Point Concentration
ERSE	Ecological Risk Screening Evaluation
ESL	Ecological Screening Level
ESV	Ecological Screening Values
°F	degree Fahrenheit
FBL	fixed-base laboratory
FOL	Field Operations Leader
GPS	global positioning system
HASP	Health and Safety Plan
HI	Hazard Index
HQ	Hazard Quotient

IDW	Investigation-derived waste
ILCR	Incremental Lifetime Cancer Risk
INRMP	Integrated Natural Resources Management Plan
LCS	laboratory control sample
LCSD	LCS duplicate
LOAELS	Lowest observed adverse effect level
MC	Munitions Constituents
MCB	Marine Corps Base
MEC	Munitions and Explosives of Concern
mg/kg	milligrams per kilogram
mm	millimeter
MS	matrix spike
MSD	MS duplicate
msl	mean sea level
MRP	Munitions Response Program
NAVFAC	Naval Facilities Engineering Command
NC	North Carolina
NC SSL	North Carolina Soil Screening Level
NCDENR	North Carolina Department of Environment and Natural Resources
NFIP	National Flood Insurance Program
NIST	National Institute of Standards and Technology
NOAEL	No observable adverse effect level
NTU	nephelometric turbidity unit
ORNL	Oak Ridge National Laboratory
ORP	oxidation-reduction potential
OSWER	Office of Solid Waste and Emergency Response
PA	Preliminary Assessment
PAH	Polyaromatic Hydrocarbon
PAL	Project Action Limit
PM	Project Manager
PPE	personal protective equipment
PVC	polyvinyl chloride
QA	quality assurance
QC	quality control
%R	percent recovery
RBC	Risk-based concentration

RCRA	Resource Conservation and Recovery Act
RCRS	Resource Conservation Recovery Sources
RFA	RCRA Facility Assessment
RfD	Reference Dose
RI	Remedial Investigation
RPD	Relative Percent Difference
RSL	Regional Screening Level
SI	Site Inspection
SOP	Standard Operating Procedure
SSL	Soil Screening Level
TAL	Target Analyte List
TtNUS	Tetra Tech NUS, Inc.
µg/L	micrograms per liter
USACE	United States Army Corps of Engineers
USEPA	United States Environmental Protection Agency
USFWS	United States Fish and Wildlife Service
USMC	United States Marine Corps
WAR	Water and Air Research
WP	Work Plan
XRF	x-ray fluorescence

EXECUTIVE SUMMARY

INTRODUCTION

This Site Inspection (SI) Report presents the results of the SI conducted at the former D-6, 50-Foot Indoor Rifle and Pistol Range (D-6, Small Arms Range), located at Marine Corps Base (MCB) Camp Lejeune, Onslow County, North Carolina. As described in the North Carolina Department of Environment and Natural Resources (NCDENR)-approved Site-Specific Work Plan (WP) [Tetra Tech NUS, Inc. (TtNUS), 2009], the main objectives of the SI at the D-6, Small Arms Range were to build on information from the Preliminary Assessment (PA) by gathering initial field data, to perform field reconnaissance and surveys to further develop the Conceptual Site Model (CSM), and to confirm the presence or absence of munitions constituents (MC).

BACKGROUND AND PHYSICAL SETTING

The D-6, Small Arms Range site covers an area of approximately 1 acre inside the main cantonment area (Compartment #31) on the eastern side of the New River, downstream of the Hadnot point area of the base. The D-6 Small Arms Range site is located north of the intersection of I Street and Julian C. Smith Road (previously named River Road).

The firing range was entirely enclosed inside Building 451 (B-451) and was used for small arms training and qualification testing for small-bore weapons from approximately 1953 to mid-1997. B-451 was formerly located on the northwestern side of I Street between Building 429 and Building 430. The D-6, Small Arms Range site supported a 50-foot firing line and a 75 foot firing line inside the building structure. The building was demolished in December 1998. The area disturbed by the building demolition and removal did not extend into the mature forested area surrounding the building demolition site.

The topography in the area of the former D-6, Small Arms Range is relatively flat, with ground surface elevations for the former indoor range between 10 feet above mean sea level (msl) to about 15 feet above msl. Much of MCB Camp Lejeune lies between 20 and 40 feet above msl. The D-6, Small Arms Range area is approximately 700 feet northeast of the edge of the New River. The area investigated during the SI is located along I Street, between Building 429 and Building 430. This property parcel slopes away from I Street to the northwest from 15 feet to 7 feet above msl.

SI FIELD ACTIVITIES

SI field activities at the D-6, Small Arms Range included the following:

- Clearing of utilities in the investigation area by use of site utility maps and a Radiodetection RD4000-series pipe and cable locator. Utilities were marked with pin flags, and all sample locations were subsequently positioned a minimum of 2 feet from these marked locations.

- Sampling of surface and subsurface soil with field X-ray fluorescence (XRF) analysis for lead and fixed-base laboratory (FBL) analysis for select Target Analyte List (TAL) metals (antimony, arsenic, copper, lead, nickel, tin, and zinc).

- Sampling of shallow groundwater from temporary groundwater monitoring wells and analysis at the FBL for select TAL metals (antimony, arsenic, copper, lead, nickel, tin, and zinc) and perchlorate.

SUMMARY OF SI RESULTS AND RISK EVALUATIONS

XRF lead concentrations exceeding the North Carolina (NC) Hazardous Waste Section Soil Screening Level (SSL) of 270 milligrams per kilogram (mg/kg) were detected in seven of the 23 discrete surface soil samples collected from the surface to a depth of 0.5 foot below ground surface (bgs). Composite surface soil samples (0 to 0.5 foot bgs) and discrete subsurface soil samples at 2-foot intervals to the shallow groundwater table were then collected at those seven sample locations (MMRP64-SB004, 005, 006, 007, 009, 010, and 011); two additional “clean” surface soil composite samples were collected in locations MMRP64-SB012 and 019 where the XRF lead concentrations were detected below the screening level. Each composite sample was comprised of four individual aliquots collected in the area of the original discrete location. All surface soil composite samples were analyzed in the field via XRF and shipped to the FBL for confirmatory select TAL metals analysis. All subsurface samples were analyzed in the field via XRF, and a number of those samples were shipped for select TAL metals analysis at the FBL.

XRF lead concentrations, greater than the NC SSL of 270 mg/kg were detected at four sample locations at depths to 2 feet bgs. Only two sample locations (MMRP64-SB005 and 007) contained samples with XRF lead concentrations greater than the NC SSL at depths greater than 2 feet bgs. No samples below 4 feet bgs had XRF lead concentrations greater than the NC SSL.

Samples were collected from four temporary monitoring wells installed within the shallow groundwater at the investigation area. Water in three of the wells had turbidity levels greater than 300 nephelometric

turbidity units (NTUs), so filtered samples were also collected at those three locations. All samples were shipped to the FBL for select TAL metals and perchlorate analysis. The four unfiltered samples all contained lead concentrations exceeding the NC Groundwater Standard of 15 micrograms per liter (µg/L); however, analyzed filtered sample results were all reported to contain less than 15 µg/L. None of the sample locations had perchlorate concentrations exceeding the United States Environmental Protection Agency (USEPA) Interim Drinking Water Health Advisory screening for exposure to perchlorate of 15 µg/L in water, established January 2009.

Lead was determined to be the main chemical of potential concern (COPC) based on exceedances of the soil and aqueous North Carolina SSLs. The human health risk screening identified lead, antimony, and arsenic as COPCs in surface and subsurface soil. Lead and arsenic were selected as COPCs for groundwater. The ecological risk screening selected lead, antimony, and zinc as COPCs in surface soil, but only lead and antimony were retained for food-chain modeling. Lead and antimony had modeled ecological effect quotients (EEQs) greater than 1.0 for one or more ecological receptors. All modeled food-chain EEQs for lead were greater than 1.0.

CONCLUSIONS

Soil

Lead soil concentrations exceeded the NC SSL at various locations at the D-6, Small Arms Range, with the greatest concentration (60,400 mg/kg for SB007) located in the area of the former bullet trap. The majority of lead contamination was limited to 0 to 2 feet bgs. Only in two locations (SB005 and SB007) within the former building footprint was lead detected at concentrations greater than the NC SSL at depths greater than 2 feet bgs. In no instance was lead detected in soil at concentrations greater than the NC SSL at depths greater than 4 feet bgs.

Groundwater

Lead was detected in all four unfiltered groundwater samples at concentrations greater then the NC Groundwater Standard. Three sample locations with elevated turbidity levels had lead filtered results less than the NC Groundwater Standard. Differences between filtered and unfiltered lead results in groundwater samples suggest that lead is absorbed to fine particles in the groundwater rather than in a dissolved phase. A groundwater sample with slight turbidity (9.7 NTU) contained lead at concentrations above the NC SSL, and a filtered sample was not collected for this location.

RECOMMENDATIONS

The focused sampling activities completed during the SI characterized the local site conditions and identified the concentrations of specific metals associated with small arms ammunition in soil and groundwater. The risk screening performed with the SI data identified areas of elevated metals concentrations in soil at the project site with corresponding exposure risks to potential human and ecological receptors. The environmental information collected during the SI is regarded as sufficient to support an interim remedial action to address limited areas of surface and shallow subsurface soil lead contamination at the site. Further investigation of the site through an RI is considered inappropriate because the removal of areas of surface/near surface metals-contaminated soil from the site, as identified during the SI, can be performed quickly and effectively and will substantially reduce potential impacts of human exposure. In this instance, an interim removal action is judged to be the most expeditious manner of remediating the site and will likely serve to reduce risks and long-term threats. As a final site remedy the interim removal action should support a no further action (NFA) designation.

The proposed interim removal action for the D-6, Small Arms Range (former B-451) will be limited to removal of detected metals concentrations present above applicable screening levels [approximately 260 cubic yards (cy) of soil] as delineated during the SI (see Figure 6-1). Elimination of localized site soil areas with elevated metals concentrations may also serve to reduce the total metals concentrations detected in local site groundwater samples through this limited source removal action.

During the limited removal of metals-contaminated soil at the site, follow-up soil sampling via XRF field analysis should be performed, in conjunction with FBL confirmatory sample analyses to verify that the contaminated soil at the site has been fully addressed and that the remaining soil at the site no longer contains elevated metals concentrations that pose exposure risks to potential human and ecological receptors. The recommended interim removal action should support an NFA designation by confirming that the local site soils have been remediated and should serve as the final site remedy.

1.0 INTRODUCTION

PURPOSE OF REPORT AND SCOPE OF WORK

This Site Inspection (SI) Report for the former D-6, 50-Foot Indoor Rifle and Pistol Range (D-6, Small Arms Range) was prepared by Tetra Tech NUS, Inc. (TtNUS) for Naval Facilities Engineering Command (NAVFAC) Mid-Atlantic under Contract Task Order (CTO) 163 of the Comprehensive Long-Term Environmental Action Navy (CLEAN) IV Contract Number N62472-03-D-0057. This report presents the results of the SI conducted at the D-6, Small Arms Range located at Marine Corps Base (MCB) Camp Lejeune, Onslow County, North Carolina.

The Department of Defense (DoD) has established a separate program to address closed military ranges known as the Military Munitions Response Program (MRP). For MRP sites, DoD is following the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) process, which is similar to the Resource Conservation and Recovery Act (RCRA) corrective action process. TtNUS conducted a Preliminary Assessment (PA) for the D-6, Small Arms Range in September 2008, which correlates with a RCRA Facility Assessment (RFA), at the D-6, Small Arms Range. The results of the PA were used to develop the field program for the SI, which is described in this report.

1.1 PURPOSE

The main objective of the SI was to build on PA information by gathering initial field data to determine whether Munitions Constituents (MCs) (e.g., lead) that may have originated from previous site operations are present and potentially contributing to environmental impacts associated with surface soil, subsurface soil, and groundwater at the D-6, Small Arms Range. Other objectives were to use the data collected to further develop the Conceptual Site Model (CSM) and to summarize the information and recommend future site actions.

1.2 SCOPE OF WORK

The SI field program for the D-6, Small Arms Range included collection of surface and subsurface soil and shallow groundwater samples to identify chemicals of potential concern (COPCs) (e.g., metals) that may exist as a result of past operations at the site. If contaminants are detected at concentrations posing a risk to human health or ecological receptors, further investigation may be warranted. The program was designed to determine the general nature and extent of contamination.

SI field activities at the D-6, Small Arms Range included the following:

- Collection of discrete and composite surface soil samples [0 to 0.5 foot below ground surface (bgs)] within a defined grid area that included the footprint of the former Building 451 (B-451) and the immediate area surrounding the former footprint of B-451.

- Collection of discrete subsurface soil samples from the ground surface to 2 feet above the groundwater level within the defined grid area.

- Collection of groundwater samples from temporary groundwater monitoring wells installed in the shallow groundwater table within the defined sample grid area for analysis by a fixed-base laboratory (FBL) for select Target Analyte List (TAL) metals (antimony, arsenic, copper, lead, nickel, tin, and zinc).

- Analysis of soil samples in the field for lead via x-ray fluorescence (XRF) analyzer and selection of a representative number of samples for shipment to the FBL for analysis of select TAL metals (antimony, arsenic, copper, lead, nickel, tin, and zinc).

1.3 DATA COLLECTION AND ARCHIVE SEARCH REPORT

The Archival Records Search Report can be found in Appendix A of this report.

1.4 REPORT ORGANIZATION

This SI Report consists of five sections: Section 1.0 is this introduction, which includes the purpose and scope and report organization. Section 2.0 describes the background and physical setting of MCB Camp Lejeune and the D-6, Small Arms Range, including SI findings. Section 3.0 describes the SI field work design and methodologies. Section 4.0 presents the results of the SI. Section 5.0 presents the updated CSM, and Section 6.0 presents conclusions and recommendations based on the SI results. The appendices include the following:

- Appendix A – Archival Records Search Report
- Appendix B – Field Forms
- Appendix C – Site Photos
- Appendix D – Analytical Results and Statistical Evaluation

- Appendix E – Data Validation Reports
- Appendix F – Ecological Risk Screening Supporting Documentation

2.0 FACILITY AND SITE BACKGROUND AND PHYSICAL SETTING

2.1 MCB CAMP LEJEUNE BACKGROUND AND PHYSICAL SETTING

MCB Camp Lejeune is a 156,000 acre installation located in the Atlantic Coastal Plain Physiographic Province in Onslow County, North Carolina, approximately 45 miles south of New Bern and 47 miles north of Wilmington (Figure 2-1). The base covers approximately 236 square miles and is bisected by the New River, which flows in a southeasterly direction and forms a large estuary before entering the Atlantic Ocean. The base is bordered by the City of Jacksonville, North Carolina, and State Route 24 to the north, the Atlantic shoreline to the south and east, and U.S. Route 17 to the west (not including the Greater Sandy Run Area of the base west of U.S. Route 17).

Surface water drainage at the base is generally toward the New River, except in areas near the coast, which drain through the Intracoastal Waterway. In developed areas, the natural drainage has been altered by asphalt cover, storm sewers, and drainage ditches. Approximately 70 percent of the base is situated in broad, flat, interstream areas. Drainage is poor in these areas, and the soils are often wet [Water and Air Research (WAR), 1983]. The United States Army Corps of Engineers (USACE) has mapped the limits of the 100-year floodplain at the base at 7 feet above mean sea level (msl) in the upper reaches of the New River increasing downstream to 11 feet above msl near the coastal area (WAR, 1983).

The United States Marine Corps (USMC) has conducted small-bore weapons training and marksmanship qualification activities at multiple ranges at MCB Camp Lejeune, including the D-6, Small Arms Range, which has since been demolished and removed from the site.

Construction of MCB Camp Lejeune began in 1941, and during World War II, the installation was used as a training area to prepare Marines for combat. MCB Camp Lejeune served as a combat Marine training center during the Korean and Vietnam conflicts as well as the Gulf War and subsequent Middle Eastern activities.

2.2 D-6, SMALL ARMS RANGE PHYSICAL SETTING

The D-6, Small Arms Range site covers an area of approximately 1 acre inside the main cantonment area (Compartment #31) on the eastern side of the New River, downstream of the Hadnot Point area of the base. The D-6, Small Arms Range site is located just north of the intersection of I Street and Julian C. Smith Road (previously named River Road), as shown on Figure 2-2.

The firing range was entirely enclosed inside B-451 and was used for small arms training and qualification testing for small-bore weapons from approximately 1953 to mid-1997. B-451 was formerly located on the northwestern side of I Street between Building 429 and Building 430 (see Figure 2-2). The D-6, Small Arms Range site included a 50-foot and 75-foot firing lines inside the building structure. Figure 2-3 presents a 1998 aerial photograph showing the location of former B-451. The building was demolished in December 1998, as shown on the 1999 aerial photograph (Figure 2-4). The area disturbed by the building demolition and removal did not extend into the mature forested area surrounding the former building site.

2.2.1 Development and Construction of the D-6, Small Arms Range

B-451 consisted of metal sheeting on a steel frame (Butler Building) and was constructed in November 1952. The original design blueprints, dated April 25, 1952, indicate outside dimensions of 120 feet, 6 inches (oriented southwest to northeast) by 40 feet. Photographs and drawing details shown on the building demolition plan dated July 9, 1997, indicate that the building entrance was on the southeastern corner and that the direction of small arms fire was to the northeast. This drawing indicates that the northeastern end of the building and approximately 86 feet along the southeastern and northwestern walls were lined with concrete masonry unit (CMU) walls inside the Butler Building sheet metal exterior wall. The CMU walls were typical cinder block construction, and inside B-451 surrounding the range area, were 12 feet 10 inches high. The indoor range at B-451 was apparently eight firing lanes wide and accommodated target practice firing from distances of 50 and 75 feet from the targets. The 75-foot firing line is consistent with the outside dimensions of the building and the dimensions of the CMU wall lining the inside of the building along the firing range.

2.2.2 Bullet Trap Design for the D-6, Small Arms Range

The indoor range bullet trap system consisted of a series of four angled-steel baffle plates suspended from the building's structural steel roof supports. The final baffle was a 13-foot-wide steel plate that extended across the width of the range and the covered area behind the targets. The steel baffle was oriented at a 45-degree downward angle from about 11 feet above the range floor to near the base of the downrange CMU wall. The leading edge of the final baffle was suspended above a 2-foot-high CMU wall about 10 feet in front of the CMU wall at the northeastern (target) end of the building. Behind the 2-foot wall approximately 8 to 16 inches of sand were placed over a 4-inch layer of gravel directly overlying the foundation slab. The sand layer thickened from the 2-foot CMU wall toward the rear (downrange) CMU wall where the final baffle plate was anchored. The sand would catch the expended bullets after they

passed through the targets and were deflected by the final steel baffle plate into the bullet trap (sand pit). No records relating to the handling or management of the expended bullets or bullet fragments in the B-451 bullet trap sand were found during the historical archive search.

2.2.3 Demolition and Removal of the D-6, Small Arms Range

Property records indicated that B-451 was improved in 1985, and the building upgrades are believed to have been to the ventilation system, electrical supply, and building acoustics, as detailed in B-451 improvement plans dated June 20, 1983. The notes on the demolition plan, dated July 9, 1997, indicate that building demolition included removal of wood-framed structures on the reinforced concrete foundation and slab including steel siding, CMU walls, partitions, and steel baffle plates. A note also indicates that the area was to be backfilled, raked, and seeded after building demolition and removal, which indicates that non-native soil may have been brought to the site during this process, and any potential surface soil contamination may now be at depth below clean fill.

Since its demolition in 1998, the area surrounding the former B-451 has gone undeveloped. A recently installed 8-foot-high chain-link fence around B-429 to the southwest bisects the southern end of the former B-451 investigation area.

2.3 PHYSICAL CHARACTERISTICS

2.3.1 Topography

The topography of MCB Camp Lejeune is relatively flat, with ground surface elevations ranging from msl to as much as 72 feet above msl across the 236 square mile installation. Most of MCB Camp Lejeune lies between 20 and 40 feet above msl. The D-6, Small Arms Range area is approximately 700 feet northeast of New River. The area investigated during the SI is located along I Street, between Building 429 and Building 430. This property parcel slopes away from I Street to the northwest from approximately 15 feet to 17 feet above msl.

The l00-year floodplain elevation for this area of MCB Camp Lejeune is approximately 10 feet above msl. The elevation of the prepared soil surface when the B-451 was constructed was approximately 13 feet above msl. The National Flood Insurance Program (NFIP) has classified the location of the D-6, Small Arms Range as Zone X, which indicates that the area has been determined to be outside the 0.2 percent annual chance floodplain.

The majority of the site is flat with a small downward slope toward the northwest. Due to the topography of the area and the heavy vegetative ground cover, the potential for erosion is limited. The local terrain at the location of the D-6, Small Arms Range is relatively level, varying between about 11 to about 13 feet above msl. To control surface runoff in this area, a drainage ditch was installed along the northwestern side of I Street. The drainage ditch conveys flow from the southwest through a culvert below the Building 430 driveway and then flows to the west between Building 430 and the former B-451 location to eventually join a small stream that flows to the southwest near H Street and eventually discharges into the New River.

2.3.2 Geology

The uppermost undifferentiated formation of Holocene and Pleistocene-age sediments consist of mostly fine loose to medium dense sands with a lesser amount of silt and clay and is present from land surface to depths of 20 to 30 feet bgs. Thin discontinuous lenses of silt and clay may be regionally associated with the Belgrade formation, which generally consists of mostly fine sands, silts and clays, with lesser amounts of shell fragments.

The upper portion of the River Bend Formation, which underlies the Quaternary-age sediments, is composed of sands, silts, shell and fossil fragments, and trace amounts of clay. The River Bend Formation overlies the Eocene Castle Hayne Formation, which consists of both poorly indurated and well-indurated biomicrite and biomicrudite limestone (Harris, et al., 1991). The thickness of the Castle Hayne Formation ranges from 150 and over 450 feet locally at MCB Camp Lejeune (Cardinell, et al., 1993).

2.3.3 Soil and Vegetation Types

The mapped soil unit for the D-6, Small Arms Range area consists of the Baymeade-Urban land complex derived from loamy and sandy marine deposits with 0 to 6 percent slopes. The Baymeade-Urban soil unit consists of well-drained fine sand material to a depth about 30 inches, underlain by about 10 inches of fine sandy loam (30 to 40 inches bgs), with a lower loamy fine sand at the soil base (40 to 80 inches bgs).

Vegetation in the site area consists of a mature stand of mixed conifer and deciduous trees (present prior to range building construction in 1952), with more recent understory vegetation including pines, which are partially growing within the former footprint of the building foundation slab.

2.3.4 Hydrology

To control surface runoff in this area, a drainage ditch was installed along the northwestern side of I Street. The drainage ditch conveys flow from the southwest through a culvert below the Building 430 driveway and then flows to the west between Building 430 and the former B-451 location to eventually join a small stream that flows to the southwest near H Street and eventually discharges into the New River, approximately 675 feet southwest of the former D-6, Small Arms Range.

2.3.5 Hydrogeology

The surficial aquifer, the Upper Castle Hayne confining unit, and the Castle Hayne aquifer have all been described at MCB Camp Lejeune (Cardinell, et al., 1993). The surficial aquifer resides within the Undifferentiated Formation, and the Caste Hayne Aquifer resides locally within the River Bend Formation. The Belgrade Formation typically acts as a confining unit between the surficial and Castle Hayne aquifers.

In the Baymeade-Urban land complex soil unit mapped at the D-6, Small Arms Range, the depth to the local water table is reported as 4 to 5 feet bgs. During the SI, groundwater at the site was encountered at depths of 8 to 10 feet bgs.

2.4 REGIONAL ECOLOGY SUMMARY

MCB Camp Lejeune is located within the New River Watershed. The New River is a slow-moving and placid river that was designated a National Scenic River in 1976. The topography along this coastal region is generally flat to gently rolling, which slopes from an elevation of 63 feet above msl to sea level. Approximately 59 percent of the New River Watershed is forested, croplands and pastures make up 35 percent, and the remaining area is considered urban.

This portion of the NC coast is a diverse region containing over 30 miles of sandy beaches that make up a continuously varying coastline. Many areas of the North Carolina coastline are highly erodable due to the sandy substrate and violent currents. These sandy coastlines transition into a region of pines (*Pinus sp*.), scrub oaks (*Quercus sp*.), sweetgum (*Liquidambar styraciflua*), and dogwood (*Cornus sp*.). Bermuda grass (*Cynodon dactylon*) is the primary undergrowth species of the area. These areas are interspersed with bottomland hardwood forests that were once more prevalent in this region. These forest types are dominated by bald cypress (*Taxodium distichum*) and swamp tupelo (*Nyssa sylvatica var. biflora*), with Atlantic white cedar (*Chamaecyparis thyoides*) being common on organic substrates

underlain by sand. Croplands are also common in this area and are predominantly corn, cotton, peanuts, and tobacco.

The climate in Onslow County, North Carolina, is characterized by short mild winters and long, hot, humid summers. Average annual net precipitation is approximately 50 inches. Ambient air temperatures generally range from 33 Fahrenheit (°F) to 53°F in the winter months and 71°F to 88°F during the summer months.

2.4.1 Endangered/Threatenend Species Within the Project Area

Many protected species have been identified in the vicinity of MCB Camp Lejeune, including the American alligator, green sea turtle, loggerhead sea turtle, piping plover, red-cockaded woodpecker, bald eagle, seabeach amaranth, and rough-leaf loosestrife (USMC, 2006). These species are listed as threatened, endangered, or of special concern by the United States Fish and Wildlife Service (USFWS) under the Endangered Species Act of 1973, as amended.

MCB Camp Lejeune has active programs in place to protect the three federally protected avian species (American bald eagle, piping plover, and red cockaded woodpecker) that are known to occur on the base. The D-6, Small Arms Range is not within the vicinity of any of the red cockaded woodpecker management areas, and suitable habitat for the piping plover does not exist at the D-6, Small Arms Range. A bald eagle's nest is documented at MCB Camp Lejeune, located at the junction of Sneads Creek and the New River, 9.26 miles from the D-6, Small Arms Range. Three protective buffers that restrict ground- and air-use activities have been established at approximately 750, 1,000, and 1,500 feet from the nest site. The D-6, Small Arms Range is not within any of these buffer zones. Non-nesting eagles may use the D-6 Small Arms Range for foraging habitat; however, the work did not impact any special habitat where eagles congregate.

The D-6, Small Arms Range is approximately 14.6 miles from the Atlantic Coast, and therefore the federally protected marine species in the MCB Camp Lejeune area (e.g., green sea turtle, leatherback sea turtle, loggerhead sea turtle, and West Indian manatee) are unlikely to inhabit the D-6, Small Arms Range. The eastern cougar is the only federally listed mammal species likely to occur in Onslow County. The only extant population of eastern cougar is located in south Florida, and the species has not been observed in North Carolina in over 50 years. Suitable habitat for the eastern cougar does not exist at the D-6, Small Arms Range, and the level of human activity in the area would tend to make the species avoid the area.

Two of the four regional federally listed plant species have been identified on the base, rough-leaved loosestrife and seabeach amaranth. Approximately 22 rough-leaved loosestrife sites have been identified on Camp Lejeune, with 76 acres buffered and marked to protect this species. Rough-leaved loosestrife sites are visually inspected annually for changes in species extent and apparent health. Approximately one-half of the rough-leaved loosestrife sites occur within protected red-cockaded woodpecker sites, obviating the need for marking each of these sites individually. The other sites, mostly falling within the Greater Sandy Run Area, are marked with white paint around a perimeter that extends 100 feet from the outermost individuals. None of these sites are located at or adjacent to the D-6, Small Arms Range site.

Seabeach amaranth is an annual species that has been described as a dune-builder because it frequently occupies areas seaward of primary dunes, often growing closer to the high tide line than any other coastal plant. As such, this plant is generally found along Onslow Beach and is not located at or adjacent to the D-6, Small Arms Range site.

2.4.2 Wetlands Within the Project Area

Jurisdictional wetland areas are known to be located within the D-6, Small Arms Range site and within the area of investigation. In addition to the jurisdictional wetlands, additional wetlands in the southwestern corner of the D-6, Small Arms Range site in the vicinity of the investigation area. To install the temporary monitoring wells and to collect environmental samples, limited vegetation removal was necessary during SI field activities. However, trees with trunk diameters greater than 3 inches were cut down, no work was performed in wetland areas, and no significant soil disturbance was performed during field activities.

2.4.3 Cultural and Archaeological Resources Within the Project Area

SI sampling activities involved a limited degree of intrusive activity. The probability that any significant cultural or archeological resources were impacted by the field investigation is low. No cultural or archaeological materials or resources were observed within the project investigation area.

2.4.4 Water Resources Within the Project Area

The area of investigation did not encompass nor was it bordered by surface water bodies. No water resources were impacted by the project.

2.4.5 Coastal Zones Within the Project Area

Onslow County is subject to the rules and policies of the North Carolina Coastal Resources Commission, which administers the Coastal Area Management Act (CAMA). The CAMA requires permits for development in Areas of Environmental Concern (AECs) if they meet all of the following conditions:

- In one of the 20 counties covered by CAMA
- Considered "development" under CAMA
- In or affects an AEC established by the Coastal Resources Commission
- Does not qualify for an exemption

"Development" includes activities such as dredging or filling coastal wetlands or waters and construction of marinas, piers, docks, bulkheads, oceanfront structures, and roads. The investigation at the D-6, Small Arms Range included surface investigations and the collection of subsurface soil and groundwater samples using direct-push technology (DPT), but these activities do not meet the definition of “development” under CAMA; therefore, a CAMA permit was not necessary for this project.

2.4.6 Vegetation Removed Within the Project Area

Vegetation was removed to access certain sampling locations. Only understory vegetation up to 3 inches in diameter was cut as part of the investigation.

2.5 PRELIMINARY ASSESSMENT REPORT RESULTS

This section presents a summary of the information collected for the D-6, Small Arms Range during the site visit conducted in September 2008.

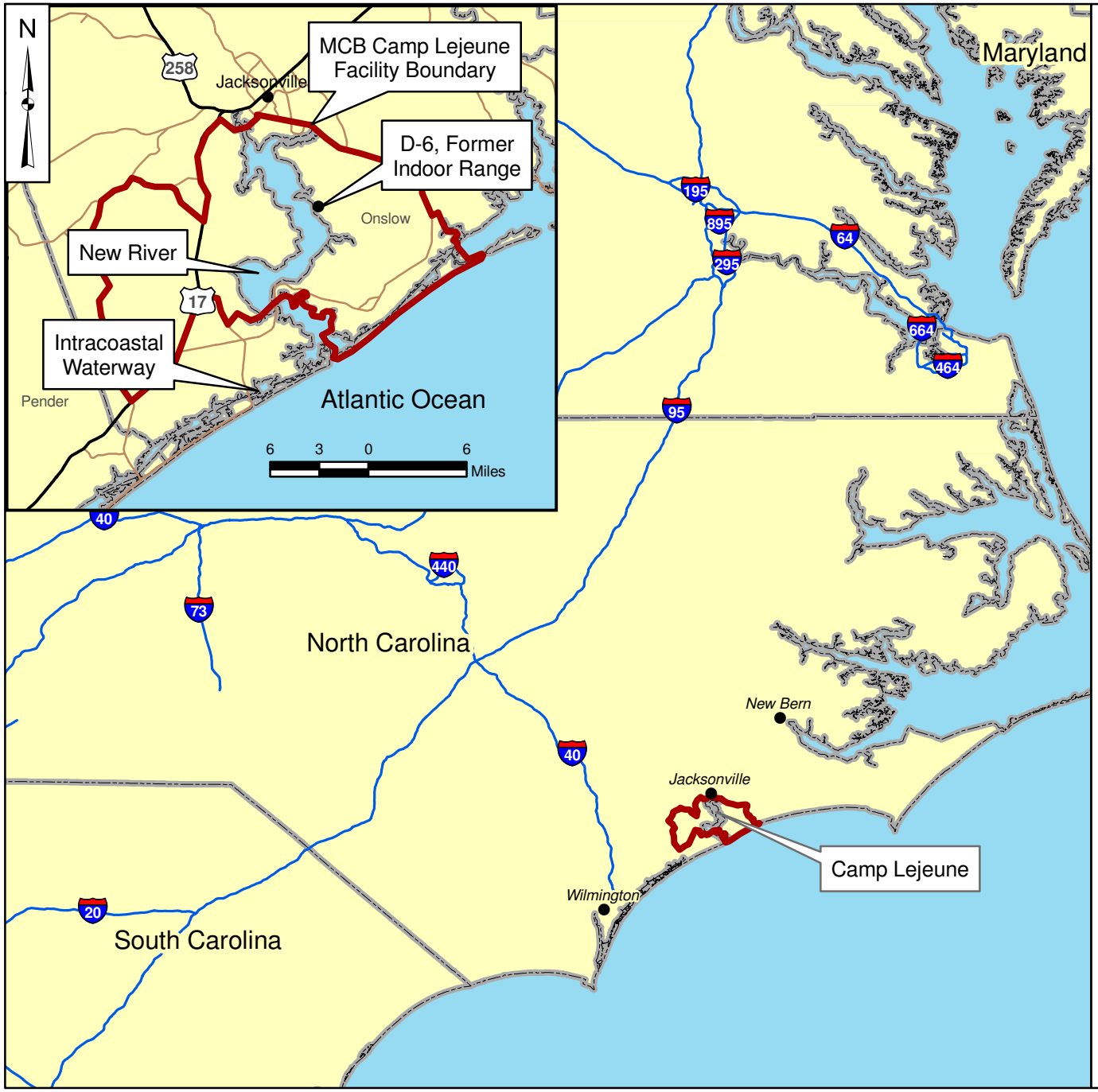
B-451 consisted of metal sheeting on a steel frame (Butler Building) constructed on November 1, 1952. The original design blueprints dated April 25, 1952 indicated outside building dimensions of 120 feet 6-inches long by 40-feet wide. Photographs and drawing details shown on the building demolition plan dated July 9, 1997 indicate the building entrance was on the southwestern wall and the direction of small arms fire was to the northeast. This drawing shows the northeastern end of the building and approximately 86 feet along the southeastern and northwestern walls were lined with CMU walls inside the Butler Building sheet metal exterior wall. The CMU walls were typical cinder block construction. The CMU walls inside B-451 surrounding the range area were 12 feet 10-inches high. The indoor range at B-451 was apparently eight firing lanes wide and accommodated target practice firing from a 50-foot

distance and a 75-foot firing distance from the targets. The 75-foot firing line is consistent with the outside dimensions of the building and the dimensions of the CMU wall lining the inside of the building wall along the firing range. See Appendix A for photographs and drawing details of the small arms range building.

The range bullet trap system consisted of a series of four angled steel plate baffle plates suspended from the building's structural steel roof supports. The final baffle was a 13-foot wide steel plate that extended across the width of the range and covered the area behind the targets. The steel baffle was oriented at a 45 degree downward angle from about 11 feet above the range floor to near the base of the downrange CMU wall. The leading edge of the final baffle was suspended above a 2-foot high CMU wall about 10 feet in front of the CMU wall at the northeastern (target) end of the building. Behind the 2-foot high wall about 8 to 16 inches of sand were placed over a 4-inch layer of gravel directly overlying the foundation slab. The sand layer thickened from the 2-foot high CMU wall toward the rear (downrange) CMU wall where the final baffle plate was anchored. The sand would catch the expended bullets once they passed through the targets and were deflected by the final steel baffle plate into the sand bullet trap. No records were discovered to document the handling or management of the expended bullets or bullet fragments that accumulated in the B-451 indoor range bullet trap (Appendix A).

As stated earlier, property records indicated that B-451 was improved in 1985 and those building upgrades may have included the ventilation system, electrical supply, and building acoustics as detailed in B-451 improvement plans dated June 20, 1983. Figure 2-3 presents a 1998 aerial photograph showing the exact location of the former D-6, Small Arms Range. The building was then demolished in December of 1998 and as shown on the 1999 aerial photograph (Figure 2-4). The area disturbed by the building demolition and removal did not extend into the mature forested area surrounding the building demolition site.

The demolition plan indicated that building demolition included removal of wood framed structures on the reinforced concrete foundation and slab including steel siding, CMU walls, partitions, and steel baffle plates. The plan (Note 4) indicated the area was to be backfilled, raked, and seeded after building demolition/removal. This indicates that non-native fill may have been brought to the site and potential surface soil MC contamination from the range may now be at depth below clean fill.



TETRA TECH

Figure 2-1
General Location Map
MCB Camp Lejeune
Onslow County, North Carolina

50 25 0 50
Miles

Drawn By: K. MOORE 12/5/08
Checked By: R. BARRINGER 9/11/09
Approved By:

Contract Number: 112G01716
CTO 163

P:\GIS\CAMP_LEJEUNE\MXD\LOCATION_MAP.MXD 9/11/09 KM

TETRA TECH

Figure 2-2
Site Location
D-6, 50-foot Indoor Rifle
and Pistol Range
(Former Building 451, ASR #2.64)
MCB Camp Lejeune
Onslow County, North Carolina

Legend

Topographic Contour (4-ft interval)

Natural Color Digital Image
Dated February 2004 (0.15m/pixel resolution)

NOTE: Digital image provided by Camp Lejeune Installation Geospatial and Information Service (IGI&S), East Coast Regional GEOFidelis (Geospatial) Center.

100 50 0 100
Feet

Drawn By: K. MOORE 10/22/08
Checked By: R. BARRINGER 9/11/09
Approved By:

Project Number: 112G01716
CTO 0163

P:\GIS\CAMP_LEJEUNE\MXD\SITE_MAP_2004.MXD 9/11/09 KM

TETRA TECH

Figure 2-3
1998 Aerial Photograph
D-6, 50-foot Indoor Rifle
and Pistol Range
(Former Building 451, ASR #2.64)
MCB Camp Lejeune
Onslow County, North Carolina

Legend

Topographic Contour (4-ft interval)

Natural Color Digital Image
Dated March 1998 (1m/pixel resolution)

NOTE: Digital image provided by Camp Lejeune Installation Geospatial and Information Service (IGI&S), East Coast Regional GEOFidelis (Geospatial) Center.

100 50 0 100
Feet

Drawn By: K. MOORE 10/22/08
Checked By: R. BARRINGER 9/11/09
Approved By:

Project Number: 112G01716
CTO 0163

P:\GIS\CAMP_LEJEUNE\MXD\SITE_MAP_1998.MXD 9/11/09 KM

TETRA TECH

Figure 2-4
1999 Aerial Photograph
D-6, 50-foot Indoor Rifle
and Pistol Range
(Former Building 451, ASR #2.64)
MCB Camp Lejeune
Onslow County, North Carolina

Legend

Topographic Contour (4-ft interval)

Natural Color Digital Image
Dated May 1999 (0.15m/pixel resolution)

NOTE: Digital image provided by
Camp Lejeune Installation Geospatial and
Information Service (IGI&S), East Coast Regional
GEOFidelis (Geospatial) Center.

100 50 0 100
Feet

Drawn By: K. MOORE 10/22/08
Checked By: R. BARRINGER 9/11/09
Approved By:

Project Number: 112G01716
CTO 0163

P:\GIS\CAMP_LEJEUNE\MXD\SITE_MAP_1999.MXD 9/11/09 KM

3.0 FIELD WORK DESIGN AND METHODS

This section describes the sampling design and methods and documentation utilized during the SI field activities performed in May 2009 at the D-6, Small Arms Range located at MCB Camp Lejeune.

3.1 OVERVIEW

SI soil samples were collected by hand auger, DPT, or plastic hand trowel at 23 locations. Table 3-1 shows the sample technique for each sample collected. Sixty-eight samples were collected at depths ranging from 0 to 0.5 feet bgs, 0 to 2 feet bgs, 2 to 4 feet bgs, and 6 to 8 feet bgs. Sixty-five of the 68 soil samples collected were analyzed in the field for lead via XRF. Select metals analysis by a FBL was conducted for six sample locations (20 soil samples) within the investigation area. Table 3-2 presents all sample locations and associated XRF and FBL lead concentrations.

All SI field work was conducted in accordance with the procedures and methodologies described in the Site-Specific Work Plan (WP), which was approved by the United States Environmental Protection Agency (USEPA) and the North Carolina Department of Environment and Natural Resources (NCDENR) (TtNUS, 2009). Standard Operating Procedures (SOPs) that governed the field work are included in Appendix D of the approved WP. Sample log sheets, field documentation, site photographs, and other supporting information associated with the SI field investigation are provided in Appendices B and C of this SI Report.

3.2 PRELIMINARY ACTIVITIES

Following approval of the WP, TtNUS personnel began mobilization activities on May 11, 2009. The field team members reviewed the approved WP, associated appendices, and Health and Safety Plan (HASP) prior to the start of project activities. In addition, the Field Operations Leader (FOL) held a field team orientation meeting to ensure that personnel were familiar with the scope of the field activities.

Prior to collecting any samples at the site, the FOL and Geophysical Technician arrived at the site and began on-site mobilization activities. Upon arrival at the site, an 8-foot-high chain-link fence was observed which had recently been installed around Building 429, which is just south and west of the former D-6, Small Arms Range. The northeast portion of the fence runs through the investigation area; however, gate access points were not restricted and the fencing did not interfere with SI activities. Mobilization activities included the receipt of all field equipment directly from vendors, and which upon receipt, each piece of equipment was checked to verify that it was in proper working condition. Utility clearance of the investigation area was then completed by TtNUS by use of site utility maps and a Radiodetection RD4000-

series pipe and cable locator. All utilities were marked with pin flags and all sample locations were subsequently positioned a minimum of two feet from these marked locations.

TtNUS conducted limited brush clearing to allow access to sample locations within the thick underbrush in the northeastern portion of the investigation area. This included the removal of underbrush and small trees less than 3 inches in diameter by use of a gas-powered trimmer.

At the conclusion of SI field activities, the FOL completed decontamination of all equipment, which was then shipped back to the appropriate vendors.

3.3 SITE INVESTIGATION METHODS AND PROCEDURES

3.3.1 Sample Design

The total area of the investigation site covered approximately 1 acre in size. To provide sample coverage, the site was then divided into four equal quadrants (A, B, C, and D), and five sample locations were collected within each of the four quadrants for a total of 20 sample locations. An additional three samples were collected in the small drainage channel located immediately northeast of the investigation area, with one sample located just upstream of the site, the second between former B-451 and Building 430, and the third sample just downstream of the site. See Figure 3-1 for all sample locations. Prior to initiating sample collection, all sample locations were marked by colored pin flags bearing the sample location ID number. Proposed sample locations identified in the approved WP were located by global positioning system (GPS) and by measurements from stationary objects (e.g.: roadways, existing buildings). All sample locations were as proposed in the approved WP except for sample location MMRP64-SO006, which was moved to the southeast approximately 10 feet due to extremely thick underbrush and large trees.

3.3.2 XRF Analyses

Soil samples undergoing field XRF analysis were processed and analyzed in the field in accordance with Standard Operating Procedure SOP-07. Prior to analyzing samples, the XRF was standardized in accordance with the manufacturers' instructions, and three known lead concentrations [National Institute of Standards and Technology (NIST) standards] were analyzed to verify the accuracy of the instrument and to assess the stability and consistency of the results.

Sample processing prior to field XRF analysis consisted of homogenizing each soil sample within a large ziploc-type baggie, removing rocks and other debris, placing the sample in a small aluminum pan, drying

the sample in an electric convection oven for approximately 10 to 15 minutes, and then physically processing the sample material to eliminate clods and produce a fine uniform particle size. Each sample was then transferred to a smaller ziploc-type baggie from which three separate XRF measurements were made, one from each end and one from the center of the sample ziploc-type baggie. The average lead concentration of the three readings was used as the final XRF lead concentration for the sample (Table 3-2).

During sample collection activities, all soil material was visually inspected in the field for the presence of bullets or bullet fragments. The soil material was again visually monitored in the field laboratory during processing for XRF analysis. No bullets or bullet fragments were observed in any of the sample material at the D-6, Small Arms Range. A single 5.56 millimeter (mm) bullet casing was observed on the ground surface in the central portion of the site near MMRP64-SB016. It is unknown if the casing was a remnant from the former small arms range.

3.3.3 Sample Logging

Soil sample log sheets maintained for the samples collected during this SI are included in Appendix B and contain the following information, as appropriate for each sample:

- Sample location and sample ID
- Name of person(s) collecting the sample
- Sample collection method
- Sample depth, date, and time
- Brief soil description

3.4 SAMPLING OPERATIONS

A total of sixty-eight soil samples were collected from 23 sampling locations during the SI at the D-6, Small Arms Range. Sixty-five of the samples underwent field XRF analysis for lead, and 20 samples were selected for metals analysis at the FBL. Soil samples were collected in accordance with SOP-05 and -06. Four groundwater samples were collected from four of the soil boring locations at the D-6, Small Arms Range. See Figure 3-1 for all sampling locations. Soil and groundwater sample log sheets are included in Appendix B of this document.

All surface soil samples collected from 0 to 0.5 feet bgs at the site were collected by hand auger during this SI. The three soil samples located in the drainage channel were collected via disposable plastic trowels. All samples collected at depths greater than 0.5 feet were collected via DPT.

The four temporary groundwater monitoring wells were purged and subsequently sampled utilizing low-flow techniques with a peristaltic pump and dedicated tubing.

3.4.1 Discrete Surface Soil Sampling

A total of 20 discrete surface soil samples (0 to 0.5 feet bgs) were collected within the four quadrants at the D-6, Small Arms Range (MMRP64-SS001D through SS020D). All 20 samples were analyzed in the field via XRF using the sample process discussed in Section 3.3.2. The average XRF lead concentration for each of these samples was used as the basis for determining if additional sampling was required in the area of that sample. Any discrete sample location with an average XRF lead concentration greater than the WP Project Action Limit (PAL) of 270 milligrams per kilogram (mg/kg) was selected for composite surface soil sampling via hand auger and additional discrete subsurface sampling via DPT at 2-foot intervals at that location.

Seven of the 20 discrete surface soil sample locations had average XRF lead concentrations greater than 270 mg/kg, with the highest concentrations located in Quadrant B at sample locations MMRP64-SS006 (1,449 mg/kg); 007 (3,163 mg/kg); and 010 (6,261 mg/kg). Sample locations MMRP64-SS007 and 010 are located in the general vicinity of where the range bullet trap would have been located within the former footprint of B-451. None of the 20 discrete surface soil samples were selected for metals analysis at the FBL. The purpose of these samples was to identify theose locations at which lead existed in soil. See Figure 3-2 for the XRF lead concentrations at all soil sample locations.

Three discrete surface soil samples (MMRP64-SB021 – 023) were collected in the drainage ditch along the northern and northeastern sections of the site. It is believed that this drainage ditch is dry for most of the year, as it was during this sampling event, even though heavy rains had fallen days before sampling. One sample was collected upgradient of the site, one was collected in the vicinity of the site, and the third sample was collected downgradient of the site from the ditch (see Figure 3-2). All three discrete surface soil samples collected within the drainage ditch were sent to the FBL for select TAL metals analysis.

3.4.2 Composite Surface Soil Sampling

Based on their XRF lead concentrations, nine of the 23 discrete sample locations were selected for additional composite surface soil sampling (0 to 0.5 feet bgs). Seven discrete sample locations (MMRP64-SB004, 005, 006, 007, 009, 010, and 011) were selected because they had average XRF lead concentrations greater than 270 mg/kg. The other two sample locations (MMRP64-SB012 and 019) were selected as confirmation samples because their average XRF lead concentrations were low (less than 20 mg/kg).

Each composite sample consisted of four aliquots collected in a circular fashion at distances of approximately 5 feet from the original location. The samples were homogenized within a large ziploc-type baggie, and a portion of the sample was processed for XRF analysis and another portion was placed in the appropriate sample container and shipped to the FBL for select TAL metals analysis.

All nine composite surface soil samples collected at the D-6, Small Arms Range were shipped to the FBL for confirmatory select TAL metals analysis. FBL lead sample results for the original seven sample locations were as high as, and in some cases much higher, than the associated composite XRF lead concentrations, and the two sample locations with the low XRF lead concentrations also had relatively low FBL lead results (see Table 3-2).

3.4.3 DPT Soil Sampling

Thirty-six discrete soil samples were collected from nine borings utilizing DPT. Four soil samples were collected at each of the nine locations at depths of 0 to 2 feet bgs, 2 to 4 feet bgs, and 4 to 6 feet bgs, and the last two feet above groundwater level. Specific sample depths can be found on Table 3-1.

Utilizing DPT, samples were removed from the ground inside a 4-foot clean plastic sleeve, which was then cut open to reveal the sample core. General observations including grain size, color, wetness, etc. were noted on the soil sample log (Appendix B). Soil was removed from each half of the plastic sleeve and placed inside a large ziploc-type baggie that was labeled with the sample date, depth, and time. The sample was thoroughly homogenized within the baggie, and a portion of the sample was then removed for processing and field XRF analysis.

Based on XRF results, specific samples were selected for shipment to the FBL where they underwent select TAL metals analysis.

3.4.4 Groundwater Sampling

A temporary groundwater well was installed within a DPT soil boring at each of the four quadrants at the D-6, Small Arms Range. The temporary wells were placed at sample locations MMRP64-SB004, 007, 012, and 019. A 1-inch-diameter polyvinyl chloride (PVC) Schedule 40 well screen and riser pipe were set into the borings at a depth approximately 4 feet below the observed groundwater level. The temporary well screens were approximately 10 feet in length. Initial groundwater levels were determined by the dry/wet transition area observed in the DPT soil cores. Prior to sampling each well, an electronic water-level indicator was used to measure the water level in each well, and this information was recorded on the groundwater sampling log (Appendix B). The water in temporary wells MMRP64-TW004, 007, and 012 was allowed to stabilize for approximately 10 hours prior to purging and sampling. Temporary well MMRP64-TW019 was purged and sampled approximately 24 hours after installation. The temporary wells were purged and sampled by use of a peristaltic pump and dedicated tubing. The temporary wells were purged for a minimum of 30 minutes in an attempt to lower turbidity levels in the wells. Water-quality parameters [pH, specific conductivity, temperature, dissolved oxygen (DO), oxidation-reduction potential (ORP), and turbidity], and water levels were recorded on low-flow well purge logs. Low-flow log sheets and groundwater sample logs can be found in Appendix B of this document. Section 3.10 describes the disposal of all investigation-derived waste (IDW) including decontamination and well development fluids.

General information regarding the four temporary groundwater monitoring wells can be found in the table below:

Table 3-3 Temporary Groundwater Monitoring Well Summary

Well Location	Quadrant	Groundwater Depth (feet bgs)	Well Casing Depth (feet bgs)	Water Level in Well (feet bgs)
MMRP64-SB/TW004	A	11.5	19.0	10.25
MMRP64-SB/TW007	B	8.0	12.0	8.7
MMRP64-SB/TW012	C	14.0	19.0	10.6
MMRP64-SB/TW019	D	11.5	19.0	12.5

3.5 FIELD SAMPLE DOCUMENTATION

Sample documentation consisted of the completion of sample log sheets, chain-of-custody records, field logbooks, and health and safety documentation. Field documentation was completed as per SOP-03. The sample log sheets contain information such as sample location and sample identification number, container requirements and analyses to be performed, and sample type, time, and date. Any unusual circumstances encountered during sample collection were noted on the form. Chain-of-custody forms

were used to track each sample from collection to receipt and analysis at the FBL. All field log sheets and field forms are included in Appendix B of this document.

3.6 SAMPLE HANDLING, PACKAGING, AND SHIPPING

Sample handling activities included field-related considerations concerning the selection of sample containers, allowable holding times, sample custody, and maintaining samples at the appropriate storage temperature. All sample containers shipped to the FBL were sealed in plastic ziploc-type bags to minimize the possibility of breakage during transport. The sample containers were then placed in a cooler lined with a large plastic garbage bag and covered with ice. A temperature blank was placed in each cooler prior to shipment. The plastic garbage bag was sealed with a knot, and the chain-of-custody form was sealed in a ziploc-type bag and taped to the inside of the cooler lid. A signed and dated custody seal was applied to each end of the cooler and then covered with strapping tape to provide a tamper-evident seal. A Federal Express® airbill was applied to the shipping cooler. TtNUS maintained custody of the samples until they were relinquished to Federal Express®. The Federal Express® tracking number (airbill number) was recorded on the chain-of-custody form, and the sender's copy of the airbill was maintained for shipment tracking, if needed. All samples were shipped to the FBL for overnight delivery and were received within sample holding times.

3.7 QUALITY CONTROL SAMPLES

Quality assurance (QA)/quality control (QC) samples were generated and collected during sampling activities to monitor both field and laboratory procedures, in accordance with the approved WP (TtNUS, 2009). QC for the XRF analyzer is detailed in Section 3.3.2 of this document. QA/QC samples included field duplicates, equipment rinsate blanks, and temperature blanks. Field duplicate results are tabulated in Appendix D of this document. Types of QA/QC samples are briefly described as follows:

- Field Duplicates - consisted of a single sample split into two portions. Field duplicates were collected at the rate of 1 in 20 during this field investigation to assess the overall precision of the sampling and analysis program.

- Equipment Rinsate Blanks - obtained under representative field conditions by collecting the rinse water generated by running analyte-free water through or over sample collection equipment after decontamination and before use. Equipment rinsate blanks were analyzed for the same chemical constituents as the associated environmental samples.

- Temperature blanks - used to determine if samples were adequately cooled during shipment. Temperature blanks consisted of analyte-free water supplied by the FBL. One temperature blank was submitted to the laboratory in each cooler, and the temperature was checked upon receipt at the laboratory.

3.8 GPS

Each sample location at the D-6, Small Arms Range was marked with a brightly covered pin flag pushed into the ground next to the boring. Northing and easting coordinates for each sample location were then logged by TtNUS personnel utilizing a Trimble XT (sub-meter) GPS unit. This information is retained in the TtNUS main database and can be used as a reference if repeat sampling is required at any of the sample locations.

3.9 DECONTAMINATION PROCEDURES

Non-dedicated non-disposable equipment (e.g., hand augers) involved in field sampling activities was decontaminated before beginning work, between sample locations, and at the completion of field activities in accordance with SOP-04.

The following decontamination steps were taken:

- Potable water and phosphate-free detergent wash (scrub if necessary)
- Potable water rinse
- Deionized (DI) water rinse
- Air dry (if possible)
- Wrap in aluminum foil (if not used immediately)

3.10 INVESTIGATION-DERIVED WASTE HANDLING

IDW consisted of decontamination and temporary well purge fluids, paper towels, pin flags, and personnel protective equipment (PPE).

All soil removed from a sample location that was not used as part of that sample was returned to its original boring.

PPE – All PPE was double bagged and placed in MCB Camp Lejeune trash receptacles (i.e., dumpsters).

Sampling Equipment Decontamination and Well Purge Fluids – Equipment decontamination and purge water fluids were retained by TtNUS in a plastic container that was labeled, sealed, and temporarily stored at MCB Camp Lejeune Resource Conservation and Recovery Services (RCRS). A composite sample was collected from the container and submitted to the FBL for metals analysis for determination of disposal requirements. The FBL lead result for the decontamination/purge water was 2.9 mg/L, less than the 5.0 mg/L RCRA threshold for designation as hazardous waste. TtNUS provided MCB Camp Lejeune RCRS with the analytical results from waste characterization sampling, and RCRS then took responsibility for IDW disposal at the Water Treatment Plant located at B-977/S-962. Analytical results are included in Appendix D.

3.11 SITE MANAGEMENT AND FACILITY SUPPORT

The FOL was designated as the lead in coordinating all day-to-day activities during the investigation. The FOL was responsible for ensuring that the field team members (including subcontractors) were familiar with the approved WP and the HASP in effect during this field investigation. Additionally, the FOL was responsible for all sampling operations, QA/QC, field documentation requirements, and field change orders. The FOL reported to the Project Manager (PM) on a daily basis regarding the status of fieldwork.

3.12 RECORD KEEPING

SI records including daily activity logs, sample log sheets, and chain-of-custody forms were completed in accordance with SOP-03. Information recorded daily included field activities, weather conditions, identity and arrival and departure times of personnel, management issues, etc. Copies of daily activity records are included in Appendix B.

TABLE 3-1

BORING DATES, DEPTHS, METHODS, AND INTERVALS
D-6, SMALL ARMS RANGE
MCB CAMP LEJEUNE
ONSLOW COUNTY, NORTH CAROLINA

Boring No.(MMRP64)	Total Depth (feet bgs)	Collection Method[(1)]	Date Drilled	Depth Interval of Soil Sample (feet bgs)
SB001	0.5	HA	05/13/09	0 - 0.5
SB002	0.5	HA	05/13/09	0 - 0.5
SB003	0.5	HA	05/13/09	0 - 0.5
SB004	10.0	HA 0-0.5 DPT 0.5-10	5/13/09 5/14/09	0-0.5 0-2, 2-4, 4-6, 8-10
SB005	10.0	HA 0-0.5 DPT 0.5-10	5/13/09 5/14/09	0-0.5 0-2, 2-4, 4-6, 8-10
SB006	8.0	HA 0-0.5 DPT 0.5-8	5/13/09 5/14/09	0-0.5 0-2, 2-4, 4-6, 6-8
SB007	8.0	HA 0-0.5 DPT 0.5-8	5/13/09 5/14/09	0-0.5 0-2, 2-4, 4-6, 6-8
SB008	0.5	HA	05/13/09	0 - 0.5
SB009	10.0	HA 0-0.5 DPT 0.5-10	5/13/09 5/14/09	0-0.5 0-2, 2-4, 4-6, 8-10
SB010	7.0	HA 0-0.5 DPT 0.5-7	5/13/09 5/14/09	0-0.5 0-2, 2-4, 4-6, 6-7
SB011	10.0	HA 0-0.5 DPT 0.5-10	5/13/09 5/14/09	0-0.5 0-2, 2-4, 4-6, 8-10
SB012	14.0	HA 0-0.5 DPT 0.5-14	5/13/09 5/14/09	0-0.5 0-2, 2-4, 4-6, 12-14
SB013	0.5	HA	05/13/09	0 - 0.5
SB014	0.5	HA	05/13/09	0 - 0.5
SB015	0.5	HA	05/13/09	0 - 0.5
SB016	0.5	HA	05/13/09	0 - 0.5
SB017	0.5	HA	05/13/09	0 - 0.5
SB018	0.5	HA	05/13/09	0 - 0.5
SB019	13.0	HA 0-0.5 DPT 0.5-13	5/13/09 5/14/09	0-0.5 0-2, 2-4, 4-6, 11-13
SB020	0.5	HA	05/13/09	0 - 0.5
SB021	0.5	PT	05/13/09	0 - 0.5
SB022	0.5	PT	05/13/09	0 - 0.5
SB023	0.5	PT	05/13/09	0 - 0.5

1 HA - hand auger; DPT = direct-push technology; PT = plastic trowel.
bgs - Below ground surface.

TABLE 3-2

FIELD XRF AND FIXED-BASE LABORATORY LEAD CONCENTRATIONS
D-6, SMALL ARMS RANGE
MCB CAMP LEJEUNE
ONSLOW COUNTY, NORTH CAROLINA

SAMPLE DATE	SAMPLE LOCATION	SAMPLE ID	XRF READINGS - Lead (mg/kg)				Fixed-Base Laboratory (mg/kg)
			1st	2nd	3rd	AVG	
5/13/2009	MMRP64-SB001	MMRP64-SS001-D-0001	105	86	75	**89**	---
5/13/2009	MMRP64-SB002	MMRP64-SS002-D-0001	11	8	ND	**6**	---
5/13/2009	MMRP64-SB003	MMRP64-SS003-D-0001	12	14	10	**12**	---
5/13/2009	MMRP64-SB004	MMRP64-SS004-D-0001	380	442	551	**458**	---
5/13/2009		MMRP64-SS004-C-0001	727	814	709	**750**	**591**
5/14/2009		MMRP64-SB004-D-0002	ND	ND	ND	**ND**	---
5/14/2009		MMRP64-SB004-D-0204	ND	ND	ND	**ND**	---
5/14/2009		MMRP64-SB004-D-0406	10	14	12	**12**	---
5/14/2009		MMRP64-SB004-D-0810	15	11	12	**13**	**92**
5/13/2009	MMRP64-SB005	MMRP64-SS005-D-0001	382	331	355	**356**	---
5/13/2009		MMRP64-SS005-C-0001	758	969	841	**856**	**1,590**
5/14/2009		MMRP64-SB005-D-0002	658	667	633	**653**	**904**
5/14/2009		MMRP64-SB005-D-0204	408	165	170	**248**	**1,140**
5/14/2009		MMRP64-SB005-D-0406	27	39	55	**40**	---
5/14/2009		MMRP64-SB005-D-0810	21	27	30	**26**	---
5/13/2009	MMRP64-SB006	MMRP64-SS006-D-0001	1283	1387	1677	**1,449**	---
5/13/2009		MMRP64-SS006-C-0001	376	351	535	**421**	**529**
5/14/2009		MMRP64-SB006-D-0002	ND	8	14	**7**	---
5/14/2009		MMRP64-SB006-D-0204	ND	ND	ND	**ND**	---
5/14/2009		MMRP64-SB006-D-0406	ND	9	ND	**3**	---
5/14/2009		MMRP64-SB006-D-0608	ND	ND	9	**3**	---
5/13/2009	MMRP64-SB007	MMRP64-SS007-D-0001	3723	2722	3043	**3,163**	---
5/13/2009		MMRP64-SS007-C-0001	8015	7428	9449	**8,297**	**23,400**
5/14/2009		MMRP64-SB007-D-0002	9484	13879	9291	**10,885**	**60,400**
5/14/2009		MMRP64-SB007-D-0204	931	845	602	**793**	---
5/14/2009		MMRP64-SB007-D-0406	98	86	100	**95**	---
5/14/2009		MMRP64-SB007-D-0608	ND	ND	ND	**ND**	---
5/13/2009	MMRP64-SB008	MMRP64-SS008-D-0001	21	14	23	**19**	---
5/13/2009	MMRP64-SB009	MMRP64-SS009-D-0001	596	601	692	**630**	---
5/13/2009		MMRP64-SS009-C-0001	550	392	474	**472**	**1,160**
5/14/2009		MMRP64-SB009-D-0002	976	883	983	**947**	**941**
5/14/2009		MMRP64-SB009-D-0204	ND	10	13	**8**	---
5/14/2009		MMRP64-SB009-D-0406	ND	11	10	**7**	**7**
5/14/2009		MMRP64-SB009-D-0810	29	51	37	**39**	---
5/13/2009	MMRP64-SB010	MMRP64-SS010-D-0001	3860	6483	8441	**6,261**	---
5/13/2009		MMRP64-SS010-C-0001	5822	3158	3446	**4,142**	**14,100**
5/14/2009		MMRP64-SB010-D-0002	113	169	136	**139**	**286**
5/14/2009		MMRP64-SB010-D-0204	ND	8	9	**6**	---
5/14/2009		MMRP64-SB010-D-0406	8	8	ND	**5**	---
5/14/2009		MMRP64-SB010-D-0607	ND	8	ND	**3**	---
5/13/2009	MMRP64-SB011	MMRP64-SS011-D-0001	379	396	388	**388**	---
5/13/2009		MMRP64-SS011-C-0001	485	426	433	**448**	**634**
5/14/2009		MMRP64-SB011-D-0002	22	26	19	**22**	**22**
5/14/2009		MMRP64-SB011-D-0204	ND	ND	ND	**ND**	---
5/14/2009		MMRP64-SB011-D-0406	9	14	13	**12**	---
5/14/2009		MMRP64-SB011-D-0810	16	28	23	**22**	---

TABLE 3-2

FIELD XRF AND FIXED-BASE LABORATORY LEAD CONCENTRATIONS
D-6, SMALL ARMS RANGE
MCB CAMP LEJEUNE
ONSLOW COUNTY, NORTH CAROLINA

SAMPLE DATE	SAMPLE LOCATION	SAMPLE ID	XRF READINGS - Lead (mg/kg)				Fixed-Base Laboratory (mg/kg)
			1st	2nd	3rd	AVG	
5/13/2009	MMRP64-SB012	MMRP64-SS012-D-0001	19	17	22	**19**	---
5/13/2009		MMRP64-SS012-C-0001	21	30	27	**26**	**26**
5/14/2009		MMRP64-SB012-D-0002	12	13	16	**14**	---
5/14/2009		MMRP64-SB012-D-0204	ND	ND	ND	**ND**	---
5/14/2009		MMRP64-SB012-D-0406	9	11	12	**11**	---
5/14/2009		MMRP64-SB012-D-1214	18	13	20	**17**	---
5/13/2009	MMRP64-SB013	MMRP64-SS013-D-0001	14	19	15	**16**	---
5/13/2009	MMRP64-SB014	MMRP64-SS014-D-0001	34	27	27	**29**	---
5/13/2009	MMRP64-SB015	MMRP64-SS015-D-0001	26	25	24	**25**	---
5/13/2009	MMRP64-SB016	MMRP64-SS016-D-0001	9	13	13	**12**	---
5/13/2009	MMRP64-SB017	MMRP64-SS017-D-0001	26	14	16	**19**	---
5/13/2009	MMRP64-SB018	MMRP64-SS018-D-0001	31	30	35	**32**	---
5/13/2009	MMRP64-SB019	MMRP64-SS019-D-0001	ND	13	8	**7**	---
5/13/2009		MMRP64-SS019-C-0001	70	77	75	**74**	**81**
5/14/2009		MMRP64-SB019-D-0002	ND	ND	ND	**ND**	---
5/14/2009		MMRP64-SB019-D-0204	ND	ND	ND	**ND**	---
5/14/2009		MMRP64-SB019-D-0406	ND	15	14	**10**	---
5/14/2009		MMRP64-SB019-D-1113	20	16	9	**15**	---
5/14/2009	MMRP64-SB020	MMRP64-SS020-D-0001	27	24	28	**26**	---
5/14/2009	MMRP64-SB021	MMRP64-SS021-D-0001	NA	NA	NA	NA	**107**
5/14/2009	MMRP64-SB022	MMRP64-SS022-D-0001	NA	NA	NA	NA	**73**
5/14/2009	MMRP64-SB023	MMRP64-SS023-D-0001	NA	NA	NA	NA	**139**

Shading of a cell indicates exceedence of the field screening lead concentration of 270 mg/kg.
"---" indicates sample not sent to the fixed-base laboratory
Sample depths of 0-0.5 feet below ground surface have been rounded up to 1 foot.
Last four digits of the sample ID indicate sample collection depth (feet).
NA = Not applicable (no XRF reading).

TETRA TECH

Figure 3-1
Site Inspection
Sample Locations
D-6, 50-foot Indoor Rifle
and Pistol Range
(Former Building 451, ASR #2.64)
MCB Camp Lejeune
Onslow County, North Carolina

Legend

- Sample Location
- Sample Boundary
- Topographic Contour (4-ft interval)
- Former Location of Demolished Building 451 (ASR #2.64)

TW = Temporary Well

SB = Soil Boring

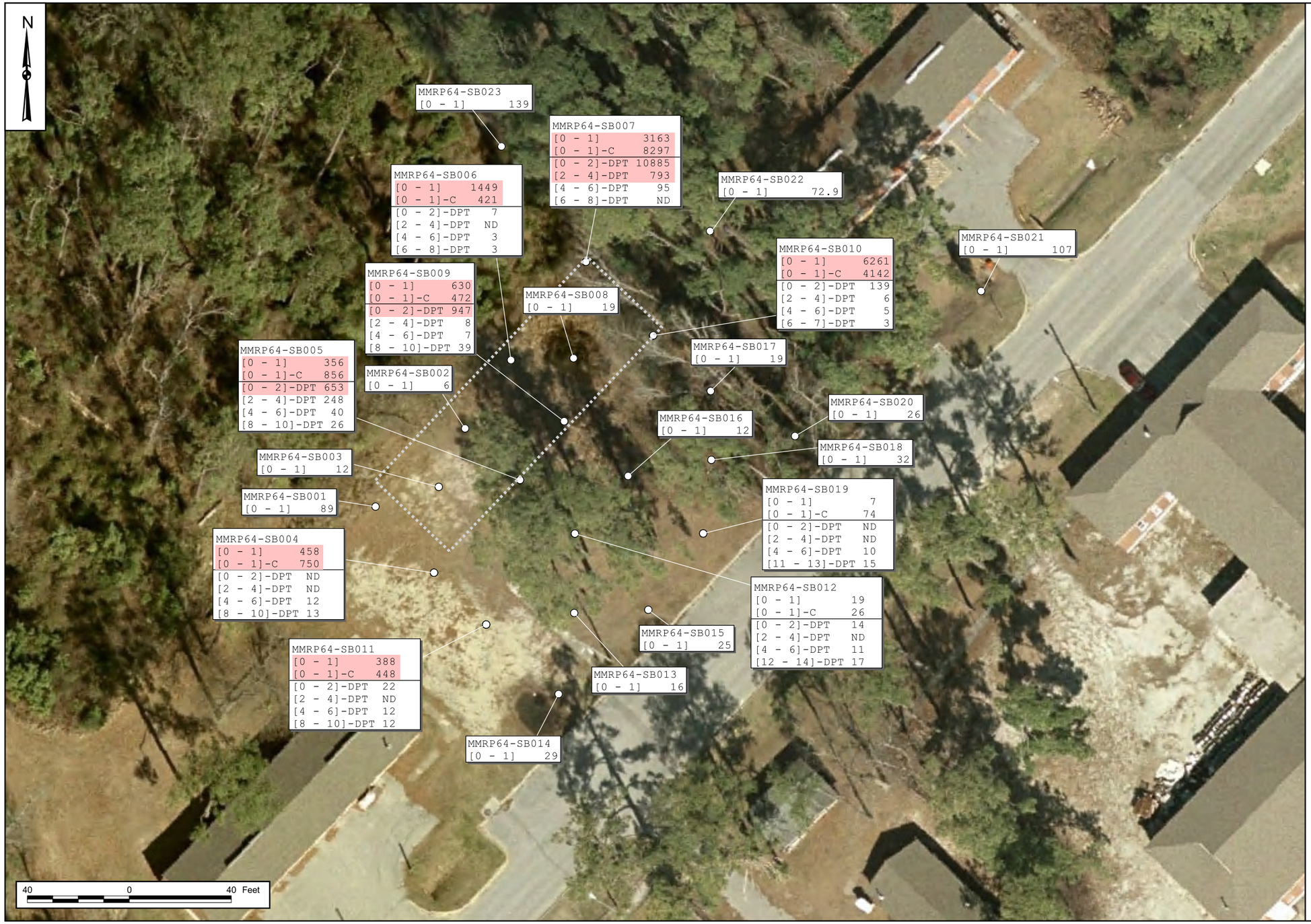
NOTE: Digital image provided by Camp Lejeune Installation Geospatial and Information Service (IGI&S), East Coast Regional GEOFidelis (Geospatial) Center.

30 15 0 30
Feet

Drawn By: K. MOORE 10/22/08
Checked By: R. BARRINGER 9/11/09
Approved By:

Project Number: 112G01716
CTO 0163

P:\GIS\CAMP_LEJEUNE\MXD\INDOOR_FIRING_RANGE.MXD 9/11/09 KM



TETRA TECH

Figure 3-2
XRF Soil Results
D-6, 50-foot Indoor Rifle
and Pistol Range
(Former Building 451, ASR #2.64)
MCB Camp Lejeune
Onslow County, North Carolina

LEGEND

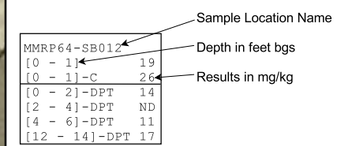
- ○ Soil Sample Location
- Former Location of Demolished Building 451 (ASR #2.64)

Pink shading indicates XRF soil lead concentrations above Project Action Limits.

C = Composite Hand Sample

DPT = Direct Push Technology Sample

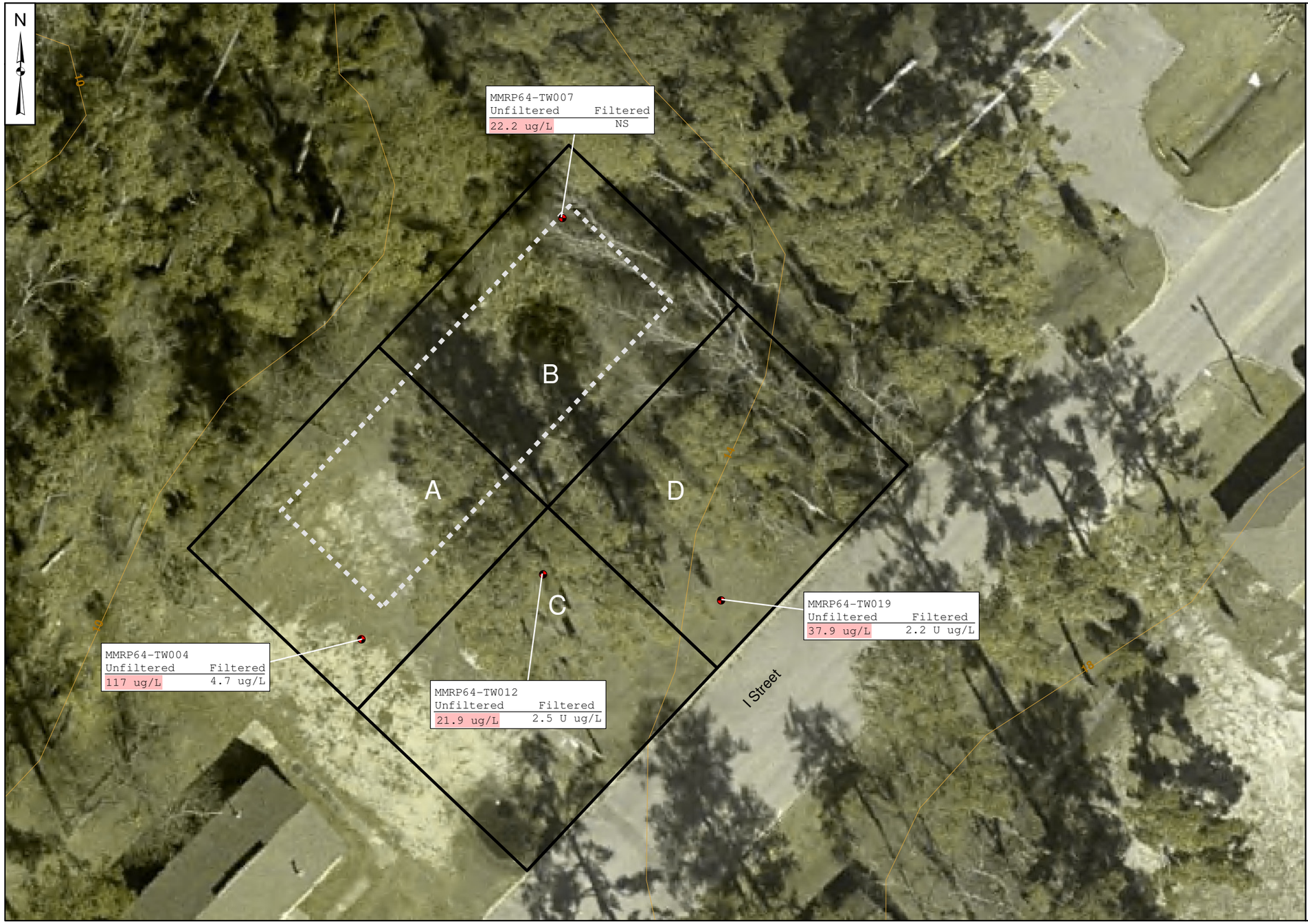
Results reported in mg/kg



Drawn By: K. MOORE 7/17/09
Checked By: R. BARRINGER 9/15/09
Approved By:

Contract Number: 112G01716
CTO 0163

P:\GIS\CAMP_LEJEUNE\APR\TAGS.APR FIELD RESULTS B SIZE
9/11/09 KM



TETRA TECH

Figure 3-3
Laboratory Groundwater Lead Results
D-6, 50-foot Indoor Rifle
and Pistol Range
(Former Building 451, ASR #2.64)
MCB Camp Lejeune
Onslow County, North Carolina

Legend

- DPT Groundwater Sample Exceedance (=> 15 ug/L for lead)
- SI Area Boundary
- Topographic Contour (4-ft interval)
- Former Location of Demolished Building 451 (ASR #2.64)

Pink shading indicates groundwater lead concentrations above Project Action Limits.

Natural Color Digital Image
Dated February 2004 (0.15m/pixel resolution)

NS = No Sample Filtered

TW = Temporary Wells Installed using Direct Push Technology

NOTE: Digital image provided by Camp Lejeune Installation Geospatial and Information Service (IGI&S), East Coast Regional GEOFidelis (Geospatial) Center.

30 15 0 30
Feet

Drawn By: K. MOORE 10/22/08
Checked By: R. BARRINGER 9/15/09
Approved By:

Project Number: 112G01716
CTO 0163

P:\GIS\CAMP_LEJEUNE\MXD\INDOOR_RANGE_GW_RESULTS.MXD
9/11/09 KM

4.0 RESULTS

4.1 MC RESULTS

4.1.1 Field Work Summary

Soil sample locations were selected based on a bias towards areas that were believed to be most likely contaminated by past operations at the site. TtNUS provided recommendations and received approval from the NCDENR and the USEPA before proceeding with the implementation of the WP. A total of 23 discrete surface soil samples were first collected at a depth of 0 to 0.5 feet bgs. Based on field XRF analysis, discrete sample locations with lead concentrations greater than the PAL of 270 mg/kg were then subject to composite surface soil sampling at depths of 0 to 0.5 feet bgs. The composite samples were comprised of four aliquots within a 5-foot radius of the discrete sample location. At sample locations where both discrete and composite surface soil samples were collected, DPT was used to advance subsurface sampling to 0 to 2 feet bgs, 2 to 4 feet bgs, and 4 to 6 feet bgs, as well as the last 2 feet above groundwater. A summary of sample locations including method of collection and sample depth is provided in Table 3-1, and sample locations are presented on Figure 3-1. Groundwater samples were collected within the shallow groundwater table from four temporary groundwater monitoring wells. Surface water and sediment sampling was proposed in the WP in the drainage channel northeast of the investigation area; however, the drainage channel was observed to be dry during the time of sample collection and no surface water or sediment samples were collected. Three surface soil samples were collected from the drainage channel.

4.1.2 Comparisons to Screening Criteria

Soil

Surface and subsurface soil sample results (XRF - lead and FBL - select TAL metals) were compared to the North Carolina Soil Screening Levels (NC SSLs). FBL sample results for tin were compared to the Oak Ridge National Laboratory (ORNL) Regional Screening Level (RSL). Surface and subsurface soil analytical results are summarized on Tables 4-1 and 4-2, respectively. Complete analytical results are presented in Appendix D.

Groundwater

Groundwater sample results (FBL) for arsenic, copper, lead, nickel, and zinc were compared to the North Carolina Groundwater standards (NCDENR 2L Standards). Sample results for antimony and tin were

compared to the ORNL RSLs. Sample results for perchlorate were compared only to the January 2009 USEPA Interim Drinking Water Health Advisory screening concentration. Perchlorate analysis was requested for this SI in the initial statement of work for this project. Groundwater analytical results are summarized in Table 4-3. Complete analytical results are presented in Appendix D.

4.1.3 Surface Soil

Twenty discrete surface soil samples were collected within the sampling grid at the site and all underwent field screening for lead via XRF. Seven of the 20 discrete surface soil sample locations had average XRF lead concentrations greater than the RSL of 270 mg/kg. This included sample locations MMRP64-SB004 (458 mg/kg), 005 (356 mg/kg), 006 (1,449 mg/kg), 007 (3,163 mg/kg), 009 (630 mg/kg), 010 (6,261 mg/kg), and 011 (388 mg/kg). The sample locations with the highest concentrations were located in Quadrant B at sample locations MMRP64-SS006, 007, and 010. Sample locations MMRP64-SB007 and 010 are located in the general vicinity of where the range bullet trap would have been located within the former footprint of B-451. The remaining 13 discrete surface soil samples all had XRF lead concentrations well below the RSL. None of the 20 discrete surface soil samples were selected for metals analysis at the FBL. The purpose of these samples was to identify those locations at which lead existed in the soil at concentrations above the RSL of 270 mg/kg. See Table 3-2 and Figure 4-1 for the XRF lead concentrations at all soil sample locations.

Three discrete surface soil samples were collected in the drainage ditch that runs along the northern and northeastern section of the site. It is believed that this drainage ditch is dry for most of the year, as it was during this sampling event, even though heavy rains had fallen just days before sampling. One sample was collected up-gradient of the site, one was collected in the vicinity of the site, and the third sample was collected down-gradient of the site (See Figure 4-1). All three discrete surface soil samples collected within the drainage ditch were sent to the FBL for metals analysis. All sample results were below the soil RSLs.

Composite samples were collected at the above mentioned seven sample locations, and an additional two composite samples were collected at sample locations MMRP64-SB012 and 019. These two sample locations had discrete sample XRF lead concentrations below 20 mg/kg, and were selected as confirmation samples. Each composite sample consisted of 4 aliquots which were spaced in a circular fashion around the original discrete sample boring at a distance of approximately 5 feet from center. All nine composite samples underwent field screening for lead with the XRF and all nine were shipped to the FBL for select metals analysis. The FBL lead composite sample results for the original seven sample locations were as high, and in some cases much higher, than its associated composite XRF lead

concentration. The FBL lead concentration for composite samples at MMRP64-SB007 and 010 were 23,400 and 14,100 mg/kg, respectively. The antimony concentration at these two composite sample locations also exceeded the RSL. The two sample locations with the low field XRF lead concentrations (MMRP64-SB012 and 019) also had relatively low FBL lead results (See Table 3-2). Figure 3-2 presents all XRF lead concentrations at all soil sample locations at the D-6, Small Arms Range.

4.1.4 Subsurface Soil

The nine sample locations that underwent composite sampling were also subject to additional subsurface sampling utilizing DPT. Sample depths at each location included 0.5 to 2 feet bgs, 2 to 4 feet bgs, and 4 to 6 feet bgs, as well as the last two feet above the shallow groundwater table.

Sample locations MMRP64-SB005, 007, 009, and 010 had XRF and/or FBL lead concentrations greater than the RSL at depths to 2 feet bgs. Only sample locations MMRP64-SB005 and 007 had XRF and/or FBL lead concentrations exceeding the RSL at depths of 2 to 4 feet bgs. No sample locations had XRF and/or FBL lead concentrations exceeding the RSL at depths greater than 4 feet bgs.

4.1.5 Groundwater

Sample locations were selected from each of the four quadrants for placement of a temporary monitoring well into the shallow groundwater table. The sample locations were MMRP64-SB004, 007, 012, and 019. Only sample location MMRP64-SB007 had a turbidity level less than 10 nephelometric turbidity units (NTUs) prior to sampling, so no filtered groundwater sample was collected at this location. The remaining three sample locations had very high (greater than 300 NTUs) turbidity levels and therefore filtered samples were also collected at each of these locations. All samples were shipped to the FBL for select TAL metals and perchlorate analysis.

Lead concentrations ranged from 22 to 117 micrograms per liter (µg/L) in each of the four non-filtered samples that exceeded the RSL of 15 µg/L. However, lead concentrations in the three filtered samples ranged from 2.2 to 4.7 µg/L, which is below the RSL.

A more detailed evaluation of this information (human health and ecological), including discussion of migration of soil contaminants to groundwater, is included in Sections 4.4 and 4.5.

4.1.6 Summary

Lead was detected in seven of the 20 discrete surface soil samples (0 to 0.5 feet bgs) that were collected within the main sample grid at concentrations greater than the PAL for residential soil. The FBL lead concentrations for the three surface soil samples collected within the drainage channel were all below the RSL. Composite samples were collected at the seven discrete sample locations which had lead concentrations greater than the PAL. The field XRF analysis and the FBL select TAL metals analysis confirmed the presence of lead in all seven samples at concentrations greater than the RSL at a depth of 0 to 0.5 feet bgs. Antimony was also detected in composite sample locations MMRP64-SB007 (126 mg/kg) and 010 (79.2 mg/kg) at concentrations greater than the PAL of 5.42 mg/kg. Lead was detected in concentrations greater than the PAL at 0 to 2 feet bgs at sample locations MMRP64-SB005 (904 mg/kg), 007 (60,400 mg/kg), 009 (941 mg/kg), and 010 (286 mg/kg). Lead was detected in concentrations greater than the PAL at 2 to 4 feet bgs at sample locations MMRP64-SB005 (1,140 mg/kg) and 007 (793 mg/kg). No lead value greater than the PAL was detected in any sample at a depth greater than 4 feet bgs (see Table 3-2).

Lead was detected in all four unfiltered groundwater sample locations at concentrations ranging from 22 to 117 µg/L which were greater than the RSL of 15 µg/L. The three filtered groundwater samples had lead concentrations ranging from 2.2 to 4.7 µg/L.

4.2 DATA QUALITY REVIEW

This section describes the data review processes used to determine whether analytical laboratory data were of acceptable technical quality for use in decision making. The review began with data validation, which is a comparison of data quality indicators (DQIs) to prescribed acceptance criteria. The DQIs used are measures to assess the bias and precision of the analytical calibrations and sample analyses. The output of this review was a set of alphabetic flags such as "U," “J,” “R,” or combinations thereof, that may have been assigned to individual results based on the validation effort. These flags were used to infer the general quality of the data. Also evaluated were the measures of data completeness, sensitivity, comparability and representativeness.

4.2.1 Data Validation Process

Limited data validation conducted to evaluate false positives included evaluations of data completeness, holding time compliance, calibrations, field QC and laboratory-generated blanks, field duplicate precision, and detection limits for the data collected during the SI. The data packages provided by the analytical laboratory are expansive enough to allow future complete formal data validation, if necessary.

Assignment of data qualification flags conformed to USEPA Contract Laboratory Program National Functional Guidelines for Organic Data Review (1999) to the greatest extent practicable for non-Contract Laboratory Program Data. Data validation specifications require that various data qualifiers be assigned when a deficiency is detected or when a result is less than its detection limit. If no qualifier is assigned to a result that has been validated, the data user is assured that no technical deficiencies were identified during validation. The qualification flags used are defined as follows:

- U – Indicates that the chemical was not detected at the numerical detection limit (sample-specific detection limit) noted. Non-detected results from the laboratory are reported in this manner. This qualifier is also added to a positive result (reported by the laboratory) if the detected concentration is determined to be attributable to contamination introduced during field sampling or laboratory analysis.

- UJ – Indicates that the chemical was not detected; however, the detection limit (sample-specific detection limit) is considered to be estimated based on problems encountered during laboratory analysis. The associated numerical detection limit is regarded as inaccurate or imprecise.

- J – Indicates that the chemical was detected; however, the associated numerical result is not a precise representation of the concentration that is actually present in the sample. The laboratory reported concentration is considered to be an estimate of the true concentration.

- UR – Indicates that the chemical may or may not be present. The non-detected analytical result reported by the laboratory is considered to be unreliable and unusable. This qualifier is applied in cases of gross technical deficiencies (e.g., holding time missed by a factor of two times the specified time limit, severe calibration non-compliance, and extremely low analyte recovery).

- R – Indicates that the chemical may or may not be present. The positive analytical result reported by the laboratory is considered to be unreliable and unusable. This qualifier is applied in cases of gross technical deficiencies.

The preceding data qualifiers may be categorized as indicative of major or minor problems. Major problems are defined as issues that result in the rejection of data and qualification with UR or R qualifiers. These data are considered invalid and are not used for decision-making purposes unless they are used in a qualitative way and the use is justified and documented. Minor problems are defined as issues resulting in the estimation of data and qualification with “U”, “J”, and “UJ” qualifiers. Estimated analytical

results are considered to be suitable for decision-making purposes unless the data use requirements are very stringent and the qualifier indicates a deficiency that is incompatible with the intended data use. A "U" qualifier does not necessarily indicate that a data deficiency exists because all non-detect values are flagged with the "U" qualifier regardless of whether a quality deficiency has been detected. No data from the D-6, Small Arms Range were rejected or considered unusable.

4.2.2 Data Validation Outputs

After data were validated, a list was developed of non-conformities requiring data qualifier flags used to alert the data user to inaccurate or imprecise data. The reviewer then prepared a technical memorandum presenting qualification of the data, if necessary, and the rationale for making such qualifications (See Appendix E). The net result was a data package that had been carefully reviewed for its adherence to prescribed technical requirements. Pertinent quality estimates are summarized in a more quantitative format in the following section.

4.2.2.1 Data Quality Review

DQIs are parameters monitored to help establish the quality of data generated during an investigation. Some of the DQIs are generated from analysis of field samples (e.g., field duplicates) and some are generated from the analysis of laboratory samples (e.g., laboratory duplicates). Individually, field and laboratory DQIs provide measures of the performance of the respective investigative operations (field or laboratory). During data validation, individual QC results were evaluated. If individual QC results were acceptable, no validation flag was assigned to an analytical result; otherwise, a flag indicating the type of QC deficiency was assigned to the result. All QC criteria were met for all samples for all parameters at the D-6, Small Arms Range.

4.2.2.2 Completeness

Completeness is a measure of the number of valid samples or measurements that are available relative to the number of samples or measurements that were intended to be generated. For this project, completeness was measured on two different bases:

- Samples collected - measure of the usable samples collected compared to those intended to be collected.

- Laboratory measurements - measure of the amount of usable valid laboratory measurements per matrix for each target analyte.

Usable valid samples (or results) were those judged, after data assessment, to represent the sampling populations and to have not been disqualified for use through data validation or additional data review. Completeness was determined using the following equation:

$$\%C = \frac{V}{T} \times 100$$

where %C = percent completeness
V = number of samples (or results) determined to be valid
T = total number of planned samples (or results)

All samples proposed for collection at the D-6, Small Arms Range were collected (100 percent completeness), and the D-6, Small Arms Range percent completeness for laboratory measurements was 100 percent.

4.2.2.3 Sensitivity

Detection limits for all D-6, Small Arms Range analytical parameters were less than screening levels (RSLs).

4.2.2.4 Accuracy

Accuracy requirements for field measurements are typically ensured through control over sample collection and handling and through routine instrument calibration. Field accuracies were monitored through the use of blanks to detect cross-contamination and by monitoring adherence to procedures that prevent sample contamination or degradation. One equipment rinsate blank was collected during the SI to assess cross-contamination via sample collection equipment. The blank was obtained under representative field conditions by collecting the rinse water generated by running analyte-free water through sample collection equipment after decontamination and before use. The rinsate blank was analyzed for the same chemical constituents as the associated environmental samples.

Accuracy in the laboratory was measured through the comparison of a spiked sample or laboratory control sample (LCS) result to a known or calculated value and was expressed as a percent recovery (%R). It was also assessed by monitoring the analytical recovery of select surrogate compounds added

to samples that are analyzed by organic chromatographic methods. LCSs were used to assess the accuracy of laboratory operations with minimal sample matrix effects. Matrix spike (MS) and surrogate compound analyses measure the combined accuracy effects of the sample matrix, sample preparation, and sample measurement. LCS and MS analyses were performed at a frequency of one per 20 associated samples of like matrix. Laboratory accuracy was assessed by comparing calculated %R values to accuracy control limits specified by the laboratory using SW-846 methods.

Percent recovery is calculated using the following equation:

$$\%R = \frac{Ss - So}{S} \times 100$$

where %R = percent recovery
Ss = result of spiked sample
So = result of non-spiked sample
S = concentration of spiked amount.

All matrix spike duplicate (MSD), LCS duplicate (LCSD), and surrogate recoveries met accuracy limits as specified by the laboratory.

4.2.2.5 Precision

Precision is a measure of the degree to which two or more measurements are in agreement and describes the reproducibility of measurements of the same parameter for samples analyzed under similar conditions. Precision for chemical parameters is expressed as a Relative Percent Difference (RPD), which is defined as the ratio of the difference to the mean for the two values being evaluated. RPDs, typically expressed as percentages, are used to evaluate both field and laboratory duplicate precision and are calculated as follows:

$$RPD = \frac{|V1 - V2|}{(V1 + V2)/2} \times 100$$

where RPD = relative percent difference
V1, V2 = two results obtained by analyzing duplicate samples

The precision estimates obtained from duplicate field samples encompass the combined uncertainty associated with sample collection, homogenization, splitting, handling, laboratory and field storage (as applicable), preparation for analysis, and analysis. In contrast, precision estimates obtained from analyzing duplicate laboratory samples incorporate only homogenization, subsampling, preparation for analysis, laboratory storage (if applicable), and analysis uncertainties.

All field duplicate, LCS/LCSD, and MS/MSD RPDs met QC limits.

4.2.2.6 Comparability

Comparability is defined as the confidence with which one data set can be compared with another (e.g., among sampling points and among sampling events). Comparability was achieved by using standardized sampling and analysis methods and standardized data reporting formats. Comparability of field data was ensured by following the SI WP (TtNUS, 2009). Comparability of laboratory measurements was achieved primarily through the use and documentation of standard sampling and analytical methods. Results were reported in units that ensured comparability with previous data and with current state and federal standards and guidelines. Comparability of laboratory measurements was assessed primarily through the use of QC samples and through adherence to the laboratory's QA plan.

4.2.2.7 Representativeness

Representativeness is an expression of the degree to which data accurately and precisely depict the actual characteristics of a population or environmental condition existing at the site. The SI WP (TtNUS, 2009) and the use of standardized sampling, sample handling, sample analysis, and data reporting procedures were designed so that the final data would accurately represent actual site conditions. It is believed that all reported data are adequately representative of site conditions.

4.3 CORRELATION BETWEEN XRF AND FIXED-BASE LABORATORY

From the samples that were analyzed in the field using XRF and also at the FBL, a regression analysis was conducted to evaluate the correlation between the FBL lead results and XRF lead results. To evaluate the regression analysis, the Pearson Correlation and the R-squared value were calculated. The Pearson Correlation is a measure of the strength of the linear relationship between two or more variables with a range of -1 to +1. The value of -1 represents a perfect negative correlation (as one variable decreases the other increases proportionally); whereas, a value of +1 represents a perfect positive correlation (as one variable increases the other increases proportionally). A value of 0 represents a lack of correlation. The initial correlation analysis grouping all the data together indicated an R-squared value

of 91 percent; however, there were three samples that were much larger than the remaining data which may have influenced the linear trend. To determine how much those three samples influenced the linear trend, the data was broken into two groups based on the PAL of 270 mg/kg for lead. The correlation between the FBL and the XRF for lead concentrations less than 270 mg/kg was 94 percent. The correlation between the FBL and the XRF for lead concentrations greater than 270 mg/kg was 95 percent. The R-squared value represents the percent of variation in the FBL lead results that can be explained by the XRF lead results. The R-squared value for the group containing XRF data below 270 mg/kg was 91 percent, and the R-squared value for the group containing XRF data above 270 mg/kg was 88 percent. An R-Squared value greater than 80 percent is considered to indicate a very strong relationship between the two measurement methods; the maximum possible value is 100 percent. The regression analysis is included in Appendix D.

4.4 HUMAN HEALTH RISK SCREENING EVALUATION

The purpose of the human health risk screening evaluation is to conservatively estimate risks posed to potential human receptors from chemicals present at the D-6, Small Arms Range. The risk screening evaluation included the following general steps involved in a baseline human health risk evaluation:

- Identification of COPCs
- Exposure Assessment
- Risk Characterization
- Uncertainty Analysis

4.4.1 Identification of Chemicals of Potential Concern

The process of identifying COPCs was conducted with the following considerations:

- Occurrence and distribution of chemicals in the environmental media
- Chemical toxicity

Any chemical detected at least once in site samples was considered for COPC selection. Chemical toxicity was considered by comparing the maximum detected concentration of each chemical to screening levels developed by the state of North Carolina, or in the case where no North Carolina RSL was available, the USEPA RSL for residential soil (2009). The USEPA RSL residential soil screening levels assume child and adult exposure to soil 350 days per year for a total of 30 years. Using residential soil criteria for a site that receives less frequent human use should result in a conservative selection of

COPCs. To account for additive effects that may result from exposure to multiple non-carcinogenic compounds, one-tenth of the values of the USEPA screening levels were used to identify COPCs for non-carcinogens. If the maximum detected concentration of an inorganic chemical in a site soil sample exceeded either the NC RSL or the USEPA RSL concentration, the chemical was retained as a COPC.

Additionally, risk-based soil screening levels (SSLs) for the protection of groundwater (USEPA, 2009) were used to evaluate the risk of leaching of chemicals to groundwater at a dilution attenuation factor (DAF) of 1. Chemicals exceeding the risk-based SSLs were also retained as COPCs. The COPCs selected for evaluation for the D-6, Small Arms Range are presented for surface soil, subsurface soil, and groundwater in the following subsections.

4.4.1.1 Surface Soil

Table 4-1 summarizes the COPC screening process for surface soil (0 to 2 feet bgs). The following chemicals were retained as COPCs for surface soil:

- Antimony
- Arsenic
- Lead

The maximum detected concentrations of antimony and lead exceeded both the NC RSL and USEPA RSLs. The maximum detected concentration of arsenic exceeded the USEPA RSLs but was less than the NC RSL.

4.4.1.2 Subsurface Soil

COPCs were also identified for subsurface soil (greater than 2 feet bgs) in the event that future activities would expose humans to this soil. Table 4-2 summarizes the results of COPC identification for subsurface soil. The following chemicals were retained as COPCs in subsurface soil:

- Antimony
- Arsenic
- Lead

The maximum detected concentrations of antimony and arsenic exceeded the USEPA RSL for direct contact exposures and protection of groundwater but were below the NC RSL. The maximum detected concentration of lead exceeded both the NC RSL and USEPA RSL.

4.4.1.3 Groundwater

Table 4-3 summarizes the results of COPC identification for groundwater. The following chemicals were retained as COPCs in groundwater:

- Total Arsenic
- Total Lead

These chemicals were retained as COPCs because their maximum concentration exceeded the NC groundwater standards RSL and the USEPA RSL for tap water.

4.4.2 Exposure Assessment

This section presents the exposure assessment for the D-6, Small Arms Range, which estimates the risks posed to human receptors from the COPCs previously identified.

Current land use at the D-6, Small Arms Range is primarily an undeveloped 1-acre parcel of land that sits among developed areas at MCB Camp Lejeune. Approximately three-quarters of the site is open land that is periodically mowed, the remaining one-quarter is overgrown with thick understory. No changes in the site's land use designation are expected in the foreseeable future. Under the current and predicted future land use patterns for this site, potential human receptors are expected to be authorized military and civilian personnel (maintenance/site workers), escorted visitors, and trespassers.

The following exposure pathways were considered during the human health risk screening evaluation:

- Ingestion
- Direct contact exposure
- Inhalation (dust)

These three pathways were evaluated for soil and subsurface soil. Residential SSLs were used to evaluate potential exposure to human receptors at the D-6, Small Arms Range, which is expected to provide a conservative estimate of potential risks because human receptors will not use the site as

intensely under current and anticipated land use as they would under a residential land use scenario. Likewise, the use of maximum concentrations of COPCs to represent exposure limits results in a conservative risk estimate because it is unlikely that a receptor would be consistently exposed to the maximum concentration during the entire exposure time.

The maximum detected concentrations of the COPCs were used as the exposure point concentrations (EPCs) to estimate potential risks (see Table 4-4).

4.4.3 Risk Characterization

The risk characterization component of the human health evaluation included comparison of maximum concentrations of COPCs to their respective toxicity levels. For cases in which a compound exhibits both carcinogenic and non-carcinogenic human health effects, both values were considered.

4.4.3.1 Human Health Effects - Carcinogens

The risk presented by carcinogenic COPCs was estimated by calculating the incremental lifetime cancer risk (ILCR) according to the following equation:

$$ILCR = \Sigma (C_{max}/RBC) \times 1 \times 10^{-6}$$

where:

ILCR	=	Incremental lifetime cancer risk (unitless)
C_{max}	=	Maximum detected site concentration (mg/kg or µg/kg)
RBC	=	Risk-based concentration (mg/kg or µg/kg)
1×10^{-6}	=	Risk assessment point of departure for carcinogenic effects (unitless)

The RBCs for the COPCs were taken from the North Carolina and USEPA screening level table, which incorporates multiple exposure pathways (ingestion and dermal contact) if possible. Residential soil screening values were used to estimate potential risks.

The resulting values from the above calculations were then compared to the USEPA target range for carcinogenic effects of 10^{-4} to 10^{-6}, and a result greater than 10^{-4}, which corresponds with one individual developing cancer out of an exposed population of 10,000 people, is typically deemed an unacceptable risk. The final values should serve as conservative risk estimates because they assume that an individual

is exposed to the maximum concentration of each COPC present at the site over a lifetime of residential exposure.

4.4.3.2 Human Health Effects – Non-Carcinogens

The risk presented by non-carcinogens was estimated by calculating the hazard quotient (HQ) and then calculating the hazard index (HI) by summing the individual HQs. The equations for HQs and the HI are as follows:

$$HQ = (C_{max}/RBC) \times 1$$

$$HI = \Sigma HQs$$

where:

HQ = Hazard quotient (unitless)
Cmax = Maximum detected site concentration (mg/kg or µg/L)
RBC = Risk-based concentration (mg/kg)
HI = Hazard index (unitless)
1 = Risk assessment point of departure for non-carcinogenic effects (unitless)

As with the ILCR calculation, the RBC values were obtained from the USEPA screening level table. Residential soil screening values were used. These RBCs incorporate multiple exposure pathways (ingestion and dermal contact). HIs greater than 1 are usually regarded as unacceptable in terms of exposure risk. However, because various chemicals can have different mechanisms of action and affect different organs of the human body, a HI greater than 1 is not necessarily an unacceptable risk for non-carcinogenic effects. If the HI is greater than 1, the chemicals are separated into categories according to the human organ that each primarily targets. HIs greater than 1 for any target organ are generally considered to represent unacceptable risk.

4.4.3.3 Surface Soil

Table 4-5 presents the estimated ILCRs and HIs for human exposure to surface soil. The cumulative ILCR is 1×10^{-5}, which is with the USEPA target range of 10^{-4} to 10^{-6}. The cumulative HI for non-cancer risk is 16, which is exceeds the USEPA's target level of 1. Antimony was the major contributor to the HI.

4.4.3.4 Subsurface Soil

Table 4-6 presents the estimated ILCRs and HIs for human health exposure to subsurface soil. The cumulative ILCR was 8 x 10^{-6}, which is with the USEPA target range of 10^{-4} to 10^{-6}. The HI for non-cancer was 0.03, which is less than the USEPA target of 1.

4.4.3.5 Groundwater

Table 4-7 presents the estimated ILCRs and HIs for human health exposure to groundwater. The cumulative ILCR was 1 x 10^{-4}, which is equal to the upper bound of the USEPA target range of 10^{-4} to 10^{-6}. The HI for non-cancer was 3, which exceeds the USEPA target of 1. Total arsenic was the major contributor to the HI. It should be noted that the groundwater samples were collected from temporary monitoring wells and the total samples were highly turbid. Arsenic was not detected in the filtered groundwater samples. This suggests that the high total arsenic concentrations are associated with the particulates in the groundwater samples.

4.4.3.6 Risks from Lead

Lead was identified as a COPC in surface soil, subsurface soil, and groundwater. The maximum detected concentration of lead in surface soil (60,400 mg/kg) and subsurface soil (1,140 mg/kg) exceeded the USEPA screening level of 400 mg/kg and NC screening level of 270 mg/kg for residential land. The maximum detected concentration of lead in groundwater (117 µg/L) exceeded the USEPA action level and NC groundwater standard of 15 µg/L.

Concentrations of lead in surface soil exceeded the USEPA screening level in 10 samples and the NC screening level in 11 samples. Concentrations of lead in subsurface soil exceeded the USEPA and NC screening level in one sample. Concentrations of total lead in groundwater exceeded the USEPA action level and NC groundwater standard in all four samples. As previously discussed, the groundwater samples were collected from temporary monitoring wells and the total samples were highly turbid. Lead was not detected in the filtered groundwater samples. This suggests that the high total lead concentrations are largely associated with the particulates in the groundwater samples.

USEPA lead guidance (USEPA, 1994) recommends using the arithmetic mean concentration to evaluate exposures to lead. The arithmetic mean concentrations of lead in surface soil (6,175 mg/kg) and subsurface soil (413 mg/kg) exceeds the USEPA and NC screening levels for residential exposures to soil. The arithmetic mean concentration of total lead in groundwater (47 µg/L) exceeds USEPA action

level and NC groundwater standard. Consequently, adverse health effects could be anticipated from exposures to lead in soil and groundwater.

4.4.4 Uncertainty Analysis

Various uncertainties are associated with every step of the risk screening process. Uncertainty in the selection of COPCs is related to the current status of the predictive databases, the grouping of samples taken from the site, and the procedures used to include or exclude constituents as COPCs. Uncertainty associated with the exposure assessment includes the values used as input variables, the determination of EPCs, and the predictions regarding future land use and potential receptors. Uncertainty in the toxicity assessment includes evidence for determining the carcinogenicity of COPCs. Uncertainty in risk characterization includes that associated with exposure to multiple chemicals and the cumulative uncertainty from combining conservative assumptions made in earlier steps of the risk screening process.

Although uncertainty exists from multiple sources, the direction of uncertainty can be influenced by decisions made throughout the risk screening analysis; in general, assumptions are made so that the risk estimates are overestimated rather than underestimated. This is done in an effort to ensure that no unacceptable risk to potential receptors goes unrecognized. In this risk screening evaluation, conservative risks were estimated by using one-tenth of the USEPA screening levels for non-carcinogens, using residential screening criteria and residential RBC estimates, and using the maximum site concentration for each COPC as the EPC.

Generally, risk evaluations include two types of uncertainty: measurement and informational uncertainty. Measurement uncertainty refers to the usual variance that accompanies scientific measurements (e.g., uncertainty associated with sample collection and analysis). The resulting risk screening analysis reflects the accumulated variances of the individual values used. Informational uncertainty is due to unavailability of information needed to complete the toxicity and exposure assessments. Examples include the absence of information on the effects of human exposure to low doses of a chemical, on the biological mechanism of action of a chemical, or on the behavior of a chemical in a particular medium.

After the risk screening analysis is complete, the uncertainty involved must be assessed to interpret the results. Reliance on results from a risk screening analysis without consideration of uncertainties, limitations, and assumptions inherent in the process can be misleading. For example, to account for uncertainties in the development of exposure assumptions, conservative estimates must be made to ensure that the particular assumptions made are protective of sensitive subpopulations or maximum exposed individuals. If a number of conservative assumptions are combined in an exposure model, the

resulting calculations can propagate the uncertainties associated with those assumptions, thereby producing a much larger uncertainty for the final results. This uncertainty is biased toward overpredicting both carcinogenic and non-carcinogenic risks. Thus, both the results of the risk screening evaluation and the uncertainties associated with those estimates must be considered when making risk management decisions.

This interpretation is especially relevant when the risk estimates exceed the point of departure for defining "acceptable" risk. For example, when risks calculated using a high degree of uncertainty are less than an "acceptable" risk level (according to USEPA standards, 1×10^{-6}), the interpretation of no significant risk is typically straightforward. However, when risks calculated using a high degree of uncertainty exceed an "acceptable" risk level (i.e., 1×10^{-6}), a conclusion can be difficult unless uncertainty is considered. In the case of this risk screening assessment, the results of the risk characterization, which were conservatively estimated, are significantly less than USEPA risk target levels, allowing for a more straightforward interpretation of potential risk.

4.4.4.1 Uncertainty in Selection of COPCs

The following issues may contribute to uncertainty in COPC selection for the D-6, Small Arms Range: the existing database and the risk screening levels used. These issues are discussed below.

Existing Database

All data used for this site risk screening evaluation were validated according to USEPA Region 4 data validation guidelines. Therefore, uncertainties associated with the quality of the data are considered to be minimal because no data were deemed unreliable due to laboratory non-compliances. Uncertainty attributed to sample collection is also considered to be minimal due to use of a site sampling plan designed with site characteristics in mind in an attempt to ensure adequate sample collection and to incorporate known and likely sources of contaminants.

COPC Screening Levels

Using residential soil screening values is a conservative approach to this risk assessment because this site is unlikely to be developed for residential land use, and exposure to soil by likely receptors (military personnel, trespassers) is expected to be less than under a residential land use scenario.

The risk screening values used to select COPCs correspond to an ILCR of 1×10^{-6} and an HI of 0.1. The use of these values ensures that significant contributors to risk are evaluated for a site. The elimination of

chemicals present at concentrations equal to or less than an ILCR of 1 x 10^{-6} and an HI less than 0.1 should not affect the final conclusions of the risk screening analysis because these chemicals are not expected to cause a potential health concern at the detected concentrations. These risk screening values should result in conservative estimates of COPCs.

4.4.4.2 Uncertainty in the Exposure Assessment

Uncertainty in the exposure assessment arises because of the methods used to calculate EPCs, assumptions made about current and future land use, selection of potential human receptors, and selection of exposure parameters.

Potential Receptors and Land Use

The current land use at D-6, Small Arms Range is limited in terms of human exposure. Approximately three-quarters of the site is open land that is periodically mowed, the remaining one-quarter is overgrown with thick understory. Site land use is not anticipated to change in the foreseeable future. However, screening levels used in this risk screening evaluation were those associated with a residential land use scenario, which would include more intense human use of the site than is currently occurring or is expected to occur. This use of residential screening values therefore results in an overestimation of exposure and conservative risk estimates.

Exposure Point Concentrations

The maximum detected concentration of each COPC was used as the EPC to quantify potential risks. It is unlikely that a receptor would be exposed to the maximum concentration of a contaminant over the entire site area and the entire time spent at the site. Thus, the use of the maximum concentration likely results in overestimation of potential risks.

Exposure Parameters

The RBC values obtained from the USEPA screening table incorporate assumptions about exposure (e.g., frequency, duration, age of receptors) into their values. These values are designed to conservatively estimate risks, and thus using these values leads to an overestimation of potential risks.

4.4.4.3 Uncertainty in the Toxicological Evaluation

Uncertainties associated with the toxicity assessment of COPCs are involved with the determination of the cancer slope factors (CSFs) and reference doses (RfDs) from which RBCs are calculated. CSFs are upper-bound estimates of the probability of a response per unit of exposure of an individual. These values are estimated from available toxicological data. RfDs are estimates of daily exposure to particular chemicals that are unlikely to result in harmful non-carcinogenic health effects even to members of sensitive populations. The USEPA screening level values used in this assessment incorporate the most recent CSFs and RfDs into the screening level values. The CSFs and RfDs are designed to overestimate potential risks and thus be conservative because both are estimated assuming long-term exposure to a particular substance. Furthermore, a conservative risk estimate is achieved for the majority of the population by accounting for sensitive subpopulations. Thus, uncertainty due to toxicology is assumed to result in an overestimation of risk in this assessment.

4.4.4.4 Uncertainty in the Risk Characterization

Uncertainty in risk characterization results primarily from assumptions made regarding additivity of effects from exposure to multiple COPCs from various exposure routes. High uncertainty exists when summing cancer risks for several substances across different exposure pathways. This assumes that each substance has a similar effect and/or mode of action. Often compounds affect different organs, have different mechanisms of action, and differ in their fate in the human body. Therefore, it may be inappropriate to assume that all effects are additive. However, the assumption of additivity is made to provide a conservative estimate of risk.

In this evaluation, only three chemicals were retained as COPCs, and arsenic was the only chemical exhibiting carcinogenic effects. As a result, this source of uncertainty does not apply to the ILCR estimation in this risk screening.

Finally, the risk characterization does not consider antagonistic or synergistic effects. Little or no information is available to determine the potential for antagonism or synergism for the COPCs. Therefore, the impact of this uncertainty on the risk screening analysis cannot be determined because the uncertainty may result in either an underestimation or overestimation of potential human health risks.

4.4.5 Human Health Risk Screening Evaluation Summary

Antimony, arsenic, and lead were selected as COPCs in surface and subsurface soil. Arsenic and lead were selected as COPCs in groundwater. Cancer risks were within the USEPA target risk range for

exposures to surface soil and subsurface soil. Noncancer risks exceeded the USEPA acceptable level for exposures to surface soil. Antimony was the major contributor to the unacceptable noncancer risk in surface soil. Noncancer risks were within acceptable levels for exposures to subsurface soil. The cancer risk for exposures to groundwater was equal to the upper bound of the USEPA target range. The noncancer risk for exposure to groundwater exceeded the USEPA acceptable level. Total arsenic was the major contributor to the noncancer risk for exposure to groundwater.

The arithmetic mean concentration of lead in surface soil, subsurface soil, and groundwater exceeded USEPA and NC screening levels. Consequently, adverse health effects could be anticipated from exposures to lead in soil and groundwater.

It should be noted that the groundwater samples were collected from temporary monitoring wells and the total samples were highly turbid. Arsenic and lead were not detected in the filtered groundwater samples. This suggests that the high total arsenic and lead concentrations are largely associated with the particulates in the groundwater samples.

4.5 ECOLOGICAL RISK SCREENING

This section presents the results of the Ecological Risk Screening Evaluation (ERSE) of chemical concentrations detected in soil and groundwater collected at the D-6, Small Arms Range in May 2009. As detailed in Section 4.2, surface soil samples were collected from a total of 23 sample locations at the D-6, Small Arms Range at depths to two feet bgs. Soil samples were analyzed for select metals. Additionally, shallow groundwater samples were collected from four temporary groundwater monitoring wells and analyzed for select metals and perchlorate. Basic descriptive statistics, ecological screening levels (ESLs), and ecological effects quotients (EEQs) for the target analytes are presented in Tables 4-8 and 4-9 for surface soil and groundwater, respectively.

This ERSE is limited to a comparison of maximum and arithmetic mean concentrations to ecological screening benchmarks typically used in ecological risk assessments prepared for regulatory review within USEPA Region 4. This ERSE also includes limited food-chain modeling with a summary of the resultant EEQs for the Meadow Vole, Bobwhite Quail, Short-tailed Shrew, and American Woodcock. The exposure parameters for the Terrestrial Wildlife Model are presented in Table 4-10. The terrestrial food chain model-average scenario herbivorous and insectivorous receptors are presented in Table 4-11. Food-chain modeling methodology, calculations, and supporting documentation are presented in Appendix F. The objective of this assessment is to determine if chemical concentrations of metals and perchlorate in the D-6, Small Arms Range soil and groundwater are high enough to warrant further ecological evaluation

as COPCs. A brief site description and discussion of potential ecological receptors of concern and exposure pathways is presented in Sections 4.5.1 and 4.5.2, respectively. The analytical results for soil samples collected for the current investigation are presented in Section 3.0. The comparison of maximum and arithmetic mean chemical concentrations to ecological screening benchmarks is presented in Section 4.5.3, as well as, results of the limited food-chain modeling. An uncertainty analysis is presented in Section 4.5.4. Summary and conclusions are presented in Section 4.5.5.

4.5.1 Site Description

Detailed site descriptions including the physical setting, physical characteristics, and regional ecology summary are presented in Sections 2.2, 2.3, and 2.4, respectively. Briefly, the D-6, Small Arms Range is a 1-acre site that in part included former B-451, which housed a firing range. B-451 was demolished in December 1998. The site is located just east, but not adjacent to the New River. Mature mixed conifer and deciduous trees surround the footprint of the former B-451 with thick understory vegetation, including pines, occupying other areas including the former footprint of the building foundation slab. Other vegetation includes maintained grasses. Soils are typically sandy, and the groundwater table is characteristically shallow. The topography is generally flat with groundwater discharging towards the New River. No threatened or endangered species are known to reside within the boundaries of the site, although foraging on site is possible.

4.5.2 Potential Ecological Receptors and Exposure Pathways

Based on the description of the site, ecological receptors could be exposed to chemicals in surface soil at the D-6, Small Arms Range (i.e., plants and soil invertebrates), or indirectly via the food chain (i.e., through the ingestion of plants and invertebrates). Additionally, groundwater discharging to the New River also provides a potential pathway for exposure to aquatic biota. This pathway is evaluated to be conservative. The primary ecological receptors of concern are:

- Soil invertebrates
- Terrestrial plants
- Small herbivorous birds and mammals
- Small insectivorous birds and mammals
- Aquatic organisms (fish and benthic invertebrates)

Large herbivorous, omnivorous, or predatory mammals and birds may visit and feed at the site; however, the site is relatively small compared to the home ranges of these animals and unlikely to sustain them exclusively.

4.5.3 Ecological Screening

The surface soil risk screening summarized in Table 4-8 was performed by comparing maximum and arithmetic mean chemical concentrations to the following ecological screening benchmarks for surface soil:

- USEPA Ecological Screening Levels (Eco-SSLs) (http://www.epa.gov/ecotox/ecossl/) – The Eco-SSLs were developed for invertebrates, plants, mammals, and birds for each chemical for which data were available. For some chemicals, adequate data were only available to develop Eco-SSLs for some receptors. The lowest Eco-SSL among plant, invertebrate, mammal, and avian values was used as the screening value. Eco-SSLs were preferentially used as soil screening values, but Eco-SSLs are currently available for only a few chemicals.

- USEPA Region 4 Ecological Screening Values (ESVs) (USEPA, 2001) were used as screening values for chemicals that do not have an Eco-SSL.

The groundwater risk screening summarized in Table 4-9 was performed by comparing maximum and arithmetic mean chemical concentrations to the USEPA Region 4 ESVs (USEPA, 2001) for freshwater surface water to evaluate shallow groundwater.

The USEPA Region 4 ESVs and USEPA Eco-SSLs are conservative and are considered the initial COPC screening levels for this assessment. However, site chemical concentrations above these screening levels are not necessarily indicative of a potential for ecological risk at a site. This is because the screening levels generally represent the lowest screening levels found in the literature for any receptor and are not always applicable to site-specific receptors and conditions

4.5.3.1 Surface Soil

Three inorganics (antimony, lead, and zinc) were initially selected as COPCs because the maximum detected concentration exceeded the ESL. All of these metals are common components of bullets.

Antimony

Antimony was initially selected as a COPC because the maximum soil concentration (493 mg/kg) at MMRP64-SB007 exceeded the Eco-SSL for mammals of 0.27 mg/kg. Because the Eco-SSL used in the conservative COPC screening is based on risks to wildlife and not risks to plants and invertebrates, antimony concentrations were compared to the Eco-SSL for soil invertebrates of 78 mg/kg (USEPA, Feb 2005). An Eco-SSL was not available for plants to evaluate risks to this receptor, so the ORNL plant benchmark of 5 mg/kg (Efroymson et al., 1997) was used to further evaluate risks from antimony to plants.

Two locations have detected antimony concentrations that exceed the Eco-SSLs for soil invertebrates. These include MMRP64-SB007 for both the discrete (126 mg/kg) and composite sample (493 mg/kg) and SB010 composite sample (79.2 mg/kg). Although these concentrations exceed the Eco-SSL for soil invertebrates, the average concentration (42.8 mg/kg) is much less than this benchmark. Therefore, adverse effects are possible to soil invertebrate from detected site concentrations of antimony, but the effects are expected to be localized to the aforementioned sample locations. In addition to the sample locations listed above for soil invertebrates, MMRP64-SB005 (7.55 mg/kg and 12.7 mg/kg for the average and duplicate sample, respectively) and the discrete MMRP64-SB009 sample only (5.3 mg/kg) exceeded the ORNL plant benchmark (5 mg/kg). The composite sample at MMRP64-SB009 was 3.2 mg/kg. Therefore, risk to plants at this location is not likely. The ORNL plant benchmark for antimony is conservative because the study used to develop the benchmark was conducted using an antimony salt, which is generally a more bioavailable form of the metal. For this reason, adverse effects at sample location MMRP64-SB005 are also not likely. Furthermore, vegetation is growing throughout most of the site. Therefore, risks to plants from antimony are possible in localized areas, are expected to be similar to the risks for soil invertebrates, and include the same sample locations. Antimony is retained as a COPC for risks to plants and soil invertebrates. Risks to terrestrial wildlife are evaluated in Section 4.5.3.3.

Lead

Lead was initially selected as a COPC because the maximum soil concentration (60,400 mg/kg) at MMRP64-SB007 exceeded the USEPA Eco-SSL for birds of 11 mg/kg. Because the Eco-SSL used in the conservative COPC screening is based on risks to wildlife and not risks to plants and invertebrates, lead concentrations were compared to the following Eco-SSLs for soil invertebrates and plants to evaluate risks to these receptors:

- Eco-SSL for plants – 120 mg/kg (USEPA, March 2005)
- Eco-SSL for soil invertebrates – 1,700 mg/kg (USEPA, March 2005)

Three sample locations exceeded the Eco-SSL for soil invertebrates. These included MMRP64-SB005 (2,472 mg/kg for the discrete average and 4,040 mg/kg for the discrete duplicate), SB007 (60,400 mg/kg for the discrete sample and 23,400 mg/kg for the composite sample), and SB010 (14,100 mg/kg for the composite sample). Therefore, adverse effects are possible to soil invertebrate from detected site concentrations of lead, but the effects are expected to be localized to the aforementioned sample locations. Several additional locations exceed the Eco-SSL for plants. These included MMRP64-SB004 (591 mg/kg in the composite sample), additional detections that did not exceed the soil invertebrate Eco-SSL at MMRP64-SB005 (904 mg/kg for the discrete sample and 1,590 mg/kg for the composite sample), MMRP64-SB006 (529 mg/kg in the composite sample), MMRP64-SB009 (941 mg/kg for the discrete sample and 1,160 mg/kg for the composite sample), MMRP64-SB010 (286 mg/kg for the discrete sample), MMRP64-SB11 (634 mg/kg for the composite sample), and MMRP64-SB023 (139 mg/kg). All of these concentrations greatly exceed the plant Eco-SSL for lead except MMRP64-SB023, which only slightly exceeds the benchmark. Therefore, risks to plants from lead are possible. Lead is retained as a COPC for risks to plants and soil invertebrates. Risks to terrestrial wildlife are evaluated in Section 4.5.3.3.

Zinc

Zinc was initially selected as a COPC because the maximum soil concentration (209 mg/kg) at MMRP64-SB023 exceeded the USEPA Eco-SSL for birds of 46 mg/kg. Because the Eco-SSL used in the conservative COPC screening is based on risks to wildlife and not risks to plants and invertebrates, zinc concentrations were compared to the following Eco-SSLs for soil invertebrates and plants to evaluate risks to these receptors:

- Eco-SSL for plants – 160 mg/kg (USEPA, June 2007)
- Eco-SSL for soil invertebrates – 120 mg/kg (USEPA, June 2007)

Two locations exceeded both the Eco-SSL for plants and soil invertebrates. These included MMRP64-SB021 (193 mg/kg) and SB023 (209 mg/kg). Both of these concentrations are only slightly greater than the plant and soil invertebrate Eco-SSLs. Furthermore, the average site concentration is 53.4 mg/kg, which is significantly less than these benchmarks. Risks to these receptors would not be expected. Therefore, risks to plants and invertebrates from zinc are expected to be acceptable, and zinc is not retained as a COPC for risks to these receptors. Risks to terrestrial wildlife are evaluated in Section 4.5.3.3.

4.5.3.2 Groundwater

Three unfiltered inorganics (copper, lead, and zinc) were retained as COPCs in groundwater because their maximum detected concentrations exceeded the surface water screening level. Perchlorate was retained as a COPC because a screening level was not available.

Inorganics

In accordance with USEPA (1993), dissolved metal more closely approximates the bioavailable fraction of metal in the water column than total recoverable metal. Copper, lead, and zinc were not detected in the filtered groundwater samples. A filtered sample for TW007 was not analyzed. However, based on concentrations in all other filtered samples, lead (the only metal detected above the screening level in the unfiltered sample) is expected to also be non-detected. The groundwater samples were evaluated as surface water because the potential exists for groundwater to discharge as a seep into surface water bodies. However, groundwater concentrations do not typically equate to surface water concentrations. Upon discharge to a surface water body, the groundwater would typically be diluted many fold. Therefore, effects to aquatic biota are expected to be minimal and these inorganics are not retained as COPCs for further evaluation. Risks to terrestrial wildlife were evaluated by incorporating groundwater concentrations into the food-chain models. These risks are evaluated in Section 4.5.3.3.

Perchlorate

A surface water screening level was not available for perchlorate. Therefore, effects to aquatic biota from detected concentrations of perchlorate cannot be quantified.

4.5.3.3 Risks to Terrestrial Wildlife

Food-chain modeling was conducted for those chemicals whose maximum detected concentration was greater than the ESL using average exposure parameters (Table 4-10) and average chemical concentrations (see Appendix F for supporting documentation and calculation sheets). No Observable Adverse Effect Level (NOAEL) Ecological Effect Quotient (EEQs) for antimony were greater than 1.0 for the vole and the shrew. A value was not able to be calculated for birds because established toxicity reference values were not available. For lead, food-chain model NOAEL EEQs were much greater than 1.0 for all receptors (vole, quail, shrew, and woodcock). None of the NOAEL EEQs for zinc were greater than 1.0. Therefore, risks to wildlife receptors are possible from antimony and lead.

4.5.4 Uncertainty Analysis

Measurement endpoints are used to evaluate the assessment endpoints selected for this ERSE. For this ERSE, the measures of effects are not the same as the assessment endpoints. Therefore, the measures are used to predict effects to the assessment endpoints by selecting surrogate species that were evaluated. The contaminant dose to terrestrial wildlife is calculated using an equation that incorporates ingestion rates, body weights, Bioaccumulation Factors (BAFs), and other exposure factors. These exposure factors are obtained from literature studies or predicted using various equations. There is uncertainty in the chemical data collected at the site. Measured levels of chemicals are only estimates of the true site chemical concentrations. Risks are possible if an EEQ is greater than or equal to 1.0 regardless of the magnitude of the EEQ. However, the magnitude of effects to ecological receptors cannot be inferred based on the magnitude of the EEQ. Rather, an EEQ greater than 1.0 simply indicates that the dose used to derive the toxicity reference value was exceeded. Finally, there is uncertainty in how the predicted risks to a species at a site translate into risk to the population in the area as a whole.

4.5.5 Ecological Risk Screening Summary

Three inorganics (antimony, lead, and zinc) were initially selected as surface soil COPCs because the maximum detected concentration exceeded the ESL. After a refinement based on specific receptor classes, spatial distribution of chemical concentrations, and average concentrations, antimony and lead were retained as COPCs for further evaluation to plants and soil invertebrates in surface soil at the D-6, Small Arms Range.

Three unfiltered inorganics (copper, lead, and zinc) were initially retained as COPCs in unfiltered groundwater samples because their maximum detected concentrations exceeded the surface water screening level. None of these metals were retained as COPCs because they were not detected in filtered groundwater samples. Perchlorate was initially retained as a COPC because a screening level was not available. Established ecotoxicity data was not available; therefore, risks to aquatic biota from perchlorate could not be evaluated.

A limited food-chain model was conducted for herbivorous and insectivorous birds and mammals for those chemicals that exceeded their respective surface soil screening levels. Average chemical concentrations and average exposure parameters were used for the evaluation. Food-chain model EEQs were greater than 1.0 for antimony for the vole and shrew and for lead for all receptors (vole, quail, shrew, and woodcock).

TABLE 4-1

SURFACE SOIL HUMAN HEALTH SCREENING ASSESSMENT
D-6, SMALL ARMS RANGE
MCB CAMP LEJEUNE
ONSLOW COUNTY, NORTH CAROLINA

CAS Number	Parameter	Frequency of Detection [1]	Minimum Detected Concentration	Maximum Detected Concentration	Sample with Maximum Detection	Minimum Non-Detect	Maximum Non-Detect	Average of Detected Concentrations	Average of All Samples[2]	USEPA RSLs[3]		North Carolina Soil Screening Levels[4]
										Residential Soil	Risk-Based SSL (Protection of Groundwater)	
Inorganics (mg/kg)												
7440-36-0	Antimony	16/17	0.15	493	MMRP64-SS007-D-0002	0.16	0.16	45.42	42.75	**3.1 N**	**0.66**	**5.42**
7440-38-2	Arsenic	17/17	0.49	4.9	MMRP64-SS007-D-0002	-	-	1.6	1.6	**0.39 C**	**0.0013**	26.2
7440-50-8	Copper	17/17	0.62	27.6	MMRP64-SS023-D-0001	-	-	8.6	8.6	310 N	51	704
7439-92-1	Lead	17/17	22.3	60,400	MMRP64-SS007-D-0002	-	-	6,175	6,175	**400**	NA	**270**
7440-02-0	Nickel	17/17	0.57	7.2	MMRP64-SS023-D-0001	-	-	2.3	2.3	150 N	48	56.4
7440-31-5	Tin	2/17	11.5	23.2	MMRP64-SS007-D-0002	0.93	5.2	17.4	2.7	2,200 N	5,500	NA
7440-66-6	Zinc	17/17	3	209	MMRP64-SS023-D-0001	-	-	53.4	53.4	2,300 N	680	550

1 - Where both a sample and duplicate results were available, the average concentration was used for the sample count.
2 - A value of one-half the reported value was used for the nondetected (U) parameters in the calculation of the average of all samples.
3 - USEPA Regional Screening Level, April 2009, Updated May 19, 2009. The noncarcinogenic values (denoted with a "N" flag) are the RSL divided by 10 to correspond to a target hazard quotient of 0.1. Carcinogenic values represent an incremental cancer risk of 1.0E-06 (carcinogens denoted with a "C" flag).
4 - North Carolina Hazardous Waste Section Soil Screening Level Concentrations (NCDENR, 2005)

Shaded criterion indicates that concentration exceeds any screening level.

C = Carcinogenic
N = Noncarcinogenic
NA = Not Available or Not Applicable
SSL = Soil Screening Level

Associated Samples:
MMRP64-SS004-C-0001
MMRP64-SS009-C-0001
MMRP64-SS009-D-0002
MMRP64-SS010-C-0001
MMRP64-SS019-C-0001
MMRP64-SS005-C-0001
MMRP64-SS005-D-0002
MMRP64-SS006-C-0001
MMRP64-SS010-D-0002
MMRP64-SS011-C-0001
MMRP64-SS011-D-0002
MMRP64-SS021-D-0001
MMRP64-SS022-D-0001
MMRP64-SS023-D-0001
MMRP64-SS007-C-0001
MMRP64-SS007-D-0002
MMRP64-SS012-C-0001

TABLE 4-2

SUBSURFACE SOIL HUMAN HEALTH SCREENING ASSESSMENT
D-6, SMALL ARMS RANGE
MCB CAMP LEJEUNE
ONSLOW COUNTY, NORTH CAROLINA

CAS Number	Parameter	Frequency of Detection [1]	Minimum Detected Concentration	Maximum Detected Concentration	Sample with Maximum Detection	Minimum Non-Detect	Maximum Non-Detect	Average of Detected Concentrations	Average of All Samples[2]	USEPA RSLs[3]		North Carolina Soil Screening Levels[4]
										Residential Soil	Risk-Based SSL (Protection of Groundwater)	
Inorganics (mg/kg)												
7440-36-0	Antimony	2/3	0.13	4.6	MMRP64-SS005-D-0204	0.091	0.091	2.37	1.59	**3.1 N**	**0.66**	5.42
7440-38-2	Arsenic	3/3	0.67	3.1	MMRP64-SS009-D-0406	-	-	1.6	1.6	**0.39 C**	**0.0013**	26.2
7440-50-8	Copper	3/3	1.3	2.1	MMRP64-SS004-D-0810	-	-	1.6	1.6	310 N	51	704
7439-92-1	Lead	3/3	6.9	1,140	MMRP64-SS005-D-0204	-	-	413	413	**400**	NA	**270**
7440-02-0	Nickel	3/3	0.61	2.3	MMRP64-SS009-D-0406	-	-	1.3	1.3	150 N	48	56.4
7440-66-6	Zinc	3/3	3.4	36.8	MMRP64-SS005-D-0204	-	-	18.2	18.2	2,300 N	680	550

1 - Where both a sample and duplicate results were available, the average concentration was used for the sample count.
2 - A value of one-half the reported value was used for the nondetected (U) parameters in the calculation of the average of all samples.
3 - USEPA Regional Screening Level, April 2009, Updated May 19, 2009. The noncarcinogenic values (denoted with a "N" flag) are the RSL divided by 10 to correspond to a target hazard quotient of 0.1. Carcinogenic values represent an incremental cancer risk of 1.0E-06 (carcinogens denoted with a "C" flag).
4 - North Carolina Hazardous Waste Section Soil Screening Level Concentrations (NCDENR, 2005)
Shaded criterion indicates that concentration exceeds any screening level.

C = Carcinogenic
N = Noncarcinogenic
NA = Not Available or Not Applicable
SSL = Soil Screening Level

Associated Samples:
MMRP64-SS004-D-0810
MMRP64-SS009-D-0406
MMRP64-SS005-D-0204

TABLE 4-3

GROUNDWATER HUMAN HEALTH SCREENING ASSESSMENT
D-6, SMALL ARMS RANGE
MCB CAMP LEJEUNE
ONSLOW COUNTY, NORTH CAROLINA

CAS Number	Parameter	Frequency of Detection [1]	Minimum Detected Concentration	Maximum Detected Concentration	Sample with Maximum Detection	Minimum Non-Detect	Maximum Non-Detect	Average of Detected Concentrations	Average of All Samples[2]	USEPA RSLs[3] Tap Water	North Carolina Groundwater Standards[4]
Total Inorganics (ug/L)											
7440-38-2	Arsenic	3/4	22.1	55.1	MMRP64-TW004	5.3	5.3	37.2	28.5	**0.045 C**	**50**
7440-50-8	Copper	3/4	11	24.5	MMRP64-TW004	5	5	16.0	12.6	150 N	1000
7439-92-1	Lead	4/4	21.9	117	MMRP64-TW004	3.2	3.2	47	47	**15 [5]**	**15**
7440-02-0	Nickel	4/4	2.3	21.7	MMRP64-TW004	-	-	12.6	12.6	73 N	100
7440-66-6	Zinc	3/4	24.3 J	272	MMRP64-TW004	24	24	168.6	129.4	1,100 N	1050
Filtered Inorganics (ug/L)											
7440-02-0	Nickel	3/3	2.4	4.8	MMRP64-TW012	-	-	3.7	3.7	73 N	100
Miscellaneous Parameters (ug/L)											
14797-73-0	Perchlorate	3/4	0.17 J	0.19 J	MMRP64-TW004, MMRP64-TW019	0.08	0.08	0.2	0.1	2.6 N	NA

1 - Where both a sample and duplicate results were available, the average concentration was used for the sample count.
2 - A value of one-half the reported value was used for the nondetected (U) parameters in the calculation of the average of all samples.
3 - USEPA Regional Screening Level, April 2009, Updated May 19, 2009. The noncarcinogenic values (denoted with a "N" flag) are the RSL divided by 10 to correspond to a target hazard quotient of 0.1. Carcinogenic values represent an incremental cancer risk of 1.0E-06 (carcinogens denoted with a "C" flag).
4 - Classification and water Quality Standards Applicable to the Groundwaters of North Carolina (NCAC, 2005).
5 - USEPA action level.

Shaded criterion indicates that concentration exceeds any screening level.

C = Carcinogenic
N = Noncarcinogenic
NA = Not Available or Not Applicable
SSL = Soil Screening Level

Associated Samples:
MMRP64-TW004
MMRP64-TW007
MMRP64-TW012
MMRP64-TW012-D
MMRP64-TW019

TABLE 4-4

EXPOSURE POINT CONCENTRATIONS
HUMAN HEALTH SCREENING ASSESSMENT
D-6, SMALL ARMS RANGE
MCB CAMP LEJEUNE
ONSLOW COUNTY, NORTH CAROLINA

Chemical	Surface Soil (mg/kg)	Subsurface Soil (mg/kg)	Groundwater (ug/L)
Antimony	493	4.6	NA
Arsenic	4.9	3.1	55.1
Lead	6,175	413	47

The maximum detected concentration is used as the exposure point concentration for antimony and arsenic. In accordance with USEPA guidance the arithmetic mean is used as the exposure point concentration for lead.

NA - Not applicable, chemical is not a chemical of potential concern for this media.

TABLE 4-5

SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs - SURFACE SOIL
HUMAN HEALTH SCREENING ASSESSMENT
D-6, SMALL ARMS RANGE
MCB CAMP LEJEUNE
ONSLOW COUNTY, NORTH CAROLINA

Chemical	Incremental Lifetime Carcinogenic Risk (ILCR)			Estimated Non-Carcinogenic Hazard Quotient (HQ)		
	Exposure Point Concentration (mg/kg)	RSL[1] (mg/kg)	Estimated ILCR	Primary Target Organs	RSL[1] (mg/kg)	Estimated HQ
Antimony	493	NA	NA	Blood	31	16
Arsenic	4.9	0.39	1E-05	Cardiovascular, Skin	22	0.2
Lead	6,175	NA	NA	NA	NA	NA
		Total ILCR	1E-05		Total HI	16

1 - USEPA Regional Screening Level, April 2009, Updated May 19, 2009
NA - Not applicable. There are no cancer slope factors (CSF) and/or reference doses (RfD) available for this chemical.

TABLE 4-6

SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs - SUBSURFACE SOIL
HUMAN HEALTH SCREENING ASSESSMENT
D-6, SMALL ARMS RANGE
MCB CAMP LEJEUNE
ONSLOW COUNTY, NORTH CAROLINA

Chemical	Incremental Lifetime Carcinogenic Risk (ILCR)			Estimated Non-Carcinogenic Hazard Quotient (HQ)		
	Exposure Point Concentration (mg/kg)	RSL[(1)] (mg/kg)	Estimated ILCR	Primary Target Organs	RSL[(1)] (mg/kg)	Estimated HQ
Antimony	4.6	NA	NA	Blood	31	0.1
Arsenic	3.1	0.39	8E-06	Cardiovascular, Skin	22	0.1
Lead	413	NA	NA	NA	NA	NA
		Total ILCR	8E-06		Total HI	0.3

1 - USEPA Regional Screening Level, April 2009, Updated May 19, 2009
NA - Not applicable. There are no cancer slope factors (CSF) and/or reference doses (RfD) available for this chemical.

TABLE 4-7

SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs - GROUNDWATER
HUMAN HEALTH SCREENING ASSESSMENT
D-6, SMALL ARMS RANGE
MCB CAMP LEJEUNE
ONSLOW COUNTY, NORTH CAROLINA

Chemical	Incremental Lifetime Carcinogenic Risk (ILCR)			Estimated Non-Carcinogenic Hazard Quotient (HQ)		
	Exposure Point Concentration (ug/L)	RSL[1] (mg/kg)	Estimated ILCR	Primary Target Organs	RSL[1] (ug/L)	Estimated HQ
Arsenic	55.1	0.39	1E-04	Cardiovascular, Skin	22	3
Lead	47	NA	NA	NA	NA	NA
		Total ILCR	1E-04		Total HI	3

1 - USEPA Regional Screening Level, April 2009, Updated May 19, 2009
NA - Not applicable. There are no cancer slope factors (CSF) and/or reference doses (RfD) available for this chemical.

TABLE 4-8

SURFACE SOIL ECOLOGICAL RISK SCREENING
D-6, SMALL ARMS RANGE
MCB CAMP LEJEUNE
ONSLOW COUNTY, NORTH CAROLINA

CAS Number	Parameter	Frequency of Detection [1]	Minimum Detected Concentration	Maximum Detected Concentration	Sample with Maximum Detection	Average of Detected Concentrations	Average of All Samples[2]	Ecological Screening Level[3]	Maximum Ecological Effects Quotient[4]	Average Ecological Effects Quotient[4]	Retain as a COPC?[5]	Rationale for COPC Deletion or Selection	Selected for Food Chain Modeling?[6]
Inorganics	**(mg/kg)**												
7440-36-0	Antimony	16/17	0.15	493	MMRP64-SS007-D-0002	45.42	42.75	0.27	1826	158	Yes	ASL	Yes
7440-38-2	Arsenic	17/17	0.49	4.9	MMRP64-SS007-D-0002	1.6	1.6	18	0.272	0.086	No	BSL	No
7440-50-8	Copper	17/17	0.62	27.6	MMRP64-SS023-D-0001	8.6	8.6	28	0.986	0.308	No	BSL	No
7439-92-1	Lead	17/17	22.3	60,400	MMRP64-SS007-D-0002	6,175	6,175	11	5491	561	Yes	ASL	Yes
7440-02-0	Nickel	17/17	0.57	7.2	MMRP64-SS023-D-0001	2.3	2.3	38	0.189	0.059	No	BSL	No
7440-31-5	Tin	2/17	11.5	23.2	MMRP64-SS007-D-0002	17.4	2.7	53 [7]	0.438	0.052	No	BSL	No
7440-66-6	Zinc	17/17	3	209	MMRP64-SS023-D-0001	53.4	53.4	46	4.54	1.16	Yes	ASL	Yes

1 - Where both a sample and duplicate results were available, the average concentration was used for the sample count.
2 - A value of one-half the reported value was used for the nondetected (U) parameters in the calculation of the average of all samples.
3 - Ecological Screening Level is the lower of plant, invertebrate, bird, or mammal Eco-SSLs (USEPA, 2005 and supporting documents) unless otherwise noted. Individual Eco-SSLs available at http://www.epa.gov/ecotox/ecossl/
4 - Ecological Effects Quotient (EEQ) is derived by dividing the maximum or average detected site concentration by the Ecological Screening Level.
5 - Chemical was retained as a COPC if the EEQ is greater than 1.0.
6 - A chemical was selected for food chain modeling if the wildlife screeing level was exceeded.
7 - USEPA Region 4 Ecological Screening Value (USEPA, 2001)

USEPA, 2001. Region 4 Ecological Risk Assessment Bulletins – Supplement to RAGS. Effective April 20.

Shaded criterion indicates that concentration exceeds any screening level.
COPC = Chemical of Potential Concern

Rationale Codes
For Selection as a COPC:
ASL = Above COPC screening level
For Elimination as a COPC:
BSL = Below COPC screening level

Associated Samples:

MMRP64-SS004-C-0001	MMRP64-SS019-C-0001	MMRP64-SS010-D-0002	MMRP64-SS022-D-0001	MMRP64-SS012-C-0001
MMRP64-SS009-C-0001	MMRP64-SS005-C-0001	MMRP64-SS011-C-0001	MMRP64-SS023-D-0001	
MMRP64-SS009-D-0002	MMRP64-SS005-D-0002	MMRP64-SS011-D-0002	MMRP64-SS007-C-0001	
MMRP64-SS010-C-0001	MMRP64-SS006-C-0001	MMRP64-SS021-D-0001	MMRP64-SS007-D-0002	

TABLE 4-9

GROUNDWATER ECOLOGICAL RISK SCREENING AS SURFACE WATER
D-6, SMALL ARMS RANGE
MCB CAMP LEJEUNE
ONSLOW COUNTY, NORTH CAROLINA

CAS Number	Parameter	Frequency of Detection [1]	Minimum Detected Concentration	Maximum Detected Concentration	Sample with Maximum Detection	Average of Detected Concentrations	Average of All Samples[2]	Surface Water Ecological Screening Level[3]	Maximum Ecological Effects Quotient[4]	Average Ecological Effects Quotient[4]	Retain as a COPC?[5]	Rationale for COPC Deletion or Selection
Total Inorganics (ug/L)												
7440-38-2	Arsenic	3/4	22.1	55.1	MMRP64-TW004	37.2	28.5	190	0.290	0.150	No	BSL
7440-50-8	Copper	3/4	11	24.5	MMRP64-TW004	16.0	12.6	6.54	3.75	1.925	Yes	ASL
7439-92-1	Lead	4/4	21.9	117	MMRP64-TW004	47	47	1.32	88.6	35.767	Yes	ASL
7440-02-0	Nickel	4/4	2.3	21.7	MMRP64-TW004	12.6	12.6	87.71	0.247	0.144	No	BSL
7440-66-6	Zinc	3/4	24.3 J	272	MMRP64-TW004	168.6	129.4	58.91	4.62	2.197	Yes	ASL
Filtered Inorganics (ug/L)												
7440-02-0	Nickel	3/3	2.4	4.8	MMRP64-TW012	3.7	3.7	87.71	0.0547	0.042	No	BSL
Miscellaneous Parameters (ug/L)												
14797-73-0	Perchlorate	3/4	0.17 J	0.19 J	MMRP64-TW004, MMRP64-TW019	0.2	0.1	NA	NA	NA	Yes	NSL

1 - Where both a sample and duplicate results were available, the average concentration was used for the sample count.
2 - A value of one-half the reported value was used for the nondetected (U) parameters in the calculation of the average of all samples.
3 - USEPA National Reccomended Water Quality Criteria (2006) Freshwater Criterion Continuous Concentration (CCC).
4 - Ecological Effects Quotient (EEQ) is derived by dividing the maximum or average detected site concentration by the Ecological Screening Level.
5 - Chemical was retained as a COPC if the EEQ is greater than 1.0.

Shaded criterion indicates that concentration exceeds any screening level.
COPC = Chemical of Potential Concern

Associated Samples:
MMRP64-TW004
MMRP64-TW007
MMRP64-TW012
MMRP64-TW012-D
MMRP64-TW019

Rationale Codes
For Selection as a COPC:
ASL = Above COPC screening level
NSL = No Screening Level

For Elimination as a COPC:
BSL = Below COPC screening level

TABLE 4-10

EXPOSURE PARAMETERS FOR THE TERRESTRIAL WILDLIFE MODEL
D-6, SMALL ARMS RANGE
MCB CAMP LEJEUNE
ONSLOW COUNTY, NORTH CAROLINA

Species/Exposure Inputs	Average Inputs	
	Values	Units
Bobwhite Quail		
Body Weight = BW	1.751E-01	kg
Food Ingestion Rate = If	4.080E-03	kg/day
Water Ingestion Rate = Iw	1.926E-02	L/day
Soil Ingestion Rate = Is	2.489E-04	kg/day
Home Range = HR	1.880E+01	acres
Meadow Vole		
Body Weight = BW	3.580E-02	kg
Food Ingestion Rate = If	3.488E-03	kg/day
Water Ingestion Rate = Iw	6.261E-03	L/day
Soil Ingestion Rate = Is	4.186E-05	kg/day
Home Range = HR	6.590E-02	acres
American Robin		
Body Weight = BW	8.04E-02	kg
Food Ingestion Rate = If	1.19E-02	kg/day
Water Ingestion Rate = Iw	1.13E-02	L/day
Soil Ingestion Rate - Is	7.601E-04	kg/day
Home Range = HR	6.095E-01	acres
Short-Tailed Shrew		
Body Weight = BW	1.610E-02	kg
Food Ingestion Rate = If	1.433E-03	kg/day
Water Ingestion Rate = Iw	3.600E-03	L/day
Soil Ingestion Rate - Is	1.289E-05	kg/day
Home Range = HR	9.699E-01	acres

Notes:
The exposure factors were derived as presented in Appendix F.

The soil ingestion rates were calculated by multiplying the food ingestion rates by the following incidental soil ingestion rates:

	Average	Source
Bobwhite quail	6.10%	1, 2
Meadow Vole	1.20%	1
American Robin	6.40%	1,2
Short-tailed Shrew	0.90%	1

1 - USEPA (U.S. Environmental Protection Agency), 2007. Attachment 4-1. Ecological Soil Screening Level Guidance, Office of Emergency and Remedial Response. February.
2 - Based on the American woodcock

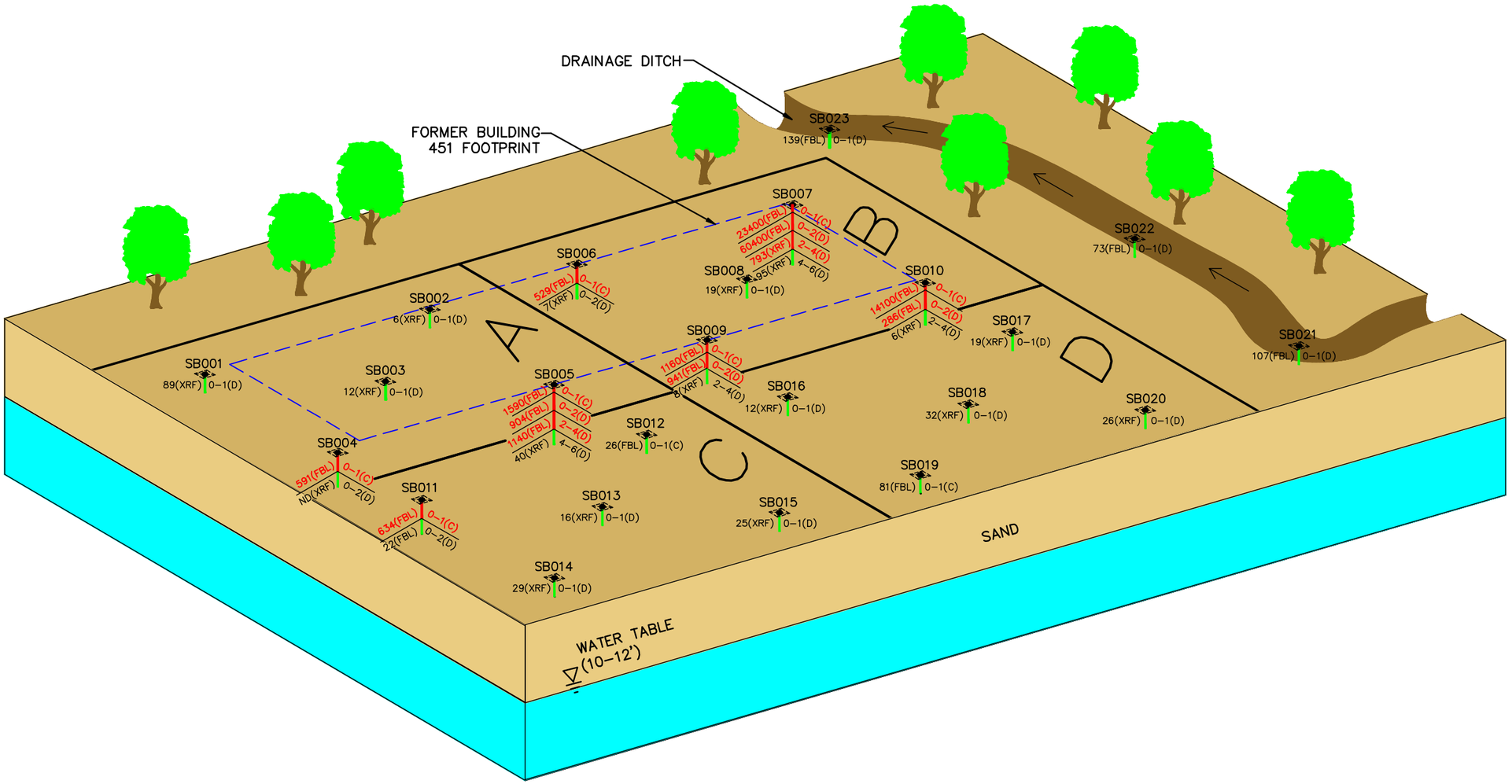
TABLE 4-11

TERRESTRIAL FOOD CHAIN MODEL - AVERAGE SCENARIO
HERBIVOROUS AND INSECTIVOROUS RECEPTORS
D-6, SMALL ARMS RANGE
MCB CAMP LEJEUNE
ONSLOW COUNTY, NORTH CAROLINA

Chemical	Herbivorous Receptors EEQs				Insectivorous Receptors EEQs			
	Bobwhite Quail		Meadow Vole		Robin		Short-Tailed Shrew	
	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL
Inorganics								
ANTIMONY	NV	NV	6.8E+00	1.4E-01	NV	NV	6.5E+01	1.4E+00
LEAD	1.5E+01	5.4E-01	1.2E+01	3.1E-01	1.2E+02	4.5E+00	2.1E+01	5.2E-01
ZINC	2.5E-01	9.8E-02	4.3E-01	1.1E-01	9.9E-01	3.8E-01	7.6E-01	1.9E-01

Cells are shaded if the value is greater than 1.0

NOAEL - No Observed Adverse Effects Level
LOAEL - Lowest Observed Adverse Effects Level
EEQ - Ecological Effects Quotient
NV - Value not able to be calculated



LEGEND

ND	NON–DETECT
(D)	DISCRETE SAMPLE
(C)	COMPOSITE SAMPLE
(XRF)	X–RAY FLUORESCENCE RESULT (FIELD READING)
(FBL)	FIXED–BASE LABORATORY RESULT

NOTES:

1.) CONCENTRATIONS ARE IN MG/KG.

2.) SAMPLE DEPTH (I.E. 0–1) IS IN FEET BELOW GROUND SURFACE.

3.) SOIL LEAD CONCENTRATIONS AND BORING SEGMENTS SHOWN IN RED INDICATE LEVELS ABOVE PROJECT ACTION LIMITS.

4.) BORING SEGMENTS SHOWN IN GREEN CONTAINED LEAD AT CONCENTRATIONS BELOW PROJECT ACTION LIMITS.

DRAWN BY CK	DATE 8–26–09	SOIL LEAD CONCENTRATIONS D–6, 50–FOOT INDOOR RIFLE AND PISTOL RANGE (FORMER BUILDING 451) MCB CAMP LEJEUNE ONSLOW COUNTY, NORTH CAROLINA	CONTRACT NO. 1716
CHECKED BY	DATE		OWNER NO.
REVISED BY	DATE		APPROVED BY DATE
SCALE NTS			DRAWING NO. FIGURE 4–1 REV. 0

NAVFAC

R:\1716\Figures\1716FG02.dwg PIT CARLY.KRAMER 9/11/2009 11:30:56 AM

5.0 UPDATED CONCEPTUAL SITE MODEL

The D-6, Small Arms Range was an indoor small arms range located inside B-451 on I Street at Camp Lejeune, between Building 429 and Building 430. The site is approximately 700 feet northeast of the New River and consists of relatively level sandy soils. The area is partially vegetated with small trees and underbrush and gently slopes away from I Street to the northwest. The elevation of the prepared soil surface when B-451 was constructed was approximately 13 feet above msl.

The building was constructed in November 1952 as a small arms training range and was used for a period of approximately 46 years. The range consisted of eight firing lanes and accommodated target practice firing from a 50-foot distance and a 75-foot firing distance from the targets. Small arms ammunition was fired downrange (to the northeast) into a bullet trap consisting of a series of angled steel plates and a sand pit. Recovered property management records indicate that the demolition and disposal activities for B-451 were completed in December 1998.

5.1 CONCEPTUAL SITE MODEL

Historical and SI visual evidence indicate that Munitions and Explosives of Concern (MEC) are not present at the D-6, Small Arms Range. Therefore, incomplete exposure pathways exist for MEC and no exposure pathway analysis was completed for MEC. For the purpose of this SI Report, only MC associated with the D-6, Small Arms Range is considered in the CSM exposure pathway analysis.

Soil impacted by MC represents a primary potential source medium, as illustrated in the CSM. Potential receptors include human [Installation personnel (military and civilian), contractors, visitors, and maintenance workers] and certain ecological receptors. The potential for receptors to come in contact with MC in soil does pose a threat to human and ecological receptors. A potentially complete exposure pathway exists for surface soil through ingestion, inhalation, and dermal contact for human receptors.

Precipitation infiltration has the potential to mobilize contaminants into subsurface soil and into the shallow or surficial groundwater aquifer, which is assumed to be connected to nearby surface water bodies. Subsurface soil represents an exposure medium when considering potential future construction or ground disturbances by Installation personnel (military and civilian), contractors, visitors, and maintenance workers. Runoff/erosion impacting surface water/sediment also presents a potential exposure medium to human receptors. Potentially complete exposure pathways do not exist for MC in shallow groundwater for ingestion in human receptors because shallow groundwater is not used for local

water supplies. A deeper aquifer (Castle Hayne Formation) is used for the local water supply. The MC exposure pathway analysis for the D-6, Small Arms Range is presented on Figure 5-1.

Problem Definition Summary

The following is a summary of the problem definition:

- Limited environmental contamination does exist at the D-6, Small Arms Range (approximately 1 acre) due to the facility being a formerly active small arms firing range from 1952 through 1998. This former indoor range featured a 75-foot firing line and a 50-foot firing line for small bore weapons target training.

- Specific small arms ammunition types and materials used at the D-6, Small Arms Range most likely included small arms and pistol ammunition (5.56mm, 7.62mm, .22-cal, and possibly other small arms ammunition).

- This indoor range was constructed with a standard deflection plate and sand pit bullet trap behind the range targets at the northeastern end of the building. To reduce the potential for ricochet hazards in the bullet trap, it is typically standard practice to routinely maintain the bullet trap sand by collecting and removing expended bullets and bullet fragments.

- No information was discovered in the installation archive describing how the bullet trap sands or the expended bullets recovered from the B-451 sand pit were managed. It is presumed that standard range management and maintenance practices would periodically recover expended lead bullets and fragments from the sand pit and that recovered lead material was removed to an offsite location for recycling. There was no mention in the demolition plan regarding the management of expended lead bullets or the bullet trap sands that could contain particulate lead and bullet fragments. It has been presumed that because this demolition activity was completed within the last ten years that the bullet trap sands and contents were most likely removed by the USMC or a designated service contractor prior to the B-451 demolition in December 1998. It has also been presumed that those materials were sent offsite to recycle the lead or support some other beneficial reuse. The absence of bullets observed at the site during the SI supports the presumption that bullet trap debris (i.e., lead) was managed as required.

Other hazardous materials noted on the B-451 demolition plans included friable asbestos in cloth-wrapped pipes, transite panels in the restroom ceiling, and details on the locations and concentrations of

lead-containing paint on the building metal siding surfaces and the steel baffle plates. The fact that these materials were specifically identified for special management also appears to support that the bullet trap may have been cleaned prior to demolition.

- Lead was the primary MC metal of concern because it is the primary constituent in spent small arms munitions (typically 85 to 96 percent lead by weight) and because of the documented toxicity of lead to both human and ecological receptors.

- To verify the potential release of MC from the former D-6, Small Arms Range to the environment in the form of expended lead bullets, lead fragments or lead dust, a limited environmental sampling program was conducted in the area of the former D-6, Small Arms Range. It was presumed that if bullet-derived contamination was present at the site, it would be concentrated in the vicinity of the former indoor range bullet trap area, specifically at the northeastern end of the former indoor range (approximately 62 feet southwest of Building 430). Based on the XRF field analysis, and confirmation FBL sample analysis, the highest concentrations of soil lead were confirmed to be present in the area of the former indoor range bullet trap (See Figure 3-2).

- Air handling and ventilation equipment installed in the mid-1980s may also have played a role in the deposition of lead in surface soils at the site. As indicated in the ventilation upgrade plan (Appendix A) the exhaust ducts from the range building were in the vicinity of location MMRP64-SB005 and SB006, which both contained elevated lead concentrations in soil.

- MC consisting of metals (primarily lead and, to a lesser extent, antimony, arsenic, copper, tin, and zinc) were detected in several locations of the investigation area. It was determined that the other analyzed metals concentrations were spatially correlated with lead concentrations.

- The highest lead concentrations were detected primarily in the 0- to 6-inch interval of soil. MC (i.e. lead) was detected in concentrations greater than the PAL in seven of the 23 sample locations, and only in two sample locations (MMRP64-SB005 and SB007) was lead detected in concentrations greater than the PAL of 270 mg/kg in soil deeper than 2 feet bgs.

- A drainage ditch is located in the northeastern perimeter of the site. During the SI sampling activities there was no water in the drainage ditch, so no surface water samples were collected. However, the three soil samples collected from the drainage ditch did not contain lead concentrations greater than the than the PAL of 270 mg/kg.

- It has not been completely determined if the lead in soil had subsequently infiltrated to underlying groundwater. FBL lead concentrations were detected in underlying groundwater in concentrations greater than the 15.0 µg/L PAL in all four of the unfiltered groundwater samples. However, lead concentrations in the three groundwater samples filtered through a 0.45 micron filter were less than the PAL. This typically indicates that the lead is potentially adhering to the soil particles rather than in a dissolved state within the groundwater. Turbidity levels in the three unfiltered sample locations were elevated and remained elevated (>300 NTUs) even after efforts to purge multiple well volumes from the wells. The one unfiltered groundwater sample with a measured turbidity reading of 9.7 NTU (very close, but still below the 10 NTU threshold level) contained lead at 22.2 µg/L (still above the 15 µg/L PAL).

- The CSM indicates that potentially complete exposure pathways for MC do exist for human receptors under both current and hypothetical future land uses.

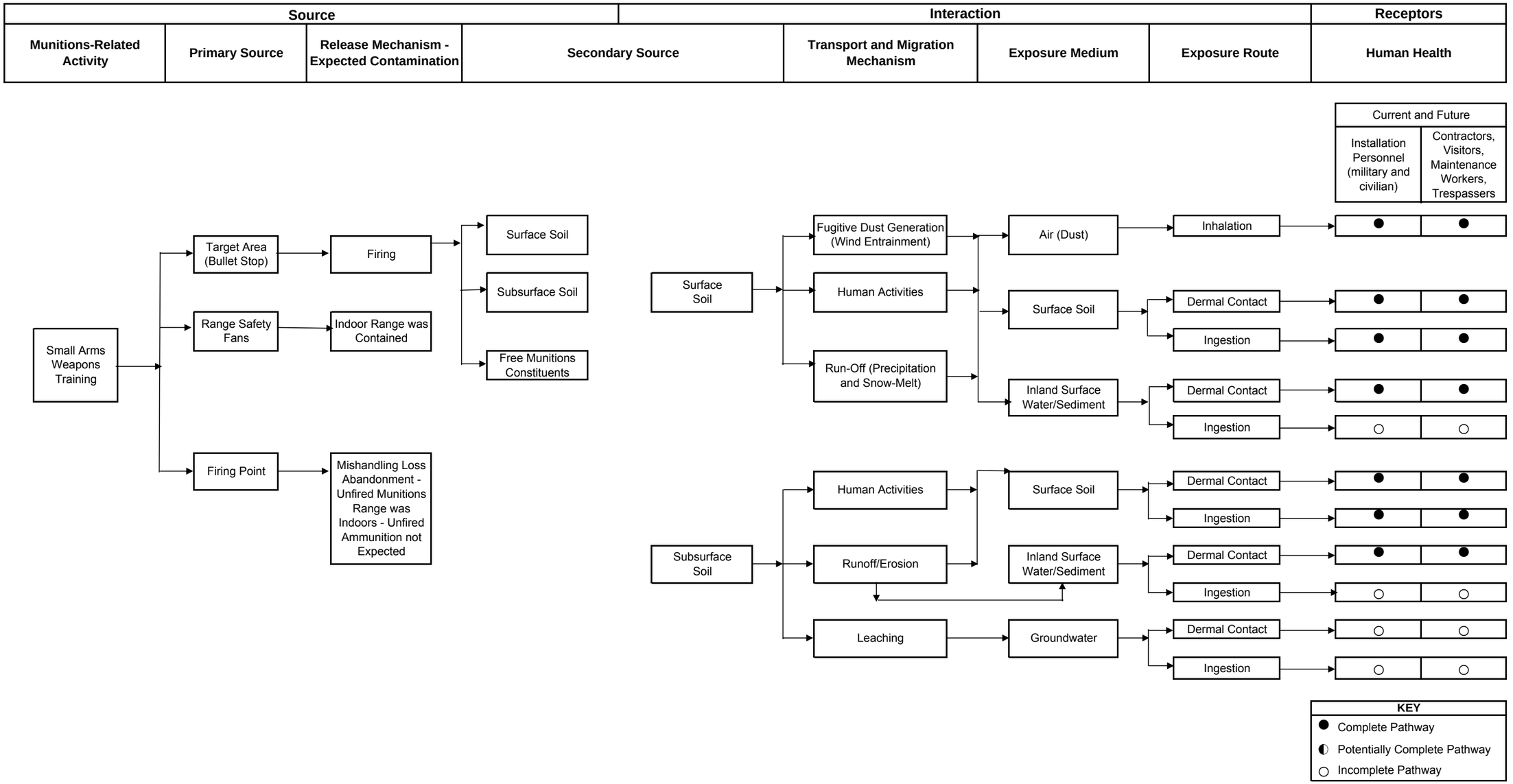
- The sampling of surface soil, subsurface soil, and groundwater with FBL analysis has determined that MC (i.e. lead) does exist in limited areas of the investigation area in concentrations great enough to pose a potential risk to human health.

- The human health risk screening identified lead, antimony, and arsenic as COPCs in surface and subsurface soil and lead and arsenic in groundwater. The arithmetic mean concentration of lead in surface soil, subsurface soil, and groundwater (unfiltered) exceeded the USEPA and NC screening levels. Adverse health affects could be anticipated from exposures to lead in soil and groundwater. Lead, Antimony, and zinc were initially selected as surface soil COPCs because the maximum detected concentrations exceeded the ESL. Lead and antimony were retained as COPCs following further refinement of receptor classes, spatial distribution of chemical concentrations at the site

- Food-chain model EEQs using average concentrations and average exposure parameters were greater than 1.0 for lead in all ecological receptors (vole, quail, shrew, and woodcock). Similar model EEQs were above 1.0 for antimony in only the vole and shrew.

FIGURE 5-1

MC EXPOSURE PATHWAY ANALYSIS
D-6, SMALL ARMS RANGE
MCB CAMP LEJEUNE
ONSLOW COUNTY, NORTH CAROLINA



6.0 CONCLUSIONS AND RECOMMENDATIONS

6.1 SUMMARY AND CONCLUSIONS

Nature and Extent of Contamination

Soil

Lead was detected in seven of twenty surface soil samples (0 to 0.5 feet bgs) and four of nine subsurface soil samples (0 to 2 feet bgs) within the main sample grid at concentrations greater then the NC SSL for residential soil. The maximum concentration was 60,400 mg/kg. Lead concentrations were greater than the NC SSL at depths of 2 to 4 feet bgs at sample locations MMRP64-SB005 (1,140 mg/kg) and SB007 (793 mg/kg). No lead concentrations above the NC SSL were detected in soil samples at depths greater than 4 feet bgs. Lead concentrations from the three surface soil samples collected within the drainage channel immediately northeast of the site were all below the NC SSL of 270 mg/kg. Antimony was detected at sample locations MMRP64-SB007 and SB010 in concentrations greater than the NC SSL. Antimony is typically co-located in sample locations where excessive lead concentrations are detected. Sample locations MMRP-SB007 and 010 were located in the general area of the bullet trap within the former B-451.

Groundwater

Lead was detected in all unfiltered samples collected from the temporary groundwater monitoring wells at concentrations greater than the NC Groundwater Standard. Arsenic was detected in one unfiltered groundwater sample (at location MMRP64-TW004) at a concentration greater than the NC SSL. Due to high turbidity in sample locations MMRP64-TW004, 012, and 019, filtered samples were also collected and measured lead concentrations were below the NC Groundwater Standard for lead. Arsenic concentrations in filtered groundwater samples also fell well below the NC Groundwater Standard especially in the filtered sample at MMRP64-TW004.

Human Health Risk Screening Evaluation

Antimony, arsenic, and lead were selected as COPCs in surface and subsurface soil. Arsenic and lead were selected as COPCs in groundwater. Cancer risks were within the USEPA target risk range for exposures to surface soil and subsurface soil. Noncancer risks exceeded the USEPA acceptable level for exposures to surface soil. Antimony was the major contributor to the unacceptable noncancer risk in surface soil. Noncancer risks were within acceptable levels for exposures to subsurface soil. The cancer

risk for exposures to groundwater was equal to the upper bound of the USEPA target range. The noncancer risk for exposure to groundwater exceeded the USEPA acceptable level. Total arsenic was the major contributor to the noncancer risk for exposure to groundwater.

The arithmetic mean concentration of lead in surface soil, subsurface soil, and groundwater exceeded USEPA and NC screening levels. Consequently, adverse health effects could be anticipated from exposures to lead in soil and groundwater.

It should be noted that the groundwater samples were collected from temporary monitoring wells and the total samples were highly turbid. Arsenic and lead were not detected in the filtered groundwater samples. This suggests that the high total arsenic and lead concentrations are largely associated with the particulates in the groundwater samples.

Ecological Risk Evaluation

Three inorganics (antimony, lead, and zinc) were initially selected as surface soil COPCs because the maximum detected concentration exceeded the ESL. After a refinement based on specific receptor classes, spatial distribution of chemical concentrations, and average concentrations, antimony and lead were retained as COPCs for further evaluation to plants and soil invertebrates in surface soils at the D-6, Indoor Firing Range.

Three unfiltered inorganics (copper, lead, and zinc) were initially retained as COPCs in unfiltered groundwater samples because their maximum detected concentrations exceeded the surface water screening level. None of these metals were retained as COPCs because they were not detected in filtered groundwater samples. Perchlorate was initially retained as a COPC because a screening level was not available. Established ecotoxicity data was not available; therefore, risks to aquatic biota from perchlorate could not be evaluated.

A limited food-chain model was conducted for herbivorous and insectivorous birds and mammals for those chemicals that exceeded their respective surface soil screening levels. Average chemical concentrations and average exposure parameters were used for the evaluation. Food-chain model EEQs were greater than 1.0 for antimony for the vole and shrew and for lead for all receptors (vole, quail, shrew, and woodcock).

Conclusions

Soil

Lead soil concentrations exceeded the NC SSL at various locations at the D-6, Small Arms Range, with the greatest concentrations located in the area of the former bullet trap. Other discrete areas of elevated surface soil lead concentration may have been associated with the air handling and ventilation equipment installed at B-451 in the mid-1980s (Appendix A), or doors and other openings in the building. The majority of lead contamination was limited to 0 to 2 feet bgs. Only in two locations was lead detected at concentrations greater than the SSL at depths greater than 2 feet bgs. In no instance was lead detected in soil at concentrations greater than the SSL at depths greater than 4 feet bgs (Figure 6-1).

Groundwater

Lead was detected in all four unfiltered groundwater samples at concentrations greater than the North Carolina Groundwater Standard (Appendix D). Differences between filtered and unfiltered lead results in groundwater samples suggest that lead is absorbed to fine silt particles in the groundwater rather than in a dissolved phase.

6.2 RECOMMENDATIONS

The purpose of the Preliminary Assessment/Site Investigation (PA/SI) phase of this project is to identify possible contaminant releases that require further investigation or pose a threat to human health and the environment. Sites that do not require further investigation and do not pose an unacceptable risk to human health and the environment may be designated as “no further action” (NFA) sites and may be eliminated from further consideration.

The current SI Report identified limited areas with elevated metals concentrations in soil within the project site that also had corresponding exposure risks to potential human and ecological receptors. Based on the SI Report findings, further actions are required for the former D-6, 50-Foot Indoor Rifle and Pistol Range site at MCB Camp Lejeune.

Following the SI phase, the CERCLA process authorizes the performance of response actions that may include an interim removal action or a remedial investigation. CERCLA regulations (40 CFR Section 300.415) direct that at sites where “there is a threat to public health or welfare of the United States or the environment” a removal action may be warranted to “abate, prevent, minimize, stabilize, mitigate, or

eliminate the release or the threat of release." The Department of the Navy has identified the following criteria for determining if a removal action is appropriate:

- The source of contamination can be removed quickly and effectively,
- Access to contamination can be limited (i.e., human exposure is substantially reduced by the removal action),
- A removal action is the most expeditious manner of remediating the site, and
- Consideration of potential economic benefit if the removal action reduces risk and long-term threats sufficiently to serve as the final remedy (removal action supports NFA designation for site).

The Remedial Investigation (RI) constitutes the investigative phase of a response action and is designed to achieve the following:

- Characterize site conditions and nature and extent of risk posed by contamination,
- Obtain data for the evaluation of remedial alternatives if the site poses an unacceptable risk, and
- Provide a basis for decision on further response actions or NFA.

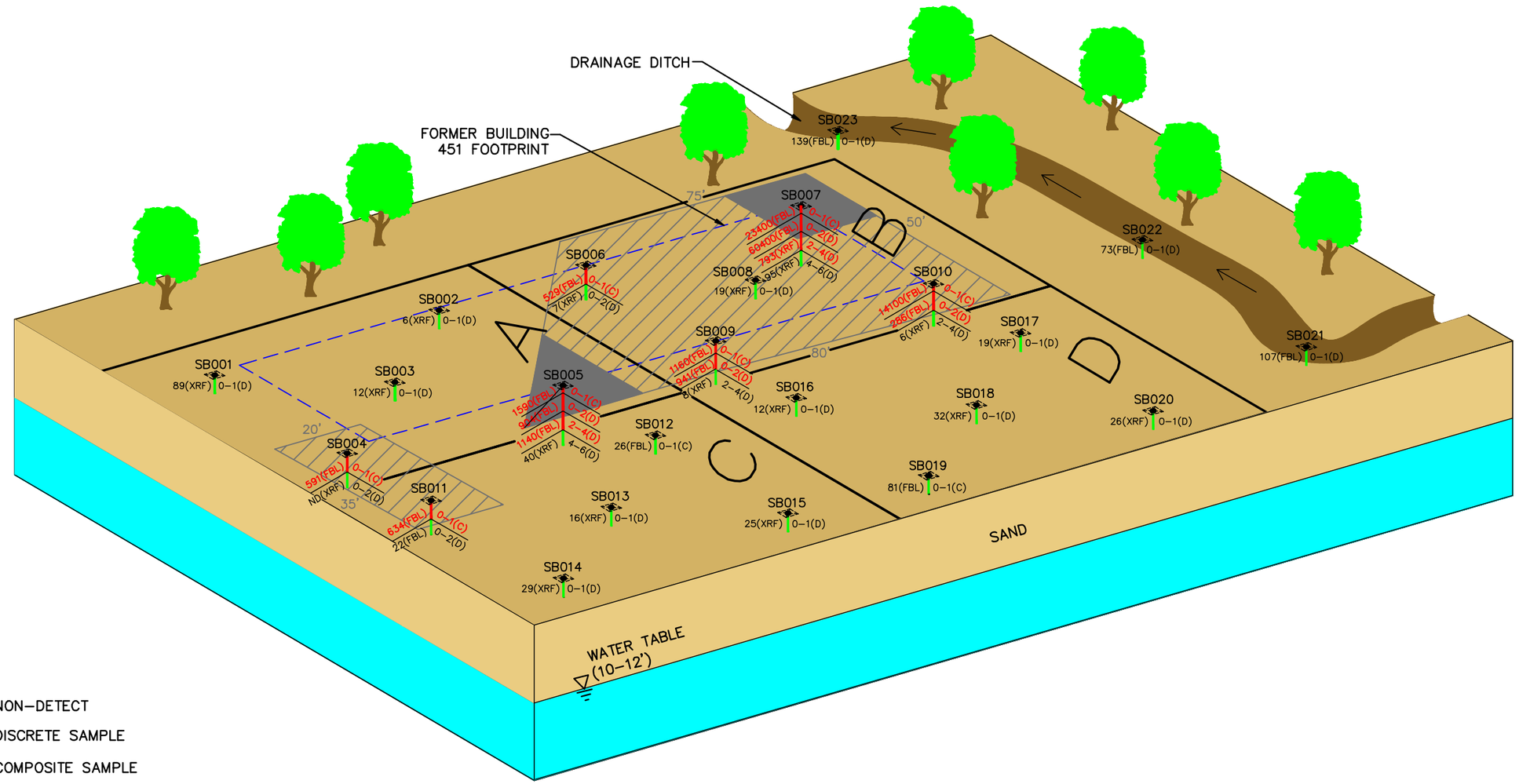
The focused SI sampling activities characterized the local site conditions and identified concentrations of specific metals (i.e., lead) associated with small arms ammunition in soil and groundwater. These SI data were used to perform risk screenings and identified discrete areas of elevated metals concentrations in soil at the project site with corresponding exposure risks to potential human and ecological receptors. The environmental data collected during the SI sampling activities are sufficient to support an interim removal action to address limited areas of surface and shallow subsurface soil lead contamination at the site.

Further investigation of the site through an RI is considered inappropriate if the removal of areas of surface/near surface metals-contaminated soil from the site, as identified during the SI, can be performed quickly and effectively while substantially reducing potential impacts of human exposure. In this instance, an interim removal action is judged as the most expeditious manner of remediating the site and will likely reduce the risk and long term threats as a final site remedy in support of an NFA designation.

The proposed interim removal action for the D-6, Small Arms Range (former B-451) will be limited to removal of detected metals concentrations present above applicable screening levels [approximately 260 cubic yards (cy) of soil] as delineated during the SI (see Figure 6-1). Elimination of localized site soil areas with elevated metals concentrations may also serve to reduce the total metals concentrations detected in local site groundwater samples through this limited source removal action.

Following removal of the metals-contaminated soil, soil sampling (XRF field analysis) will be needed with fixed-base laboratory (FBL) confirmatory sample analyses to verify that the contaminated soil at the site has been fully remediated and that the soil remaining at the site no longer contains elevated metals concentrations that pose exposure risks to potential human and ecological receptors.

In conclusion, the proposed interim removal action will support an NFA site designation by proving that the site has been remediated and will serve as a final site remedy.



LEGEND

ND	NON–DETECT
(D)	DISCRETE SAMPLE
(C)	COMPOSITE SAMPLE
(XRF)	X–RAY FLUORESCENCE RESULT (FIELD READING)
(FBL)	FIXED–BASE LABORATORY RESULT
	0–1' SOIL DEPTH AREA
	0–4' SOIL DEPTH AREA

NOTES:

1.) CONCENTRATIONS ARE IN MG/KG.

2.) SAMPLE DEPTH (I.E. 0–1) IS IN FEET BELOW GROUND SURFACE.

3.) SOIL LEAD CONCENTRATIONS AND BORING SEGMENTS SHOWN IN RED INDICATE LEVELS ABOVE PROJECT ACTION LIMITS.

4.) BORING SEGMENTS SHOWN IN GREEN CONTAINED LEAD AT CONCENTRATIONS BELOW THE PROJECT ACTION LIMITS.

DRAWN BY CK	DATE 8–26–09	NAVFAC	IDENTIFICATION OF SOIL AREAS WITH LEAD CONCENTRATIONS ABOVE PROJECT ACTION LIMITS D–6, 50–FOOT INDOOR RIFLE AND PISTOL RANGE (FORMER BUILDING 451) MCB CAMP LEJEUNE ONSLOW COUNTY, NORTH CAROLINA
CHECKED BY	DATE		
REVISED BY	DATE		
SCALE NTS			

CONTRACT NO.	1716
OWNER NO.	
APPROVED BY	DATE
DRAWING NO.	FIGURE 6–1
REV.	0

R:\1716\Figures\1716FG03.dwg PIT CARLY.KRAMER 9/11/2009 11:27:02 AM

7.0 REFERENCES

Cardinell, Alex P. et. al. Hydrologic Framework of U.S. Marine Corps Base at Camp Lejeune, North Carolina. U.S. Geological Survey, Water-Resources Investigations Report 93-4049. 1993.

Efroymson, R.A., M.E. Will, G.W. Suter II, and A.C. Wooten. 1997. Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Terrestrial Plants: 1997 Revision. Oak Ridge National Laboratory. November. ES/ER/TM-85/R3.

Harris, W. B., and V. A. Zullo. 1991. Eocene and Oligocene Stratigraphy of the Outer Coastal Plain. In J.W. Horton, Jr., and V.A. Zullo (eds.), The Geology of the Carolinas: Carolina Geological Society, 50th Anniversary Volume.

North Carolina Department of Environment and Natural Resources (NCDENR). NCAC, 2005. Title 15A Environment and Natural Resources, Subchapter 2L – Classifications and Water Quality Standards Applicable to The Groundwaters of North Carolina. December 1. Guidelines for Establishing Remediation Goals at RCRA Hazardous Waste Sites.

Oak Ridge National Laboratory Regional Screening Table. 2008. Residential Soil Screening Levels and Tap Water Screening Levels. September.

Tetra Tech NUS, Inc. (TtNUS). 2009. Site-Specific Work Plan for Preliminary Assessment/Site Inspection, D-6, 50-Foot Indoor Rifle and Pistol Range – UXO-01 (Former Building451). April.

United States Environmental Protection Agency (USEPA), 1993. Technical Guidance on Interpretation and Implementation of Aquatic Life Metals Criteria. Memorandum from Martha G. Prothro. October 1, 1993.

USEPA, 1994. Guidance Manual for the Integrated Exposure Uptake Kinetic Model for Lead in Children. EPA/540/R-93-081. Office of Emergency and Remedial Response, Washington, D.C. February 1994

USEPA, 2001. Region 4 Ecological Risk Assessment Bulletins – Supplement to RAGS. Effective April 20. http://www.epa.gov/region04/waste/ots/ecolbul.htm

USEPA, 2005. Guidance for Developing Ecological Soil Screening Levels. Office of Solid Waste and Emergency and Response. OSWER Directive 92857-55. February.

USEPA, 2005. Ecological Soil Screening Level for Antimony, Interim Final. Office of Emergency and Remedial Response. OSWER Directive 9285.7-61. February.

USEPA, 2005. Ecological Soil Screening Level for Lead, Interim Final. Office of Emergency and Remedial Response. OSWER Directive 9285.7-70. March.

USEPA, 2007. Ecological Soil Screening Level for Zinc, Interim Final. Office of Emergency and Remedial Response. OSWER Directive 9285.7-73. November.

USEPA, 2009. United States Environmental Protection Agency Regions 3, 6, and 9. April 2009, Updated May 19, 2009. Regional Screening Levels for Chemical Contaminants at Superfund Sites.

United States Marine Corps (USMC). 2006. Integrated Natural Resource Management Plan (INRMP) 2007-2011. Marine Corps Base, Camp Lejeune, Onslow County, North Carolina. November.

Water and Air Research (WAR). Initial Assessment Study of Marine Corps Base Camp Lejeune, North Carolina. Prepared for Naval Energy and Environmental Support Activity. 1983.

APPENDIX A

ARCHIVAL RECORDS SEARCH REPORT

APPENDIX A

Archival Records Search Report

D-6, 50-FOOT INDOOR RIFLE AND PISTOL RANGE (FORMER BUILDING 451)

MARINE CORPS BASE CAMP LEJEUNE
ONSLOW COUNTY, NORTH CAROLINA

Prepared for:
Department of the Navy
Naval Facilities Engineering Command Mid-Atlantic

Prepared by:
Tetra Tech
234 Mall Boulevard, Suite 260
King of Prussia, Pennsylvania 19406

CONTRACT NUMBER N62467-03-D-0057
CONTRACT TASK ORDER 163

APPENDIX A-1

SITE BACKGROUND INFORMATION
D-6, 50-FOOT INDOOR RIFLE AND PISTOL RANGE (FORMER BUILDING 451)
(ARCHIVE SEARCH REPORT #2.64), BUILDING 451
CAMP LEJEUNE CANTONMENT, NORTH CAROLINA

(from Normalized Database/Defense Site Environmental Reporting and Tracking System)

MCB Lejeune Cantonment 50-ft Indoor Range (D-6 50-ft indoor rifle and pistol range) is located at Building 451 in the area of I Street. Area is cleared. Potentially contaminated media are soil and groundwater. This range is identified as a .22 cal. indoor range located in Building 451.

The range appeared on a 1954 base map and is identified in Base Order 11102.B, dated 5 May 1960. The description of the range remained the same in BO P11102.1G, dated 6 February 1970, and in BO P11102.1K, dated 1 December 1986. Range fan information is extracted from range maps and one or more of the following documents: Training Regulations 140-5, dated 20 November 1931; AR 750-10, dated 22 May 1939; AR 750-10, dated 14 February 1942; AR 750-10, dated 22 January 1944; TM 9-855, dated 17 August 1944; TM 9-855, dated November 1951; Training Circular 25-1, dated 4 August 1978; Training Circular 25-8, dated 25 February 1992; MCO P3570.1A, dated 15 November 1983; MCO P3570.2, dated 5 January 1977, w/change 1, dated 1 June 1983; and Archive Search Report, USACoE, 2001. A site walk was performed by the IR/MMRP Program Manager for Camp Lejeune and evidence of range activities was found.

The Environmental Management office on Camp Lejeune initially identified the range. Also, the range was identified in the Archive Search Report (ASR 2.64) prepared for Camp Lejeune by the Corps of Engineers and finalized in 2001.

This range entered the CERCLA process (IRP) as a preliminary assessment. No CERCLA phases have been completed at the site, and the next phase is a PA/SI.

The estimated dates of range use are from 1954 – 2002. DERA-MRP funds will be used to fund this activity. This site is considered a range and was recommended for closure. See letter 5090 BEMD, dated 17 SEP 2002 “MILITARY RANGE INVENTORY COMMENTS FOR MARINE CORPS BASE (MCB), CAMP LEJEUNE AND MARINE CORPS AIR STATION, NEW RIVER.” The Normalized Database/Defense Site Environmental Reporting and Tracking System (NORM/DSERTS) form dated 19 April 2002 completed for this indoor small arms indoor range indicates that there is unexploded ordnance at the range. This statement is inconsistent with the typical information for a small arms range.

APPENDIX A-2

FIELD NOTES AND INTERVIEW FINDINGS
D-6, 50-FOOT INDOOR RIFLE AND PISTOL RANGE (FORMER BUILDING 451)
CAMP LEJEUNE, NORTH CAROLINA

September 10, 2008

0745 Met with Mr. Bob Lowder, Env. Eng. (910) 451-9607 at his office. Mr. Lowder provided names of individuals who might be available to assist us with information gathering: Mr. Duane Richardson (Range Control – Bldg. 54) and Ms. Linda Futrell at the base records vault (mapping) Bldg 1005.

0820 Met with Mr. Duane Richardson at Range Control (Building 54). Mr. Richardson said he actually trained within Building 451 in the 1970's. He also stated that small caliber was used within the building and it had a V-shaped bullet trap. He was not aware of any UXO ever used at the building. He also indicated that building usage for small bore (.22-caliber) target training was pretty low. Mr. Richardson identified Mr. Steve LeConto as the Base's Facilities Utilization Manager (910-451-4600) and Master Gunnery Sergeant (MGySgt) Charles Dailey (910-451-4600) as potential information sources on building specifications and usage.

0845 Stopped by location of former Building 451. The only visible element that appears to confirm the location of the Building 451 is a partial sidewalk that originated near the curb on I Street and lead back toward the former building area. Several large pine trees noted in the area may assist in determining the exact location of the former building.

0900 Base Library. Public Services Research Librarian Ms. Linda Hopkins provided (by e-mail) a general document on the history of MCB Camp Lejeune: *Semper Fidelis—A Brief history of Onslow County, North Carolina and Marine Corps Base Camp Lejeune*, Lewis Berger Group, Inc., Camp Lejeune Publications Department, North Carolina, 2002.

0925 Building 1005 (Mapping). Spoke with Kenneth at the front desk who took us back to meet with Ms. Shelly Parulis. Ms. Parulis did not have specific information on Building 451, but introduced us to Ms. Linda Futrell who turned out to be very helpful. Once we explained the purpose of our visit, Ms. Futrell was able to provide us with the Building 451 original design blue prints (PW Drawing Numbers 8493 through 8501) dated 25 April 1952. She also discovered an additional drawing dated 20 June 1983 (PW Drawing Number 14534) that indicated planned improvements to Building 451, primarily related to construction and installation of new mechanical equipment rooms to support improved facility ventilation and exhaust systems, improved acoustical treatment of interior walls and ceilings, and improved building lighting and electrical systems. Ms Futrell also provided us with a demolition date recorded for Building 451 as 14 December 1998. Ms. Futrell located the demolition plan (NAVFAC Drawing 4360682, Sheet 6 of 31) dated 9 July 1997 that shows the general layout of the Building 451 immediately before demolition. Black and white photographs of Building 451 were included on the drawing and appear to indicate that the mechanical equipment rooms for ventilation equipment added to the original metal building (in 1984) had already been removed.

1045 Returned to the Base Library. Reviewed base newspaper (*The Globe*) on micro fiche to determine if there were any items reported in the articles related to the demolition of the former Building 451. No information was discovered at the library.

1345 Met again with Bob Lowder at his office and discussed our findings as well as the eventual field sampling task. Bob indicated he should be able to provide trailer space on base from other contractors for our use. Bob had sent us a few GIS maps; however, they were low resolution images and would not support site map development. He indicated if we needed aerials from the GIS Department, a formal request via e-mail would be required.

September 11, 2008

0805 Met with Bob Lowder at his office. Mr. Lowder accompanied us to the location of former Building 451. We completed a site walk and took several photos. The adjacent building southwest of the former Building 451 location is Building 429, which is used as a storage warehouse. To the northeast of the former Building 451 location is Building 430, the Individual Simulated Marksman Facility.

The large pine trees in the area helped to determine the general location of the former building. Surface drainage in the area is to the southwest. A small drainage ditch lies just to the northwest of the site and discharges into the New River. Mr. Lowder indicated that groundwater is usually encountered at 4 to 8 feet below ground surface.

0905 Returned to Mr. Lowder's office. He indicated DRMO may have records on the demolition and disposal of the former building. He also gave us contact names for the GIS Department for possible aerial photograph coverage: Debbie Moffitt, Mike Becker, and Mike Lee (Manager).

0920 Stopped by GIS. No one was currently available to meet with us. Left our contact number and reason for our visit and asked that they call when available. Proceeded to the DRMO Hazardous Waste 90-day accumulation facility.

0935 Arrived at DRMO (Building 490) and spoke with Ms. Nancy Clemmer. She indicated that they did not have any records at that location. She sent us to speak with Mr. Bill Thomas on Lewis Road (Building 906).

0945 Met with Mr. Thomas who informed us that they do not keep any records on range residue and was not aware of anyone on base who would have any such type of information. DRMO does not take any lead residue from range traps, nor do they maintain any of the ranges on base. Mr. Thomas suggested that the Range Managers may have documentation on specific bullet trap cleaning and range waste management activities.

1030 Stopped back at GIS (Building 11) and met with Ms. Debbie Moffitt. She was able to pull up aerials from 1938, 1956, 1998 and 1999. The building was determined to be demolished in December 1998. The aerials from 1998 and 1999 provided good area detail in real color showing the actual building (1998) and then showing the former building location after the demolition had been completed (1999). She stated that we would have to request these aerials formally through our POC, Mr. Bob Lowder.

1055 Returned to the Range Control Office and met again with Duane Richardson. He was not aware of any range clean-up that routinely occurred at any of the ranges. Left a phone message for Steve LeConto regarding any knowledge he might have concerning the former Building 451.

1135 Stopped at Building 12 to contact Mr. LeConto. We were informed that he was on leave until September 24. We met with MGySgt. Charles Daily, the Base Facilities Manager. He was not able to directly provide any additional information regarding Building 451. However, MGySgt. Charles Daily did escort us down to meet with Mr. Fred Estes who works with Mr. LeConto. At that time Mr. Estes was not in his office. It was approaching lunch time and a brief break was taken with the intention of returning to Mr. Estes' office after lunch.

1310 Stopped back at Mr. Estes' office. Mr. Estes was able to provide us with a copy of the Class 2 Property Record (#204789) that included the construction/acquisition date for Building 451 as 01 November 1952. The property record also indicated that Building 451 was improved in 1985 and those building improvements may be the ventilation, electric, and acoustic upgrades that were detailed in the 20 June 1983 (PW Drawing Number 14534) plans. Mr. Estes also provided us with a copy of the Class 2 Disposal Record (#204789) that included the recorded date of disposal by demolition for Building 451 as 18 December 1998.

APPENDIX A-3

SUMMARY OF INFORMATION COLLECTED FOR THE D-6, 50-FOOT INDOOR RIFLE AND PISTOL RANGE (FORMER BUILDING 451) CAMP LEJEUNE, NORTH CAROLINA

Building 451 consisted of metal sheeting on steel frame (Butler Building) constructed on 01 November 1952. The original design blueprints dated 25 April 1952 indicated outside building dimensions of 120 feet 6-inches long by 40-feet wide. Photographs and drawing details shown on the building demolition plan dated 09 July 1997 indicate the building entrance was on the southwestern wall and the direction of small arms fire was to the northeast. This drawing shows the northeastern end of the building and approximately 86 feet along the southeastern and northwestern walls were lined with concrete masonry unit (CMU) walls inside the Butler Building sheet metal exterior wall. The CMU walls were typical cinder block construction. The CMU walls inside Building 451 surrounding the range area were 12 feet 10-inches high. The indoor range at Building 451 was apparently eight firing lanes wide and accommodated target practice firing from a 50-foot distance and a 75-foot firing distance from the targets. The 75-foot firing line is consistent with the outside dimensions of the building and the dimensions of the CMU wall lining the inside of building wall along the firing range.

The range bullet trap system consisted of a series of four angled steel plate baffle plates suspended from the building's structural steel roof supports. The final baffle was a 13-foot wide steel plate that extended across the width of the range and covered the area behind the targets. The steel baffle was oriented at a 45 degree downward angle from about 11-feet above the range floor to near the base of the downrange CMU wall. The leading edge of the final baffle was suspended above a two-foot high CMU wall about ten feet in front of the CMU wall at the northeastern (target) end of the building. Behind the two-foot wall about 8 to 16 inches of sand were placed over a four-inch layer of gravel directly overlying the foundation slab. The sand layer thickened from the 2-foot CMU wall toward the rear (downrange) CMU wall where the final baffle plate was anchored. The sand would catch the expended bullets once they passed through the targets and were deflected by the final steel baffle plate into the sand bullet trap. No records were discovered to document the handling or management of the expended bullets or bullet fragments that accumulated in the Building 451 indoor range bullet trap.

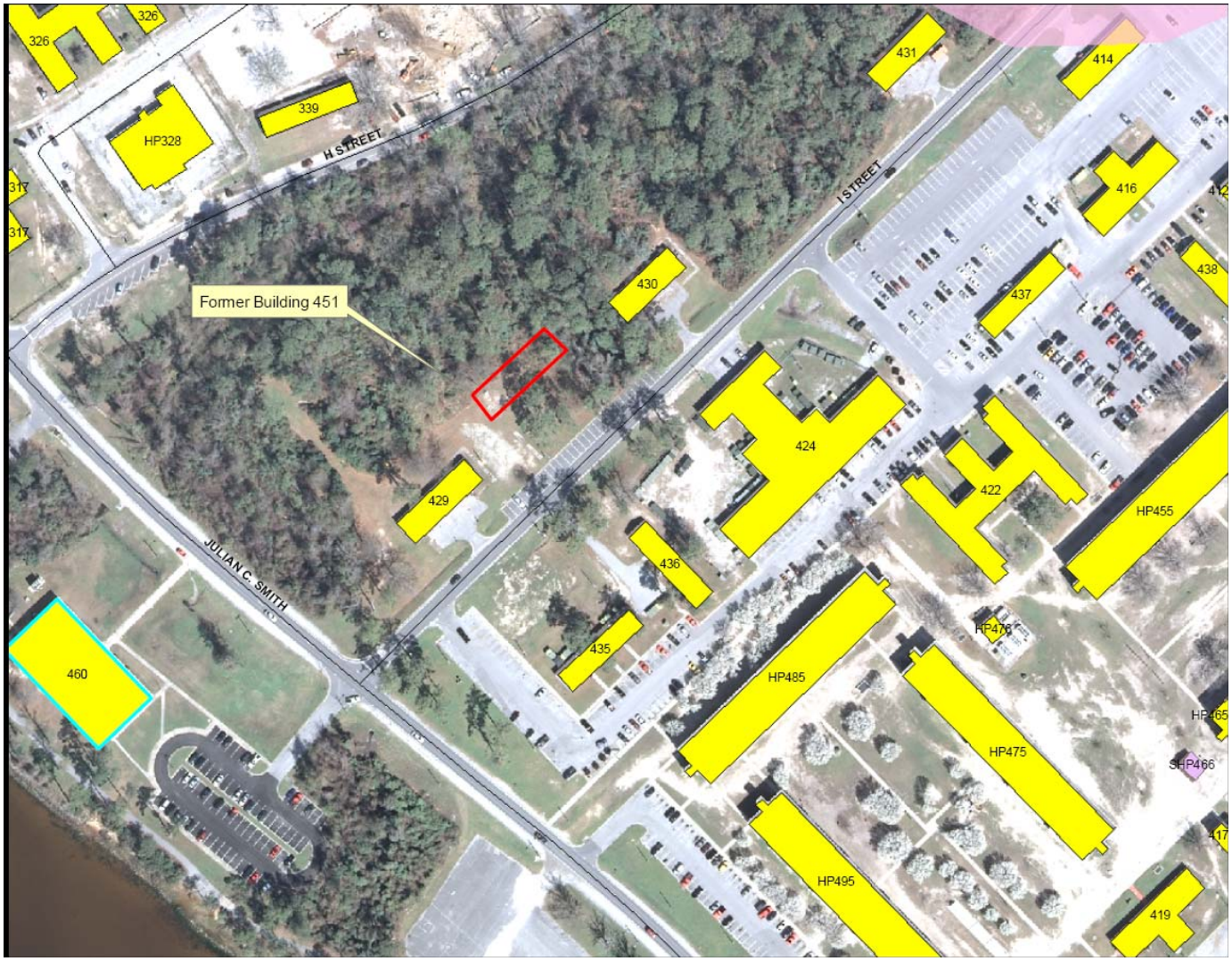
Property records indicated that Building 451 was improved in 1985 and those building upgrades may have included the ventilation system, electrical supply, and building acoustics as detailed in Building 451 improvement plans dated 20 June 1983. The demolition plan indicated that building demolition included removal of wood framed structures on the reinforced concrete foundation and slab including steel siding, CMU walls, partitions, and steel baffle plates. The plan (Note 4) indicated the area was to be backfilled, raked, and seeded after building demolition/removal. This indicates that non-native fill may have been brought to the site and potential surface soil MC contamination from the range may now be at depth below clean fill.

The Class 2 Disposal Record dated 21 December 1998 indicated Building 451 was managed as property record number 204789. The disposal contract was recorded as FACLTR3DEC98, and the demolition/disposal for Building 451 was dated 18 December 1998.

APPENDIX A-4

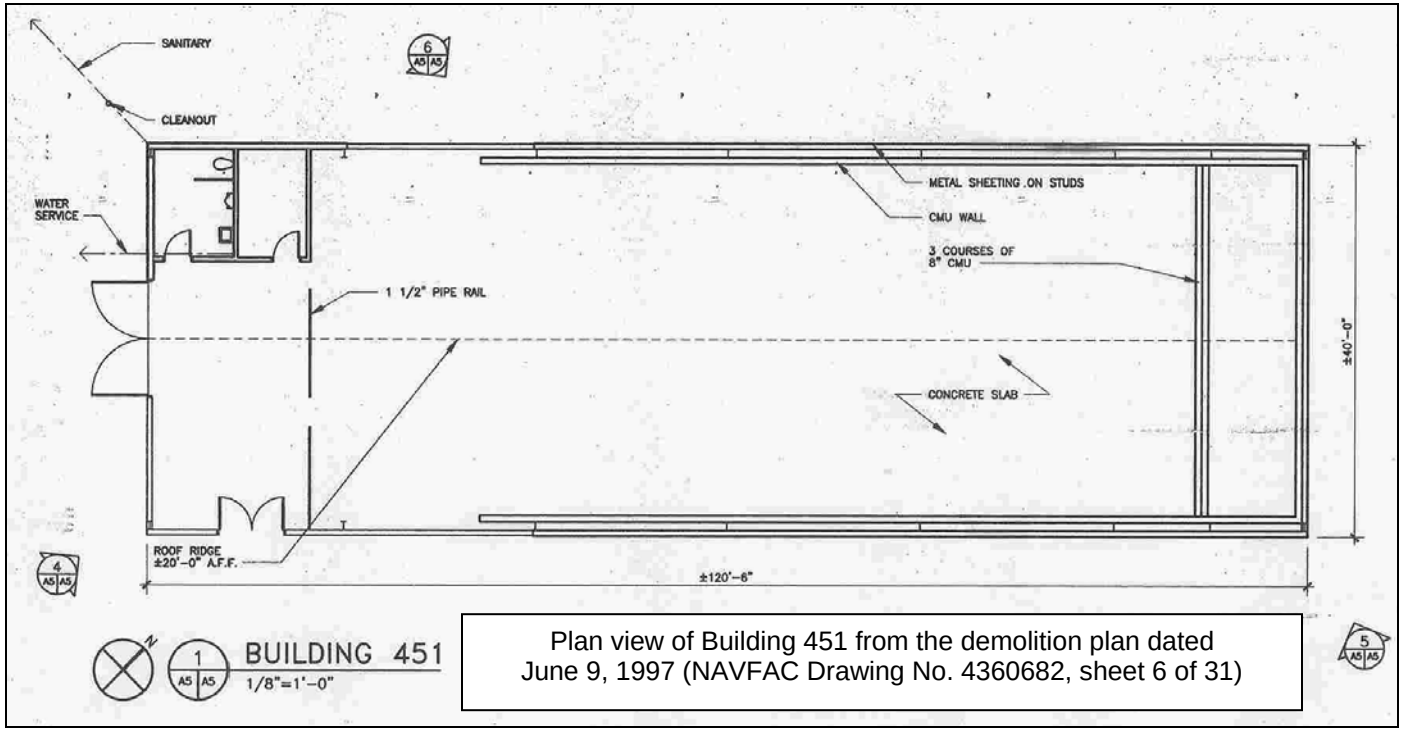
PRIMARY MAPS AND DOCUMENTS
D-6, 50-FOOT INDOOR RIFLE AND PISTOL RANGE (FORMER BUILDING 451)
ONSLOW COUNTY, NORTH CAROLINA

D-6 50-ft Indoor Rifle and Pistol Range, (ASR 2.64), Former Building 451, Camp Lejeune Cantonment

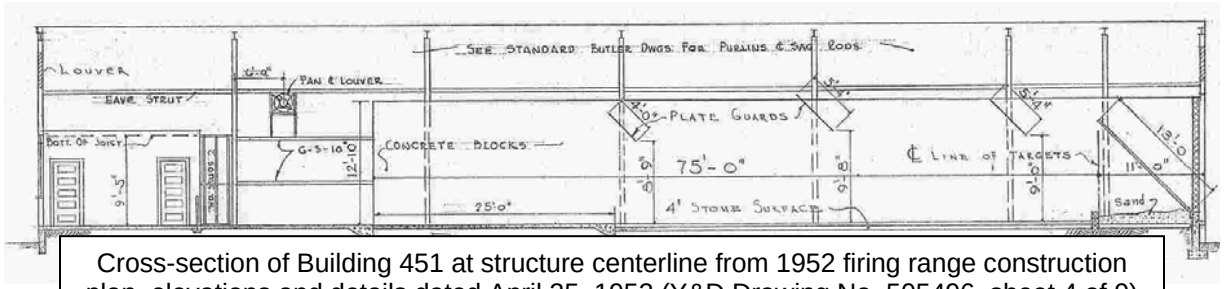


Location map of D-6, 59-Foot Indoor Rifle and Pistol Range (Former Building 451) at MCB Camp Lejeune, provided by Camp Lejeune personnel.

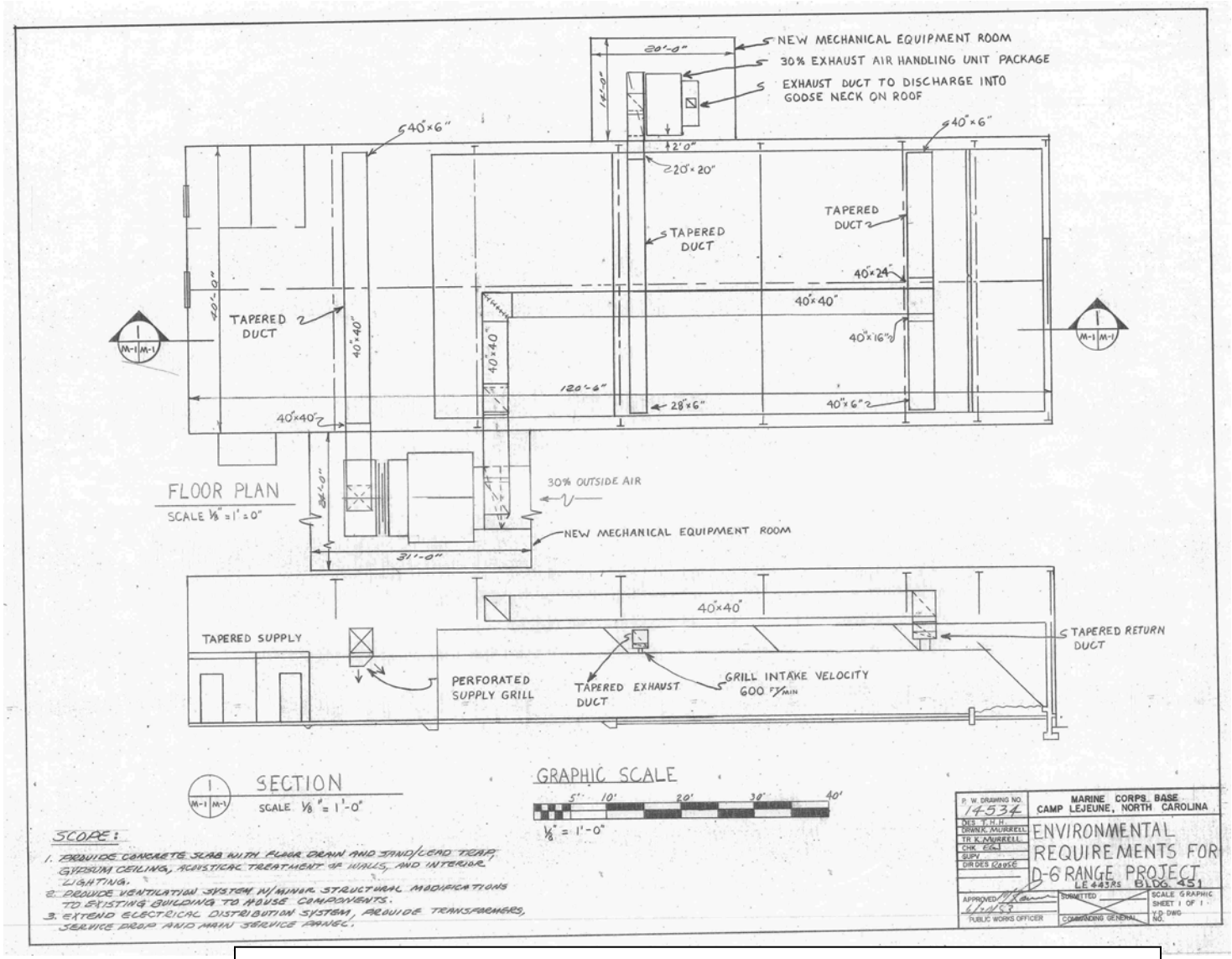
Photograph of Building 451 from the building demolition plan dated June 9, 1997 (NAVFAC Drawing No. 4360682, sheet 6 of 31)



Plan view of Building 451 from the demolition plan dated June 9, 1997 (NAVFAC Drawing No. 4360682, sheet 6 of 31)



Cross-section of Building 451 at structure centerline from 1952 firing range construction plan, elevations and details dated April 25, 1952 (Y&D Drawing No. 505496, sheet 4 of 9)



Plan view and cross-section of Building 451 from construction plan for ventilation system details dated June 20, 1983 (P.W. Drawing No. 14534, sheet 1 of 1)

APPENDIX B

FIELD FORMS

Tetra Tech NUS, Inc.

GROUNDWATER SAMPLE LOG SHEET

Project Site Name: MCB Camp Lejeune
Project No.: 112G01716 CTO 163

Sample ID No.: MMRP64-TW004
Sample Location: MMRP64-TW004
Sampled By: J. Goerdt
C.O.C. No.: 0200

[ ] Domestic Well Data
[ ] Monitoring Well Data
[X] Other Well Type: Temporary Monitoring Well
[ ] QA Sample Type:

Type of Sample:
[X] Low Concentration
[ ] High Concentration

SAMPLING DATA:

		Color	pH	S.C.	Temp.	Turbidity	DO	Salinity	ORP
Date:	5/14/2009	(Visual)	(S.U.)	(mS/cm)	(°C)	(NTU)	(mg/l)	(%)	(mV)
Time:	1900								
Method:	Peristaltic	cloudy	6.29	0.31	19.73	>500	9.73	0	39

PURGE DATA:

		Volume	pH	S.C.	Temp.	Turbidity	DO	Salinity	Other
Date:	5/14/2009								
Method:	Peristaltic								
Monitor Reading (ppm):									
Well Casing Diameter & Material Type:	1" PVC								
Total Well Depth (TD):	19.5 feet								
Static Water Level (WL):	10.25 feet								
One Casing Volume(gal/L):									
Start Purge (hrs):	1830								
End Purge (hrs):	1900								
Total Purge Time (min):	30								
Total Vol. Purged (gal/L):									

SAMPLE COLLECTION INFORMATION:

Analysis	Preservative	Container Requirements	Collected
Metals	Cool 4°C / HNO3	(1) 250 ml plastic bottle	Yes
Metals - Filtered	Cool 4°C / HNO3	(1) 250 ml plastic bottle	Yes
Perchlorate	Cool 4°C	(1) 250 ml plastic bottle	Yes

OBSERVATIONS / NOTES:

Well stick-up was approximately 6" above ground surface

Wetness of soil boring began at approximately 11' 6"
Approximately 19' of pvc placed in boring.

Circle if Applicable:

MS/MSD	Duplicate ID No.:

Signature(s):

J. Goerdt

Tetra Tech NUS, Inc.

GROUNDWATER SAMPLE LOG SHEET

Page 1 of 1

Project Site Name:	MCB Camp Lejeune	Sample ID No.:	MMRP64-TW007
Project No.:	112G01716 CTO 163	Sample Location:	MMRP64-TW007
		Sampled By:	J. Goerdt
[ ] Domestic Well Data		C.O.C. No.:	0200
[ ] Monitoring Well Data		Type of Sample:	
[X] Other Well Type:	Temporary Monitoring Well	[X] Low Concentration	
[ ] QA Sample Type:		[ ] High Concentration	

SAMPLING DATA:

		Color	pH	S.C.	Temp.	Turbidity	DO	Salinity	ORP
Date:	5/14/2009								
Time:	1945	(Visual)	(S.U.)	(mS/cm)	(^{0}C)	(NTU)	(mg/l)	(%)	(mV)
Method:	Peristaltic	Clear	6.57	0.378	18.8	9.7	9.81	0.1	76

PURGE DATA:

		Volume	pH	S.C.	Temp.	Turbidity	DO	Salinity	Other
Date:	5/14/2009								
Method:	Peristaltic								
Monitor Reading (ppm):									
Well Casing Diameter & Material									
Type:	1" PVC								
Total Well Depth (TD):	12.1 feet								
Static Water Level (WL):	8.7 feet								
One Casing Volume(gal/L):									
Start Purge (hrs):	1830								
End Purge (hrs):	1900								
Total Purge Time (min):	30								
Total Vol. Purged (gal/L):									

SAMPLE COLLECTION INFORMATION:

Analysis	Preservative	Container Requirements	Collected
Metals	Cool 4°C / HNO3	(1) 250 ml plastic bottle	Yes
Metals - Filtered	Cool 4°C / HNO3	(1) 250 ml plastic bottle	Yes
Perchlorate	Cool 4°C	(1) 250 ml plastic bottle	Yes

OBSERVATIONS / NOTES:

Well stick-up was approximately 6" above ground surface

Wetness of soil boring began at approximately 8'
Approximately 12' of pvc placed in boring.

Circle if Applicable:		Signature(s):
MS/MSD	Duplicate ID No.:	
Yes - metals		J. Goerdt

Tetra Tech NUS, Inc.

GROUNDWATER SAMPLE LOG SHEET

Page 1 of 1

Project Site Name:	MCB Camp Lejeune	Sample ID No.:	MMRP64-TW012
Project No.:	112G01716 CTO 163	Sample Location:	MMRP64-TW012
		Sampled By:	J. Goerdt
[ ] Domestic Well Data		C.O.C. No.:	0200
[ ] Monitoring Well Data		Type of Sample:	
[X] Other Well Type:	Temporary Monitoring Well	[X] Low Concentration	
[ ] QA Sample Type:		[ ] High Concentration	

SAMPLING DATA:

		Color	pH	S.C.	Temp.	Turbidity	DO	Salinity	ORP
Date:	5/14/2009								
Time:	2035	(Visual)	(S.U.)	(mS/cm)	(^{0}C)	(NTU)	(mg/l)	(%)	(mV)
Method:	Peristaltic	Cloudy	5.27	0.157	18.97	343	9.78	0.1	148

PURGE DATA:

		Volume	pH	S.C.	Temp.	Turbidity	DO	Salinity	Other
Date:	5/14/2009								
Method:	Peristaltic								
Monitor Reading (ppm):									
Well Casing Diameter & Material									
Type:	1" PVC								
Total Well Depth (TD):	19.5 feet								
Static Water Level (WL):	10.6 feet								
One Casing Volume(gal/L):									
Start Purge (hrs):	1830								
End Purge (hrs):	1900								
Total Purge Time (min):	30								
Total Vol. Purged (gal/L):									

SAMPLE COLLECTION INFORMATION:

Analysis	Preservative	Container Requirements	Collected
Metals	Cool 4°C / HNO3	(1) 250 ml plastic bottle	Yes
Metals - Filtered	Cool 4°C / HNO3	(1) 250 ml plastic bottle	Yes
Perchlorate	Cool 4°C	(1) 250 ml plastic bottle	Yes

OBSERVATIONS / NOTES:

Well stick-up was approximately 6" above ground surface

Wetness of soil boring began at approximately 14'
Approximately 19' of pvc placed in boring.

Circle if Applicable:		Signature(s):
MS/MSD	Duplicate ID No.:	
Yes-Perchlorate	FD05140901	J. Goerdt
	Metals (Mitkem Labs) Perchlorate (Columbia Analytical)	

Tetra Tech NUS, Inc.

GROUNDWATER SAMPLE LOG SHEET

Project Site Name:	MCB Camp Lejeune	Sample ID No.:	MMRP64-TW019
Project No.:	112G01716 CTO 163	Sample Location:	MMRP64-TW019
		Sampled By:	J. Goerdt
[ ] Domestic Well Data		C.O.C. No.:	0200
[ ] Monitoring Well Data		Type of Sample:	
[X] Other Well Type:	Temporary Monitoring Well	[X] Low Concentration	
[ ] QA Sample Type:		[ ] High Concentration	

SAMPLING DATA:

		Color	pH	S.C.	Temp.	Turbidity	DO	Salinity	ORP
Date:	5/15/2009								
Time:	815	(Visual)	(S.U.)	(mS/cm)	(^{0}C)	(NTU)	(mg/l)	(%)	(mV)
Method:	Peristaltic	Cloudy	6.01	0.014	19.68	>500	9.35	0	88

PURGE DATA:

		Volume	pH	S.C.	Temp.	Turbidity	DO	Salinity	Other
Date:	5/14/2009								
Method:	Peristaltic								
Monitor Reading (ppm):									
Well Casing Diameter & Material									
Type:	1" PVC								
Total Well Depth (TD):	19.5 feet								
Static Water Level (WL):	12.15 feet								
One Casing Volume(gal/L):									
Start Purge (hrs):	1830								
End Purge (hrs):	1900								
Total Purge Time (min):	30								
Total Vol. Purged (gal/L):									

SAMPLE COLLECTION INFORMATION:

Analysis	Preservative	Container Requirements	Collected
Metals	Cool 4°C / HNO3	(1) 250 ml plastic bottle	Yes
Metals - Filtered	Cool 4°C / HNO3	(1) 250 ml plastic bottle	Yes
Perchlorate	Cool 4°C	(1) 250 ml plastic bottle	Yes

OBSERVATIONS / NOTES:

Well stick-up was approximately 6" above ground surface

Wetness of soil boring began at approximately 11'6"
Approximately 19' of pvc placed in boring.

Circle if Applicable:		Signature(s):
MS/MSD	Duplicate ID No.:	
		J. Goerdt

LOW FLOW PURGE DATA SHEET

PROJECT SITE NAME: MCB Camp Lejeune
PROJECT NUMBER: 112G01716 CTO 163
WELL ID.: MMRP64-TW004
DATE: 5/14/2009

Time (Hrs.)	Water Level (Ft. below TOC)	Flow (mL/Min.)	pH (S.U.)	S. Cond. (mS/cm)	Turb. (NTU)	DO (mg/L)	Temp. (Celcius)	ORP mV	Salinity % or ppt	Comments
1830	10.17									Brown water
1840	10.35									Light brown
1845	10.35				>500					
1850	10.28									
1855	10.25				>500					Cloudy
1900	10.26									End purge

SIGNATURE(S): _____ J. Goerdt

PAGE_1_OF_1_

LOW FLOW PURGE DATA SHEET

PROJECT SITE NAME: MCB Camp Lejeune
PROJECT NUMBER: 112G01716 CTO 163
WELL ID.: MMRP64-TW007
DATE: 5/14/2009

Time (Hrs.)	Water Level (Ft. below TOC)	Flow (mL/Min.)	pH (S.U.)	S. Cond. (mS/cm)	Turb. (NTU)	DO (mg/L)	Temp. (Celcius)	ORP mV	Salinity % or ppt	Comments
1920	8.72				156					Slightly cloudy
1925	9.11				85					Clear
1935	8.91				40					Clear
1945	8.94				9.7					End purge

SIGNATURE(S): _____ J. Goerdt

PAGE_1_OF_1_

LOW FLOW PURGE DATA SHEET

PROJECT SITE NAME: MCB Camp Lejeune
PROJECT NUMBER: 112G01716 CTO 163
WELL ID.: MMRP64-TW012
DATE: 5/14/2009

Time (Hrs.)	Water Level (Ft. below TOC)	Flow (mL/Min.)	pH (S.U.)	S. Cond. (mS/cm)	Turb. (NTU)	DO (mg/L)	Temp. (Celcius)	ORP mV	Salinity % or ppt	Comments
2000	10.55				>500					Brown
2010	10.59				>500					Brown
2020	10.61				430					Brown
2030	10.61				343					End purge

SIGNATURE(S): _____ J. Goerdt

PAGE_1_OF_1_

LOW FLOW PURGE DATA SHEET

PROJECT SITE NAME: MCB Camp Lejeune
PROJECT NUMBER: 112G01716 CTO 163
WELL ID.: MMRP64-TW012
DATE: 5/15/2009

Time (Hrs.)	Water Level (Ft. below TOC)	Flow (mL/Min.)	pH (S.U.)	S. Cond. (mS/cm)	Turb. (NTU)	DO (mg/L)	Temp. (Celcius)	ORP mV	Salinity % or ppt	Comments
730	12.00				>500					Brown
745	12.18				>500					Brown
810	12.15				>500					Brown
										End purge

SIGNATURE(S): _____ J. Goerdt

PAGE_1_OF_1_

MULTIPLE SAMPLE LOG SHEET

Tetra Tech NUS, Inc.

[ ] SURFACE SOIL [ ] SEDIMENT
[X] SUBSURFACE SOIL [ ] LAGOON / POND
[] OTHER _____

SIGNATURE(S): _____

SAMPLER (S): _James Goerdt / James Coffman

PROJECT NAME: **MCB Camp Lejeune - D-6, Small Arms Range**
PROTECT NUMBER: **112G01716 CTO: 163**

LOCATION: **MCB Camp Lejeune**

SAMPLE No.	SAMPLE METHOD	DEPTH (Ft.)	DATE	TIME	CONCENTRATION (L)LOW (H)HIGH	(G) GRAB (C) COMPOSITE	TOTAL No. OF CONTAINERS	ANALYSES: XRF 1	XFR 2	XRF 3	AVG XRF		Metals	USCS	PID READING	SOIL DESCRIPTION
MMRP64-SB004D-0002	DPT	0-2	5/14/2009	1155		X	1	ND	ND	ND	**0**				NA	brown/tan - dry (gravel on top 4")
MMRP64-SS004D-0204	DPT	2-4	5/14/2009	1155		X	1	ND	ND	ND	**0**				NA	tan/orange sand - damp
MMRP64-SB004D-0406	DPT	4-6	5/14/2009	1155		X	1	10	14	12	**12**				NA	tan/orange sand - damp
MMRP64-SB004D-0608	DPT	6-8	5/14/2009	1155			0	NA	NA	NA	**0**				NA	grey/orange molted sand - moist
MMRP64-SB004D-0810	DPT	8-10	5/14/2009	1155		X	1	15	11	12	**13**				NA	grey sand - moist
MMRP64-SB004D-1012	DPT	10-12	5/14/2009	1155			0	NA	NA	NA	**0**				NA	grey/orange wet sand (water-11'6")
MMRP64-SB005D-0002	DPT	0-2	5/14/2009	1410		X	1	658	667	633	**653**				NA	brown soil/sand - dry
MMRP64-SS005D-0204	DPT	2-4	5/14/2009	1410		X	1	408	165	170	**248**				NA	brown to tan sand - damp
MMRP64-SB005D-0406	DPT	4-6	5/14/2009	1410		X	1	27	39	55	**40**				NA	brown to tan sand - damp
MMRP64-SB005D-0608	DPT	6-8	5/14/2009	1410			0	NA	NA	NA	**0**				NA	grey to tan sand - damp
MMRP64-SB005D-0810	DPT	8-10	5/14/2009	1410		X	1	21	27	30	**26**				NA	grey to tan clayey sand - moist
MMRP64-SB005D-1012	DPT	10-12	5/14/2009	1410			0	NA	NA	NA	**0**				NA	orange/grey molted clayey sand-wet
MMRP64-SB006D-0002	DPT	0-2	5/14/2009	1450		X	1	ND	8	14	**7**				NA	brown soil/sand - damp
MMRP64-SS006D-0204	DPT	2-4	5/14/2009	1450		X	1	ND	ND	ND	**0**				NA	brown to tan sand - damp
MMRP64-SB006D-0406	DPT	4-6	5/14/2009	1450		X	1	ND	9	ND	**3**				NA	tan to orange sand - moist
MMRP64-SB006D-0608	DPT	6-8	5/14/2009	1450		X	1	ND	ND	9	**3**				NA	orange to tan sand - wet

REMARKS: Shading indicates exceedence of field decision criteria (33 mg/kg).
DPT = Direct-push technology

FD05140901 = MMRP64-SB005D-0002

LABORATORY: Mitkem Laboratories

COC No.:
0197, 0199, and Mitkem supplied COC

MULTIPLE SAMPLE LOG SHEET

Tetra Tech NUS, Inc.

[ ] SURFACE SOIL [ ] SEDIMENT
[X] SUBSURFACE SOIL [ ] LAGOON / POND
[] OTHER _____

SIGNATURE(S): _____

SAMPLER (S): _James Goerdt / James Coffman

PROJECT NAME: **MCB Camp Lejeune - D-6, Small Arms Range**
PROTECT NUMBER: **112G01716 CTO: 163**

LOCATION: **MCB Camp Lejeune**

SAMPLE No.	SAMPLE METHOD	DEPTH (Ft.)	DATE	TIME	CONCENTRATION (L)LOW (H)HIGH	(G) GRAB (C) COMPOSITE	TOTAL No. OF CONTAINERS	ANALYSES: XRF 1	XFR 2	XRF 3	AVG XRF		Metals	USCS	PID READING	SOIL DESCRIPTION
MMRP64-SB007D-0002	DPT	0-2	5/14/2009	1055		X	1	9484	13879	9291	**10885**				NA	brown sand soil - damp
MMRP64-SS007D-0204	DPT	2-4	5/14/2009	1055		X	1	931	845	602	**793**				NA	brown to tan sandy soil - damp
MMRP64-SB007D-0406	DPT	4-6	5/14/2009	1055		X	1	98	86	100	**95**				NA	orange/tan molted sand - moist
MMRP64-SB007D-0608	DPT	6-8	5/14/2009	1055		X	1	ND	ND	ND	**0**				NA	tan with some orange - wet (water at 8')
MMRP64-SB009D-0002	DPT	0-2	5/14/2009	1430		X	1	976	883	983	**947**				NA	brown sand soil - slightly damp
MMRP64-SS009D-0204	DPT	2-4	5/14/2009	1430		X	1	ND	10	13	**8**				NA	orange/grey sand - damp
MMRP64-SB009D-0406	DPT	4-6	5/14/2009	1430		X	1	ND	11	10	**7**				NA	orange/grey sand - damp
MMRP64-SB009D-0608	DPT	6-8	5/14/2009	1430			0	NA	NA	NA	NA				NA	grey/tan sand - damp
MMRP64-SB009D-0810	DPT	8-10	5/14/2009	1430		X	1	29	51	37	**39**				NA	grey clayey sand - moist
MMRP64-SB009D-1012	DPT	10-12	5/14/2009	1430			0	NA	NA	NA	NA				NA	orange/grey clayey sand - wet
MMRP64-SB010D-0002	DPT	0-2	5/14/2009	1130		X	1	113	169	136	**139**				NA	black/brown soil and sand - damp
MMRP64-SS010D-0204	DPT	2-4	5/14/2009	1130		X	1	ND	8	9	**6**				NA	brown/tan sand - damp
MMRP64-SB010D-0406	DPT	4-6	5/14/2009	1130		X	1	8	8	ND	**5**				NA	orange/tan molted sand - damp
MMRP64-SB010D-0608	DPT	6-8	5/14/2009	1130		X	1	ND	8	ND	**3**				NA	tan sand - wet (water at 7')

REMARKS: Shading indicates exceedence of field decision criteria (33 mg/kg).
DPT = Direct-push technology

LABORATORY: Mitkem Laboratories

COC No.:
0197, 0199, and Mitkem supplied COC

MULTIPLE SAMPLE LOG SHEET

Tetra Tech NUS, Inc.

[ ] SURFACE SOIL [ ] SEDIMENT
[X] SUBSURFACE SOIL [ ] LAGOON / POND
[] OTHER _____

SIGNATURE(S): _____

SAMPLER (S): _James Goerdt / James Coffman

PROJECT NAME: **MCB Camp Lejeune - D-6, Small Arms Range**
PROTECT NUMBER: **112G01716 CTO: 163**

LOCATION: **MCB Camp Lejeune**

								ANALYSES								
SAMPLE No.	SAMPLE METHOD	DEPTH (Ft.)	DATE	TIME	CONCENTRATION (L)OW (H)IGH	(G) GRAB (C) COMPOSITE	TOTAL No. OF CONTAINERS	XRF 1	XFR 2	XRF 3	AVG XRF		Metals	USCS	PID READING	SOIL DESCRIPTION
MMRP64-SB011D-0002	DPT	0-2	5/14/2009	1350		X	1	22	26	19	**22**				NA	gravel/sand mix - dry
MMRP64-SS011D-0204	DPT	2-4	5/14/2009	1350		X	1	ND	ND	ND	**0**				NA	orange to tan sand - damp
MMRP64-SB011D-0406	DPT	4-6	5/14/2009	1350		X	1	9	14	13	**12**				NA	orange sand - damp
MMRP64-SB011D-0608	DPT	6-8	5/14/2009	1350			0	NA	NA	NA	NA				NA	grey sand - damp
MMRP64-SB011D-0810	DPT	8-10	5/14/2009	1350		X	1	16	28	23	**22**				NA	grey sand - moist
MMRP64-SB011D-1012	DPT	10-12	5/14/2009	1350			0	NA	NA	NA	NA				NA	grey to orange sand - wet
MMRP64-SB012D-0002	DPT	0-2	5/14/2009	1000		X	1	12	13	16	**14**				NA	soil/clayey sand - damp
MMRP64-SS012D-0204	DPT	2-4	5/14/2009	1000		X	1	ND	ND	ND	**0**				NA	tan sand - damp
MMRP64-SB012D-0406	DPT	4-6	5/14/2009	1000		X	1	9	11	12	**11**				NA	orange/tan sand - damp
MMRP64-SB012D-0608	DPT	6-8	5/14/2009	1000			0	NA	NA	NA	NA				NA	orange/tan clayey sand - damp
MMRP64-SB012D-0810	DPT	8-10	5/14/2009	1000			0	NA	NA	NA	NA				NA	orange/tan/black clayey sand - damp
MMRP64-SB012D-1012	DPT	10-12	5/14/2009	1000			0	NA	NA	NA	NA				NA	grey sand - moist
MMRP64-SB012D-1214	DPT	12-14	5/14/2009	1000		X	1	18	13	20	**17**				NA	grey sand - moist
MMRP64-SB012D-1416	DPT	14-16	5/14/2009	1000			0	NA	NA	NA	NA				NA	orange/grey sand - wet

REMARKS: Shading indicates exceedence of field decision criteria (33 mg/kg).
DPT = Direct-push technology

LABORATORY: Mitkem Laboratories

COC No.:
0197, 0199, and Mitkem supplied COC

MULTIPLE SAMPLE LOG SHEET

Tetra Tech NUS, Inc.

[ ] SURFACE SOIL [ ] SEDIMENT
[X] SUBSURFACE SOIL [ ] LAGOON / POND
[] OTHER _____

SIGNATURE(S): _____

SAMPLER (S): _James Goerdt / James Coffman

PROJECT NAME: **MCB Camp Lejeune - D-6, Small Arms Range**
PROTECT NUMBER: **112G01716 CTO: 163**

LOCATION: **MCB Camp Lejeune**

								ANALYSES								
SAMPLE No.	SAMPLE METHOD	DEPTH (Ft.)	DATE	TIME	CONCENTRATION (L)LOW (H)HIGH	(G) GRAB (C) COMPOSITE	TOTAL No. OF CONTAINERS	XRF 1	XFR 2	XRF 3	AVG XRF		Metals	USCS	PID READING	SOIL DESCRIPTION
MMRP64-SB019D-0002	DPT	0-2	5/14/2009	0835		X	1	ND	ND	ND	**0**				NA	soil (0-3") sand - dry
MMRP64-SS019D-0204	DPT	2-4	5/14/2009	0835		X	1	ND	ND	ND	**0**				NA	tan sand - wet
MMRP64-SB019D-0406	DPT	4-6	5/14/2009	0835		X	1	ND	15	14	**10**				NA	clayey sand - damp
MMRP64-SB019D-0608	DPT	6-8	5/14/2009	0835			0	NA	NA	NA	NA				NA	orange to tan sand - moist
MMRP64-SB019D-0810	DPT	8-10	5/14/2009	0835			0	NA	NA	NA	NA				NA	orange to tan sand - moist
MMRP64-SB019D-1012	DPT	10-12	5/14/2009	0835			0	NA	NA	NA	NA				NA	orange to tan sand - moist
MMRP64-SB019D-1214	DPT	12-14	5/14/2009	0835		X	1	20	16	9	**15**				NA	grey to orange sand - wet

REMARKS: Shading indicates exceedence of field decision criteria (33 mg/kg).
DPT = Direct-push technology

LABORATORY: Mitkem Laboratories

COC No.:
0197, 0199, and Mitkem supplied COC

MULTIPLE SAMPLE LOG SHEET

Tetra Tech NUS, Inc.

[X] SURFACE SOIL [ ] SEDIMENT
[ ] SUBSURFACE SOIL [ ] LAGOON / POND
[] OTHER _____

SIGNATURE(S): _____

SAMPLER (S): _James Goerdt / James Coffman

PROJECT NAME: **MCB Camp Lejeune - D-6, Small Arms Range**
PROTECT NUMBER: **112G01716 CTO: 163**

LOCATION: **MCB Camp Lejeune**

								ANALYSES							
SAMPLE No.	SAMPLE METHOD	DEPTH (Ft.)	DATE	TIME	CONCENTRATION (L)LOW (H)HIGH	(G) GRAB (C) COMPOSITE	TOTAL No. OF CONTAINERS	XRF 1	XFR 2	XRF 3	AVG XRF		Metals (FBL)	PID READING	SOIL DESCRIPTION
MMRP64-SS001-D-0001	HA	0.5	5/13/2009	930		X	1	105	86	75	88.7			NA	Molted Grey/Brown Fine Sand
MMRP64-SS002-D-0001	HA	0.5	5/13/2009	936		X	1	11	8	ND	6.33			NA	Molted Grey/Brown Fine Sand
MMRP64-SS003-D-0001	HA	0.5	5/13/2009	942		X	1	12	14	10	12			NA	Molted Grey/Brown Fine Sand
MMRP64-SS004-D-0001	HA	0.5	5/13/2009	947		X	1	380	442	551	458			NA	Molted Grey/Brown Fine Sand
MMRP64-SS004-C-0001	HA	0.5	5/13/2009	1552		X	1	727	814	709	750		X	NA	Molted Grey/Brown Fine Sand
MMRP64-SS005-D-0001	HA	0.5	5/13/2009	1013		X	1	382	331	355	356			NA	Molted Grey/Brown Fine Sand
MMRP64-SS005-C-0001	HA	0.5	5/13/2009	1541		X	1	758	969	841	856		X	NA	Molted Grey/Brown Fine Sand
MMRP64-SS006-D-0001	HA	0.5	5/13/2009	1017		X	1	1283	1387	1677	1449			NA	Molted Grey/Brown Fine Sand
MMRP64-SS006-C-0001	HA	0.5	5/13/2009	1515		X	1	376	351	535	421		X	NA	Molted Grey/Brown Fine Sand
MMRP64-SS007-D-0001	HA	0.5	5/13/2009	1038		X	1	3723	2722	3043	3163			NA	Molted Grey/Brown Fine Sand
MMRP64-SS007-C-0001	HA	0.5	5/13/2009	1520		X	1	8015	7428	9449	8297		X	NA	Molted Grey/Brown Fine Sand
MMRP64-SS008-D-0001	HA	0.5	5/13/2009	1032		X	1	21	14	23	19.3			NA	Molted Grey/Brown Fine Sand
MMRP64-SS009-D-0001	HA	0.5	5/13/2009	1020		X	1	596	601	692	630			NA	Sand/Gravel
MMRP64-SS009-C-0001	HA	0.5	5/13/2009	1506		X	1	550	392	474	472		X	NA	Sand/Gravel
MMRP64-SS010-D-0001	HA	0.5	5/13/2009	1044		X	1	3860	6483	8441	6261			NA	Molted Grey/Brown Fine Sand
MMRP64-SS010-C-0001	HA	0.5	5/13/2009	1525		X	1	5822	3158	3446	4142		X	NA	Molted Grey/Brown Fine Sand
MMRP64-SS011-D-0001	HA	0.5	5/13/2009	951		X	1	379	396	388	388			NA	Sand/Gravel
MMRP64-SS011-C-0001	HA	0.5	5/13/2009	1550		X	1	485	426	433	448		X	NA	Sand/Gravel
MMRP64-SS012-D-0001	HA	0.5	5/13/2009	1010		X	1	19	17	22	19.3			NA	Molted Grey/Brown Fine Sand
MMRP64-SS012-C-0001	HA	0.5	5/13/2009	1533		X	1	21	30	27	26		X	NA	Molted Grey/Brown Fine Sand

REMARKS: Shading indicates exceedence of decision criteria (300 mg/kg).
HA = Hand Auger PT = Plastic trowel

LABORATORY: Mitkem

COC No.: 0197

MULTIPLE SAMPLE LOG SHEET

Tetra Tech NUS, Inc.

[X] SURFACE SOIL [ ] SEDIMENT
[ ] SUBSURFACE SOIL [ ] LAGOON / POND
[] OTHER _____

SIGNATURE(S): _____

SAMPLER (S): _James Goerdt / James Coffman

PROJECT NAME: **MCB Camp Lejeune - D-6, Small Arms Range**
PROTECT NUMBER: **112G01716 CTO: 163**

LOCATION: **MCB Camp Lejeune**

								ANALYSES							
SAMPLE No.	SAMPLE METHOD	DEPTH (Ft.)	DATE	TIME	CONCENTRATION (L)OW (H)IGH	(G) GRAB (C) COMPOSITE	TOTAL No. OF CONTAINERS	XRF 1	XFR 2	XRF 3	AVG XRF		Metals (FBL)	PID READING	SOIL DESCRIPTION
MMRP64-SS013-D-0001	HA	0.5	5/13/2009	1000		X	1	14	19	15	16				Molted Grey/Brown Fine Sand
MMRP64-SS014-D-0001	HA	0.5	5/13/2009	955		X	1	34	27	27	29.3				Sand/Gravel
MMRP64-SS015-D-0001	HA	0.5	5/13/2009	1005		X	1	26	25	24	25				Molted Grey/Brown Fine Sand
MMRP64-SS016-D-0001	HA	0.5	5/13/2009	1024		X	1	9	13	13	11.7			NA	Molted Grey/Brown Fine Sand
MMRP64-SS017-D-0001	HA	0.5	5/13/2009	1048		X	1	26	14	16	18.7			NA	Molted Grey/Brown Fine Sand
MMRP64-SS018-D-0001	HA	0.5	5/13/2009	1026		X	1	31	30	35	32			NA	Molted Grey/Brown Fine Sand
MMRP64-SS019-D-0001	HA	0.5	5/13/2009	1035		X	1	ND	13	8	7			NA	Molted Grey/Brown Fine Sand
MMRP64-SS019-C-0001	HA	0.5	5/13/2009	1453		X	1	70	77	75	74		X	NA	Molted Grey/Brown Fine Sand
MMRP64-SS020-D-0001	HA	0.5	5/13/2009	1055		X	1	27	24	28	26.3			NA	Molted Grey/Brown Fine Sand
MMRP64-SS021-D-0001	PT	0.5	5/14/2009	1310		X	1	NA	NA	NA	NA		X	NA	Black Soil
MMRP64-SS022-D-0001	PT	0.5	5/14/2009	1315		X	1	NA	NA	NA	NA		X	NA	Black Soil
MMRP64-SS023-D-0001	PT	0.5	5/14/2009	1320		X	1	NA	NA	NA	NA		X	NA	Black Soil

REMARKS: Shading indicates exceedence of decision criteria (300 mg/kg).
HA = Hand Auger PT = Plastic trowel

LABORATORY: Mitkem

COC No.: 0197

Tetra Tech NUS, Inc.

EQUIPMENT CALIBRATION LOG

PROJECT NAME : MCB Camp Lejeune

INSTRUMENT NAME/MODEL: Turbidimeter / 2020

SITE NAME: D-6, 50-Foot Indoor Rifle Range and Pistol Range

MANUFACTURER: LaMotte

PROJECT No.: 112G01716 CTO 163

SERIAL NUMBER:

Date of Calibration	Instrument I.D. Number	Person Performing Calibration	Instrument Settings		Instrument Readings		Calibration Standard (Lot No.)	Remarks and Comments
			Pre-calibration "0"	Post-calibration "0"	Pre-calibration "10"	Post-calibration "10"		
5/14/2009	001	J. Goerdt	0	0	13.9	9.92		
5/15/2009	001	J. Goerdt	0	0	11.5	9.98		

Tetra Tech NUS, Inc.

EQUIPMENT CALIBRATION LOG

PROJECT NAME : MCB Camp Lejeune

INSTRUMENT NAME/MODEL: Horiba U22 Water Quality Meter

SITE NAME: D-6, 50-Foot Indoor Rifle Range and Pistol Range

MANUFACTURER: Horiba

PROJECT No.: 112G01716 CTO 163

SERIAL NUMBER:

Date of Calibration	Instrument I.D. Number	Person Performing Calibration	Calibration										Remarks and Comments
			pH		Cond ms/sec		DO %		Temp C		ORP mV		
			pre	post	pre	post	pre	post	pre	post	pre	post	
5/14/2009	001	J. Goerdt	3.92	4.00	4.66	4.49	9.07	8.79	22.59	22.59	271	273	
5/15/2009	001	J. Goerdt	4.03	4.00	4.26	4.40	8.69	8.81	21.28	21.85	268	275	

APPENDIX C

SITE PHOTOS

Marine Corps Base Camp Lejeune

SITE: D-6, 50-foot Indoor Rifle and Pistol Range (UXO 1)	**PHOTOGRAPHER:** J. Goerdt **VIEW:** Northwest	**DESCRIPTION:** General view of the site looking northwest from I Street. Sample location SB018 right center.	1 5/14/09

SITE: D-6, 50-foot Indoor Rifle and Pistol Range (UXO 1)	**PHOTOGRAPHER:** J. Goerdt **VIEW:** Northwest	**DESCRIPTION:** General view of the site looking northwest from I Street. Sample location SB019 front center.	2 5/14/09

Marine Corps Base Camp Lejeune

SITE: D-6, 50-foot Indoor Rifle and Pistol Range (UXO 1)	**PHOTOGRAPHER:** J. Goerdt **VIEW:** Northwest	**DESCRIPTION:** View of the gravel area looking northwest from I Street. Sample location SB013 left corner.	3 5/14/09

SITE: D-6, 50-foot Indoor Rifle and Pistol Range (UXO 1)	**PHOTOGRAPHER:** J. Goerdt **VIEW:** Northwest	**DESCRIPTION:** General view of the site looking northwest from I Street. Sample location SB004 in upper left.	4 5/14/09

SITE: D-6, 50-foot Indoor Rifle and Pistol Range (UXO 1)	**PHOTOGRAPHER:** J. Goerdt **VIEW:** Northeast	**DESCRIPTION:** Photo showing typical height of undergrowth at the site. View is to the northeast.	5 5/14/09

SITE: D-6, 50-foot Indoor Rifle and Pistol Range (UXO 1)	**PHOTOGRAPHER:** J. Goerdt **VIEW:** Northeast	**DESCRIPTION:** Sample location SB009 on edge of tree line. View is to the northeast.	6 5/14/09

SITE: D-6, 50-foot Indoor Rifle and Pistol Range (UXO 1)	**PHOTOGRAPHER:** J. Goerdt **VIEW:** Northeast	**DESCRIPTION:** Clearing of understory. Looking to the northeast towards SB010.	7 5/14/09

SITE: D-6, 50-foot Indoor Rifle and Pistol Range (UXO 1)	**PHOTOGRAPHER:** J. Goerdt **VIEW:** North	**DESCRIPTION:** Sampling at SB007. View is to the north.	8 5/14/09

Marine Corps Base Camp Lejeune

SITE: D-6, 50-foot Indoor Rifle and Pistol Range (UXO 1)	**PHOTOGRAPHER:** J. Goerdt **VIEW:** Northeast	**DESCRIPTION:** DPT rig at SB009. View is to the northeast.	9 5/14/09

SITE: D-6, 50-foot Indoor Rifle and Pistol Range (UXO 1)	**PHOTOGRAPHER:** J. Goerdt	**DESCRIPTION:** Typical view of DPT core showing visible wetness in sand.	10 5/14/09

APPENDIX D

ANALYTICAL RESULTS AND STATISTICAL EVALUATION

Figure 1 is a scatterplot of the Average XRF Lead results and the Laboratory lead results for each sample. From the scatterplot, a linear trend is evident, however there are three samples that are much larger than the remaining data that may be influencing the linear trend.

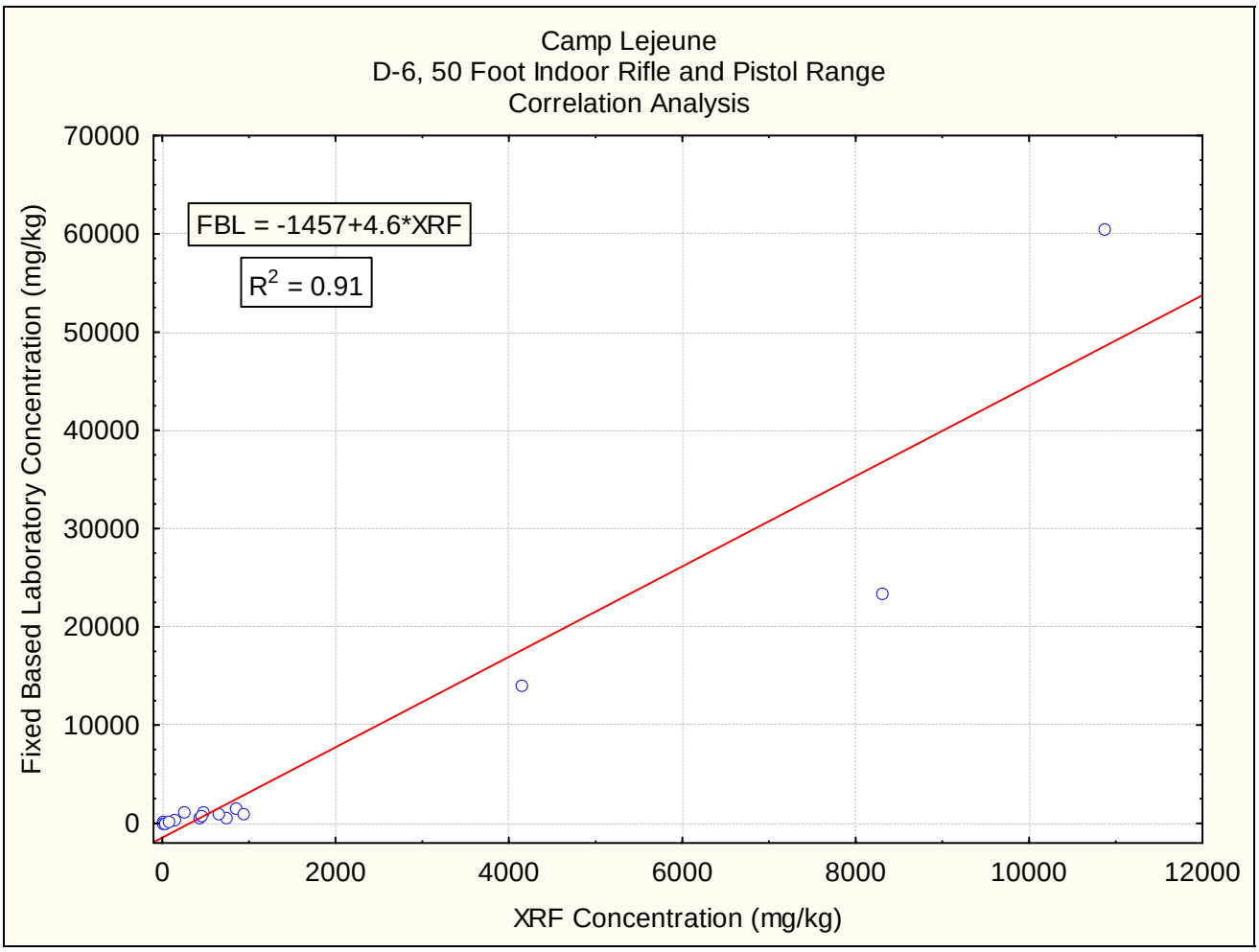


Figure 1

To determine how much the three samples influence the linear trend the data was broken into two groups based on the action level of 270 mg/kg for lead. Figure 2 is a scatterplot of all the samples where the XRF concentration is less than 270mg/kg. From this figure a positive linear trend is also apparent. Again one concentration is separated from the rest of the samples but this is most likely due to the small sample size. The regression equation used to predict laboratory concentrations from XRF concentrations and the R squared value also appear on Figure2.

The correlation between the fixed based laboratory concentrations and the XRF is 0.94. The correlation always falls between -1 and 1. Values of r near 0 indicate a very weak linear relationship. The strength of the linear relationship increases as r moves away from 0 toward either -1 or 1. Values of r close to -1 and 1 indicate that the points lie close to a straight line. The extreme values -1 and 1 occur only in the case of a perfect linear relationship. So the correlation indicates a strong linear trend. The R-squared value is 88 percent. This value represents the percent of variation in laboratory lead concentrations that can be explained by the

lead XRF concentration. An R-Squared value greater than about 80 percent is considered to indicate a very strong relationship between the two measurement methods. The maximum possible value is 100 percent. Note that XRF concentrations below 89.87 will predict negative fixed based laboratory concentrations. This is not problematic because the predicted concentrations are less than the action level and is most likely due to the lack of samples between the maximum concentration of 260 mg/kg and the rest of the data.

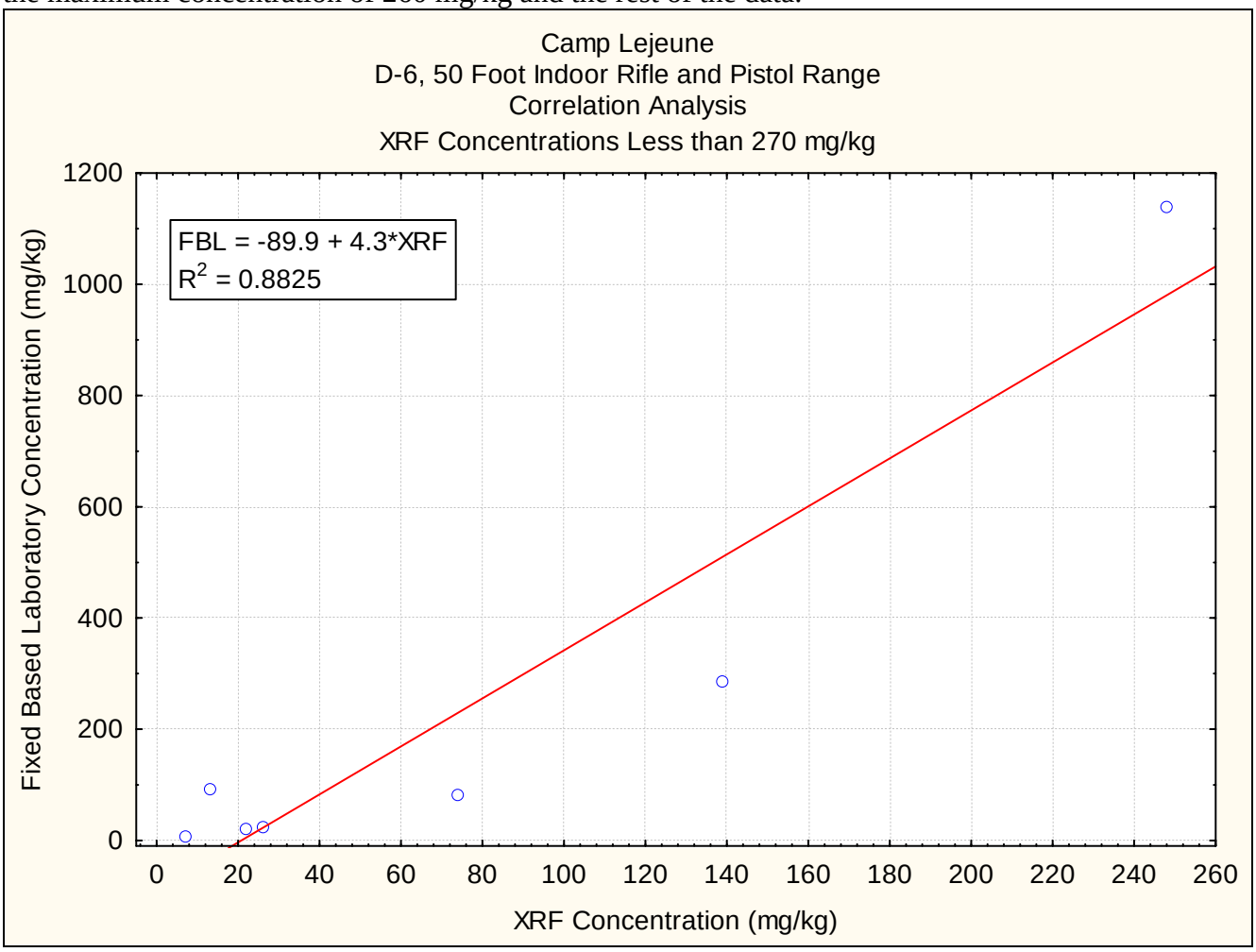


Figure 2

Figure 3 is a scatterplot of all the samples where the XRF concentration is greater than 270 mg/kg. From this figure a positive linear trend is also apparent. Again the three extreme concentrations pointed out in Figure 1 can be seen. In this case the influential points are not as big of a problem because the XRF and Laboratory results are predicting the concentrations to be greater than the action level. The regression equation used to predict laboratory concentrations from XRF concentrations and the R squared value also appear on Figure3. The correlation between the fixed based laboratory concentrations and the XRF is 0.95. The correlation always falls between -1 and 1. Values of r near 0 indicate a very weak linear relationship. The strength of the linear relationship increases as r moves away from 0 toward either -1 or 1. Values of r close to -1 and 1 indicate that the points lie close to a straight line. So the correlation indicates a

strong linear trend. The R-squared value is 90 percent. This value represents the percent of variation in laboratory lead concentrations that can be explained by the lead XRF concentration. An R-Squared value greater than about 80 percent is considered to indicate a very strong relationship between the two measurement methods. The maximum possible value is 100 percent. Note that XRF concentrations less than 614mg/kg will predict fixed based laboratory concentrations less than 0. In this situation the XRF concentration is above the action level so it is not too problematic.

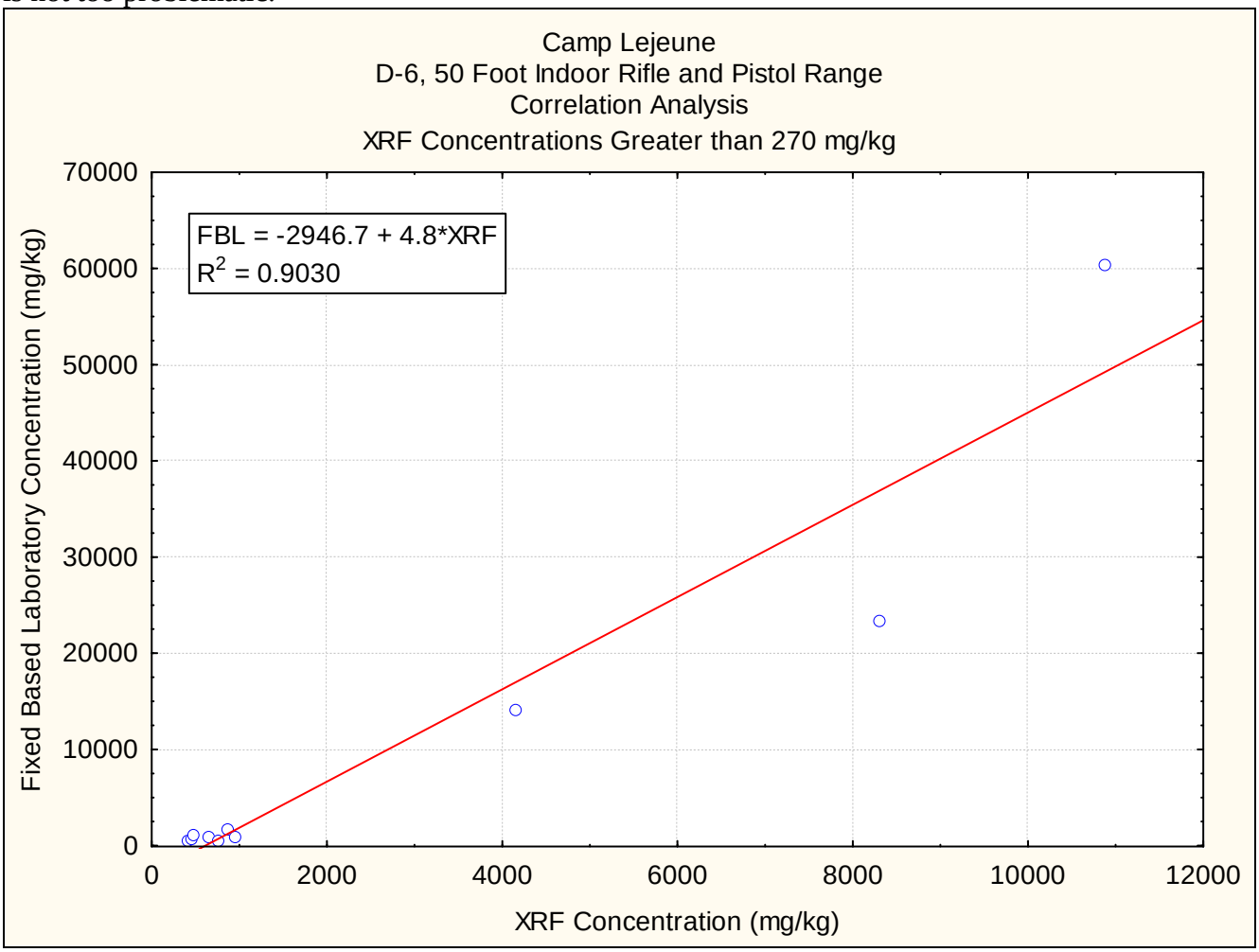


Figure 3

Predicted Laboratory Values
D-6 Small Arms Range
MCB Camp Lejeune
Onslow County, North Carolina
1 of 2

SAMPLE DATE	SAMPLE LOCATION	SAMPLE ID	XRF	FBL	Predicted Lab Value
5/14/2009	MMRP64-SB021	MMRP64-SS021-0001	NA	107	NA
5/14/2009	MMRP64-SB022	MMRP64-SS022-0001	NA	72.9	NA
5/14/2009	MMRP64-SB023	MMRP64-SS023-0001	NA	139	NA
5/14/2009	MMRP64-SB007	MMRP64-SB007D-0002	10884.67	60400	49299.7
5/13/2009	MMRP64-SB007	MMRP64-SS007C-0001	8297.333	23400	36880.5
5/13/2009	MMRP64-SB010	MMRP64-SS010D-0001	6261.333	---	27107.7
5/13/2009	MMRP64-SB010	MMRP64-SS010C-0001	4142	14100	16934.9
5/13/2009	MMRP64-SB007	MMRP64-SS007D-0001	3162.667	---	12234.1
5/13/2009	MMRP64-SB006	MMRP64-SS006D-0001	1449	---	4008.5
5/14/2009	MMRP64-SB009	MMRP64-SB009D-0002	947.3333	941	1600.5
5/13/2009	MMRP64-SB005	MMRP64-SS005C-0001	856	1590	1162.1
5/14/2009	MMRP64-SB007	MMRP64-SB007D-0204	792.6667	---	858.1
5/13/2009	MMRP64-SB004	MMRP64-SS004C-0001	750	591	653.3
5/14/2009	MMRP64-SB005	MMRP64-SB005D-0002	652.6667	904	186.1
5/13/2009	MMRP64-SB009	MMRP64-SS009D-0001	629.6667	---	75.7
5/13/2009	MMRP64-SB009	MMRP64-SS009C-0001	472	1160	0
5/13/2009	MMRP64-SB004	MMRP64-SS004D-0001	457.6667	---	0
5/13/2009	MMRP64-SB011	MMRP64-SS011C-0001	448	634	0
5/13/2009	MMRP64-SB006	MMRP64-SS006C-0001	420.6667	529	0
5/13/2009	MMRP64-SB011	MMRP64-SS011D-0001	387.6667	---	0
5/13/2009	MMRP64-SB005	MMRP64-SS005D-0001	356	---	0
5/14/2009	MMRP64-SB005	MMRP64-SB005D-0204	247.6667	1140	975.0666667
5/14/2009	MMRP64-SB010	MMRP64-SB010D-0002	139.3333	286	509.2333333
5/14/2009	MMRP64-SB007	MMRP64-SB007D-0406	94.66667	---	317.1666667
5/13/2009	MMRP64-SB001	MMRP64-SS001D-0001	88.66667	---	291.3666667
5/13/2009	MMRP64-SB019	MMRP64-SS019C-0001	74	81.1	228.3
5/14/2009	MMRP64-SB005	MMRP64-SB005D-0406	40.33333	---	83.53333333
5/14/2009	MMRP64-SB009	MMRP64-SB009D-0810	39	---	77.8
5/13/2009	MMRP64-SB018	MMRP64-SS018D-0001	32	---	47.7
5/13/2009	MMRP64-SB014	MMRP64-SS014D-0001	29.33333	---	36.23333333
5/14/2009	MMRP64-SB020	MMRP64-SS020D-0001	26.33333	---	23.33333333
5/14/2009	MMRP64-SB005	MMRP64-SB005D-0810	26	---	21.9
5/13/2009	MMRP64-SB012	MMRP64-SS012C-0001	26	25.6	21.9
5/13/2009	MMRP64-SB015	MMRP64-SS015D-0001	25	---	17.6
5/14/2009	MMRP64-SB011	MMRP64-SB011D-0002	22.33333	22.3	6.133333333
5/14/2009	MMRP64-SB011	MMRP64-SB011D-0810	22.33333	---	6.133333333
5/13/2009	MMRP64-SB008	MMRP64-SS008D-0001	19.33333	---	0
5/13/2009	MMRP64-SB012	MMRP64-SS012D-0001	19.33333	---	0
5/13/2009	MMRP64-SB017	MMRP64-SS0171D-0001	18.66667	---	0
5/14/2009	MMRP64-SB012	MMRP64-SB012D-1214	17	---	0
5/13/2009	MMRP64-SB013	MMRP64-SS013D-0001	16	---	0
5/14/2009	MMRP64-SB019	MMRP64-SB019D-1113	15	---	0
5/14/2009	MMRP64-SB012	MMRP64-SB012D-0002	13.66667	---	0
5/14/2009	MMRP64-SB004	MMRP64-SB004D-0810	12.66667	92.2	0

Predicted Laboratory Values
D-6 Small Arms Range
MCB Camp Lejeune
Onslow County, North Carolina
2 of 2

SAMPLE DATE	SAMPLE LOCATION	SAMPLE ID	XRF	FBL	Predicted Lab Value
5/13/2009	MMRP64-SB003	MMRP64-SS003D-0001	12	---	0
5/14/2009	MMRP64-SB004	MMRP64-SB004D-0406	12	---	0
5/14/2009	MMRP64-SB011	MMRP64-SB011D-0406	12	---	0
5/13/2009	MMRP64-SB016	MMRP64-SS016D-0001	11.66667	---	0
5/14/2009	MMRP64-SB012	MMRP64-SB012D-0406	10.66667	---	0
5/14/2009	MMRP64-SB019	MMRP64-SB019D-0406	9.666667	---	0
5/14/2009	MMRP64-SB009	MMRP64-SB009D-0204	7.666667	---	0
5/14/2009	MMRP64-SB006	MMRP64-SB006D-0002	7.333333	---	0
5/14/2009	MMRP64-SB009	MMRP64-SB009D-0406	7	6.9	0
5/13/2009	MMRP64-SB019	MMRP64-SS019D-0001	7	---	0
5/13/2009	MMRP64-SB002	MMRP64-SS002D-0001	6.333333	---	0
5/14/2009	MMRP64-SB010	MMRP64-SB010D-0204	5.666667	---	0
5/14/2009	MMRP64-SB010	MMRP64-SB010D-0406	5.333333	---	0
5/14/2009	MMRP64-SB006	MMRP64-SB006D-0406	3	---	0
5/14/2009	MMRP64-SB006	MMRP64-SB006D-0608	3	---	0
5/14/2009	MMRP64-SB010	MMRP64-SB010D-0607	2.666667	---	0
5/14/2009	MMRP64-SB004	MMRP64-SB004D-0002	0	---	0
5/14/2009	MMRP64-SB004	MMRP64-SB004D-0204	0	---	0
5/14/2009	MMRP64-SB006	MMRP64-SB006D-0204	0	---	0
5/14/2009	MMRP64-SB007	MMRP64-SB007D-0608	0	---	0
5/14/2009	MMRP64-SB011	MMRP64-SB011D-0204	0	---	0
5/14/2009	MMRP64-SB012	MMRP64-SB012D-0204	0	---	0
5/14/2009	MMRP64-SB019	MMRP64-SB019D-0002	0	---	0
5/14/2009	MMRP64-SB019	MMRP64-SB019D-0204	0	---	0

SURFACE SOIL SAMPLES
FIXED-BASE LABORATORY RESULTS AND XRF FIELD PARAMETERS
D-6, SMALL ARMS RANGE
MCB CAMP LEJEUNE
ONSLOW COUNTY, NORTH CAROLINA
Page 1

nsample		**MMRP64-SS001D-0001**	**MMRP64-SS002D-0001**	**MMRP64-SS003D-0001**	**MMRP64-SB004D-0002**	**MMRP64-SS004C-0001**	**MMRP64-SS004D-0001**	**MMRP64-SB005D-0002**
location		MMRP64-SO001	MMRP64-SO002	MMRP64-SO003	MMRP64-SO004	MMRP64-SO004	MMRP64-SO004	MMRP64-SO005
sample_dat		20090513	20090513	20090513	20090514	20090513	20090513	20090514
sample_tim		00:00:00	00:00:00	00:00:00	00:00:00	15:52:00	00:00:00	14:10:00
field_poc		GOERDT,J	GOERDT,J	GOERDT,J	GOERDT,J	GOERDT,J	GOERDT,J	GOERDT,J
sample_typ		NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL
qc_type		NM	NM	NM	NM	NM	NM	NM
sacode		NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	ORIG
matrix		SO	SO	SO	SO	SO	SO	SO
duplicate								
top_depth		0	0	0	0	0	0	0
bottom_dep		1	1	1	2	1	1	2
depth_unit		FT	FT	FT	FT	FT	FT	FT
submatrix	**PALs**	SS	SS	SS	SS	SS	SS	SS
Inorganics (mg/kg)								
ANTIMONY	5.42					3.2		2.4 J
ARSENIC	26.2					1.1		0.57
COPPER	704					2.6		2.4
LEAD	270					**591**		**904 J**
NICKEL	56.4					3.3		0.96
TIN	47000					1.4 U		1 U
ZINC	550					17.2		25.5 J
XRF Field Parameters (mg/kg)								
LEAD	270	89	6	12	0	**750**	**458**	**653**

SURFACE SOIL SAMPLES
FIXED-BASE LABORATORY RESULTS AND XRF FIELD PARAMETERS
D-6, SMALL ARMS RANGE
MCB CAMP LEJEUNE
ONSLOW COUNTY, NORTH CAROLINA
Page 2

nsample		**MMRP64-SB005D-0002-AV**	**MMRP64-SB005D-0002-D**	**MMRP64-SS005C-0001**	**MMRP64-SS005D-0001**	**MMRP64-SB006D-0002**	**MMRP64-SS006C-0001**	**MMRP64-SS006D-0001**
location		MMRP64-SO005	MMRP64-SO005	MMRP64-SO005	MMRP64-SO005	MMRP64-SO006	MMRP64-SO006	MMRP64-SO006
sample_dat		20090514	20090514	20090513	20090513	20090514	20090513	20090513
sample_tim		14:10:00	00:00:00	15:41:00	00:00:00	00:00:00	15:15:00	00:00:00
field_poc		GOERDT,J	GOERDT,J	GOERDT,J	GOERDT,J	GOERDT,J	GOERDT,J	GOERDT,J
sample_typ		NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL
qc_type		NM	FD	NM	NM	NM	NM	NM
sacode		AVG	DUP	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL
matrix		SO	SO	SO	SO	SO	SO	SO
duplicate			MMRP64-SB005D 0002					
top_depth		0	0	0	0	0	0	0
bottom_dep		2	2	1	1	2	1	1
depth_unit		FT	FT	FT	FT	FT	FT	FT
submatrix	**PALs**	SS	SS	SS	SS	SS	SS	SS
Inorganics (mg/kg)								
ANTIMONY	5.42	**7.55 J**	**12.7 J**	3.6			1.8	
ARSENIC	26.2	0.64	0.71	0.5			0.71	
COPPER	704	4.2 J	6 J	4.2			10.3	
LEAD	270	**2472 J**	**4040 J**	**1590**			**529**	
NICKEL	56.4	1.08	1.2	1.2			1.2	
TIN	47000	1.15 U	1.3 U	1.1 U			1.5 U	
ZINC	550	58.65 J	91.8 J	73.8			16.6	
XRF Field Parameters (mg/kg)								
LEAD	270	**653**		**856**	**356**	7	**421**	**1449**

SURFACE SOIL SAMPLES
FIXED-BASE LABORATORY RESULTS AND XRF FIELD PARAMETERS
D-6, SMALL ARMS RANGE
MCB CAMP LEJEUNE
ONSLOW COUNTY, NORTH CAROLINA
Page 3

nsample		**MMRP64-SB007D-0002**	**MMRP64-SS007C-0001**	**MMRP64-SS007D-0001**	**MMRP64-SS008D-0001**	**MMRP64-SB009D-0002**	**MMRP64-SS009C-0001**	**MMRP64-SS009D-0001**
location		MMRP64-SO007	MMRP64-SO007	MMRP64-SO007	MMRP64-SO008	MMRP64-SO009	MMRP64-SO009	MMRP64-SO009
sample_dat		20090514	20090513	20090513	20090513	20090514	20090513	20090513
sample_tim		10:55:00	15:20:00	00:00:00	00:00:00	14:30:00	15:06:00	00:00:00
field_poc		GOERDT,J	GOERDT,J	GOERDT,J	GOERDT,J	GOERDT,J	GOERDT,J	GOERDT,J
sample_typ		NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL
qc_type		NM	NM	NM	NM	NM	NM	NM
sacode		NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL
matrix		SO	SO	SO	SO	SO	SO	SO
duplicate								
top_depth		0	0	0	0	0	0	0
bottom_dep		2	1	1	1	2	1	1
depth_unit		FT	FT	FT	FT	FT	FT	FT
submatrix	**PALs**	SS	SS	SS	SS	SS	SS	SS
Inorganics (mg/kg)								
ANTIMONY	5.42	**493**	**126**			5.3	3.2	
ARSENIC	26.2	4.9	2.3			2.3	0.67	
COPPER	704	25.5	10.3			5.3	5.4	
LEAD	270	**60400**	**23400**			**941**	**1160**	
NICKEL	56.4	0.78	1.1			1.4	1.4	
TIN	47000	23.2	11.5			0.93 U	1.1 U	
ZINC	550	19	17.7			36.1	46.6	
XRF Field Parameters (mg/kg)								
LEAD	270	**10885**	**8297**	**3163**	19	**947**	**472**	**630**

SURFACE SOIL SAMPLES
FIXED-BASE LABORATORY RESULTS AND XRF FIELD PARAMETERS
D-6, SMALL ARMS RANGE
MCB CAMP LEJEUNE
ONSLOW COUNTY, NORTH CAROLINA
Page 4

nsample		**MMRP64-SB010D-0002**	**MMRP64-SS010C-0001**	**MMRP64-SS010D-0001**	**MMRP64-SB011D-0002**	**MMRP64-SS011C-0001**	**MMRP64-SS011D-0001**	**MMRP64-SB012D-0002**
location		MMRP64-SO010	MMRP64-SO010	MMRP64-SO010	MMRP64-SO011	MMRP64-SO011	MMRP64-SO011	MMRP64-SO012
sample_dat		20090514	20090513	20090513	20090514	20090513	20090513	20090514
sample_tim		11:30:00	15:25:00	00:00:00	13:50:00	15:50:00	00:00:00	00:00:00
field_poc		GOERDT,J	GOERDT,J	GOERDT,J	GOERDT,J	GOERDT,J	GOERDT,J	GOERDT,J
sample_typ		NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL
qc_type		NM	NM	NM	NM	NM	NM	NM
sacode		NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL
matrix		SO	SO	SO	SO	SO	SO	SO
duplicate								
top_depth		0	0	0	0	0	0	0
bottom_dep		2	1	1	2	1	1	2
depth_unit		FT	FT	FT	FT	FT	FT	FT
submatrix	**PALs**	SS	SS	SS	SS	SS	SS	SS
Inorganics (mg/kg)								
ANTIMONY	5.42	2.4	**79.2**		0.16 U	2.7		
ARSENIC	26.2	0.55	1.6		0.83	2.2		
COPPER	704	1.7	7.2		0.62	2.7		
LEAD	270	**286**	**14100**		22.3	**634**		
NICKEL	56.4	0.57	1.2		0.9	6.1		
TIN	47000	1.1 U	5.2 U		1.5 U	1.1 U		
ZINC	550	43.1	22.2		3	19.3		
XRF Field Parameters (mg/kg)								
LEAD	270	139	**4142**	**6261**	22	**448**	**388**	14

SURFACE SOIL SAMPLES
FIXED-BASE LABORATORY RESULTS AND XRF FIELD PARAMETERS
D-6, SMALL ARMS RANGE
MCB CAMP LEJEUNE
ONSLOW COUNTY, NORTH CAROLINA
Page 5

nsample		**MMRP64-SS012C-0001**	**MMRP64-SS012D-0001**	**MMRP64-SS013D-0001**	**MMRP64-SS014D-0001**	**MMRP64-SS015D-0001**	**MMRP64-SS016D-0001**	**MMRP64-SS017D-0001**
location		MMRP64-SO012	MMRP64-SO012	MMRP64-SO013	MMRP64-SO014	MMRP64-SO015	MMRP64-SO016	MMRP64-SO017
sample_dat		20090513	20090513	20090513	20090513	20090513	20090513	20090513
sample_tim		15:33:00	00:00:00	00:00:00	00:00:00	00:00:00	00:00:00	00:00:00
field_poc		GOERDT,J	GOERDT,J	GOERDT,J	GOERDT,J	GOERDT,J	GOERDT,J	GOERDT,J
sample_typ		NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL
qc_type		NM	NM	NM	NM	NM	NM	NM
sacode		NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL
matrix		SO	SO	SO	SO	SO	SO	SO
duplicate								
top_depth		0	0	0	0	0	0	0
bottom_dep		1	1	1	1	1	1	1
depth_unit		FT	FT	FT	FT	FT	FT	FT
submatrix	**PALs**	SS	SS	SS	SS	SS	SS	SS
Inorganics (mg/kg)								
ANTIMONY	5.42	0.2						
ARSENIC	26.2	0.59						
COPPER	704	1.9						
LEAD	270	25.6						
NICKEL	56.4	0.64						
TIN	47000	0.98 U						
ZINC	550	14.7						
XRF Field Parameters (mg/kg)								
LEAD	270	26	19	16	29	25	12	19

SURFACE SOIL SAMPLES
FIXED-BASE LABORATORY RESULTS AND XRF FIELD PARAMETERS
D-6, SMALL ARMS RANGE
MCB CAMP LEJEUNE
ONSLOW COUNTY, NORTH CAROLINA
Page 6

nsample		**MMRP64-SS018D-0001**	**MMRP64-SB019D-0002**	**MMRP64-SS019C-0001**	**MMRP64-SS019D-0001**	**MMRP64-SS020D-0001**	**MMRP64-SB021-0001**	**MMRP64-SB022-0001**	**MMRP64-SB023-0001**
location		MMRP64-SO018	MMRP64-SO019	MMRP64-SO019	MMRP64-SO019	MMRP64-SO020	MMRP64-SO021	MMRP64-SO022	MMRP64-SO023
sample_dat		20090513	20090514	20090513	20090513	20090513	20090514	20090514	20090514
sample_tim		00:00:00	00:00:00	14:53:00	00:00:00	00:00:00	13:10:00	13:15:00	13:20:00
field_poc		GOERDT,J	GOERDT,J	GOERDT,J	GOERDT,J	GOERDT,J	GOERDT,J	GOERDT,J	GOERDT,J
sample_typ		NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL
qc_type		NM	NM	NM	NM	NM	NM	NM	NM
sacode		NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL
matrix		SO	SO	SO	SO	SO	SO	SO	SO
duplicate									
top_depth		0	0	0	0	0	0	0	0
bottom_dep		1	2	1	1	1	1	1	1
depth_unit		FT	FT	FT	FT	FT	FT	FT	FT
submatrix	**PALs**	SS	SS	SS	SS	SS	SS	SS	SS
Inorganics (mg/kg)									
ANTIMONY	5.42			0.15			1.5	1.1	0.95
ARSENIC	26.2			0.49			2.7	2.1	2.3
COPPER	704			0.99			20.9	17	27.6
LEAD	270			81.1			107	72.9	139
NICKEL	56.4			0.6			5.9	3.8	7.2
TIN	47000			1.3 U			1.6 U	2.4 U	1.2 U
ZINC	550			8.8			193	142	209
XRF Field Parameters (mg/kg)									
LEAD	270	32	0	74	7	26	NA	NA	NA

SUBSURFACE SOIL SAMPLES
FIXED-BASE LABORATORY RESULTS AND XRF FIELD PARAMETERS
D-6, SMALL ARMS RANGE
MCB CAMP LEJEUNE
ONSLOW COUNTY, NORTH CAROLINA
Page 1

nsample		**MMRP64-SB004D-0204**	**MMRP64-SB004D-0406**	**MMRP64-SB004D-0810**	**MMRP64-SB005D-0204**	**MMRP64-SB005D-0406**	**MMRP64-SB005D-0810**	**MMRP64-SB006D-0204**
location		MMRP64-SO004	MMRP64-SO004	MMRP64-SO004	MMRP64-SO005	MMRP64-SO005	MMRP64-SO005	MMRP64-SO006
sample_dat		20090514	20090514	20090514	20090514	20090514	20090514	20090514
sample_tim		00:00:00	00:00:00	11:55:00	14:10:00	00:00:00	00:00:00	00:00:00
field_poc		GOERDT,J	GOERDT,J	GOERDT,J	GOERDT,J	GOERDT,J	GOERDT,J	GOERDT,J
sample_typ		NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL
qc_type		NM	NM	NM	NM	NM	NM	NM
sacode		NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL
matrix		SO	SO	SO	SO	SO	SO	SO
duplicate								
top_depth		2	4	8	2	4	8	2
bottom_dep		4	6	10	4	6	10	4
depth_unit		FT	FT	FT	FT	FT	FT	FT
submatrix	**PALs**	SB	SB	SB	SB	SB	SB	SB
Inorganics (mg/kg)								
ANTIMONY	5.42			0.13	4.6			
ARSENIC	26.2			1.1	0.67			
COPPER	704			2.1	1.5			
LEAD	270			92.2	**1140**			
NICKEL	56.4			0.94	0.61			
TIN	47000			1.2 U	0.92 U			
ZINC	550			3.4	36.8			
XRF Field Parameters (mg/kg)								
LEAD	270	0	12	13	248	40	26	0

SUBSURFACE SOIL SAMPLES
FIXED-BASE LABORATORY RESULTS AND XRF FIELD PARAMETERS
D-6, SMALL ARMS RANGE
MCB CAMP LEJEUNE
ONSLOW COUNTY, NORTH CAROLINA
Page 2

nsample		**MMRP64-SB006D-0406**	**MMRP64-SB006D-0608**	**MMRP64-SB007D-0204**	**MMRP64-SB007D-0406**	**MMRP64-SB007D-0608**	**MMRP64-SB009D-0204**	**MMRP64-SB009D-0406**
location		MMRP64-SO006	MMRP64-SO006	MMRP64-SO007	MMRP64-SO007	MMRP64-SO007	MMRP64-SO009	MMRP64-SO009
sample_dat		20090514	20090514	20090514	20090514	20090514	20090514	20090514
sample_tim		00:00:00	00:00:00	00:00:00	00:00:00	00:00:00	00:00:00	14:30:00
field_poc		GOERDT,J	GOERDT,J	GOERDT,J	GOERDT,J	GOERDT,J	GOERDT,J	GOERDT,J
sample_typ		NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL
qc_type		NM	NM	NM	NM	NM	NM	NM
sacode		NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL
matrix		SO	SO	SO	SO	SO	SO	SO
duplicate								
top_depth		4	4	2	4	4	2	4
bottom_dep		6	6	4	6	6	4	6
depth_unit		FT	FT	FT	FT	FT	FT	FT
submatrix	**PALs**	SB	SB	SB	SB	SB	SB	SB
Inorganics (mg/kg)								
ANTIMONY	5.42							0.091 U
ARSENIC	26.2							3.1
COPPER	704							1.3
LEAD	270							6.9
NICKEL	56.4							2.3
TIN	47000							0.84 U
ZINC	550							14.3
XRF Field Parameters (m								
LEAD	270	3	3	**793**	95	0	8	7

SUBSURFACE SOIL SAMPLES
FIXED-BASE LABORATORY RESULTS AND XRF FIELD PARAMETERS
D-6, SMALL ARMS RANGE
MCB CAMP LEJEUNE
ONSLOW COUNTY, NORTH CAROLINA
Page 3

nsample		**MMRP64-SB009D-0810**	**MMRP64-SB010D-0204**	**MMRP64-SB010D-0406**	**MMRP64-SB010D-0607**	**MMRP64-SB011D-0204**	**MMRP64-SB011D-0406**	**MMRP64-SB011D-0810**
location		MMRP64-SO009	MMRP64-SO010	MMRP64-SO010	MMRP64-SO010	MMRP64-SO011	MMRP64-SO011	MMRP64-SO011
sample_dat		20090514	20090514	20090514	20090514	20090514	20090514	20090514
sample_tim		00:00:00	00:00:00	00:00:00	00:00:00	00:00:00	00:00:00	00:00:00
field_poc		GOERDT,J	GOERDT,J	GOERDT,J	GOERDT,J	GOERDT,J	GOERDT,J	GOERDT,J
sample_typ		NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL
qc_type		NM	NM	NM	NM	NM	NM	NM
sacode		NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL
matrix		SO	SO	SO	SO	SO	SO	SO
duplicate								
top_depth		8	2	4	6	2	4	8
bottom_dep		10	4	6	7	4	6	10
depth_unit		FT	FT	FT	FT	FT	FT	FT
submatrix	**PALs**	SB	SB	SB	SB	SB	SB	SB
Inorganics (mg/kg)								
ANTIMONY	5.42							
ARSENIC	26.2							
COPPER	704							
LEAD	270							
NICKEL	56.4							
TIN	47000							
ZINC	550							
XRF Field Parameters (m								
LEAD	270	39	6	5	3	0	12	22

SUBSURFACE SOIL SAMPLES
FIXED-BASE LABORATORY RESULTS AND XRF FIELD PARAMETERS
D-6, SMALL ARMS RANGE
MCB CAMP LEJEUNE
ONSLOW COUNTY, NORTH CAROLINA
Page 4

nsample		**MMRP64-SB012D-0204**	**MMRP64-SB012D-0406**	**MMRP64-SB012D-1214**	**MMRP64-SB019D-0204**	**MMRP64-SB019D-0406**	**MMRP64-SB019D-1113**
location		MMRP64-SO012	MMRP64-SO012	MMRP64-SO012	MMRP64-SO019	MMRP64-SO019	MMRP64-SO019
sample_dat		20090514	20090514	20090514	20090514	20090514	20090514
sample_tim		00:00:00	00:00:00	00:00:00	00:00:00	00:00:00	00:00:00
field_poc		GOERDT,J	GOERDT,J	GOERDT,J	GOERDT,J	GOERDT,J	GOERDT,J
sample_typ		NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL
qc_type		NM	NM	NM	NM	NM	NM
sacode		NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL
matrix		SO	SO	SO	SO	SO	SO
duplicate							
top_depth		2	4	12	2	4	11
bottom_dep		4	6	14	4	6	13
depth_unit		FT	FT	FT	FT	FT	FT
submatrix	**PALs**	SB	SB	SB	SB	SB	SB
Inorganics (mg/kg)							
ANTIMONY	5.42						
ARSENIC	26.2						
COPPER	704						
LEAD	270						
NICKEL	56.4						
TIN	47000						
ZINC	550						
XRF Field Parameters (m							
LEAD	270	0	11	17	0	10	15

SUMMARY OF GROUNDWATER SAMPLE RESULTS
D-6, SMALL ARMS RANGE
MCB CAMP LEJEUNE
ONSLOW COUNTY, NORTH CAROLINA
Page 1

nsample		MMRP64-TW004	MMRP64-TW007	MMRP64-TW012	MMRP64-TW012-AVG	MMRP64-TW012-D	MMRP64-TW019
location		MMRP64-TW004	MMRP64-TW007	MMRP64-TW012	MMRP64-TW012	MMRP64-TW012	MMRP64-TW019
sample_dat		20090514	20090514	20090514	20090514	20090514	20090515
sample_tim		19:00:00	19:45:00	20:30:00	20:30:00	00:00:00	08:15:00
sent_to_la		20090515	20090515	20090515	20090515	20090515	20090515
coc_no		0200	0200	0200	0200	0200	0200
field_poc		GOERDT,J	GOERDT,J	GOERDT,J	GOERDT,J	GOERDT,J	GOERDT,J
sample_typ		NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL
qc_type		NM	NM	NM	NM	FD	NM
sacode		NORMAL	NORMAL	ORIG	AVG	DUP	NORMAL
matrix	**PALs**	GW	GW	GW	GW	GW	GW
Inorganics (ug/L)							
ANTIMONY	15	4.6 U	4.6 U	7.9 U	6.25 U	4.6 U	4.6 U
ARSENIC	50	**55.1**	5.3 U	22.1	12.375	5.3 U	44
COPPER	1000	24.5	5 U	11	6.75	5 U	16.6
LEAD	15	**117**	**22.2**	**21.9**	11.75	3.2 U	**37.9**
NICKEL	100	21.7	2.3	14.3	9.55	4.8	17
TIN	22000	16 U	16 U	16 U	16 U	16 U	16 U
ZINC	1050	272	24 U	135 J	79.65 J	24.3 J	154
Filtered Inorganics (ug/L)							
ANTIMONY	15	4.6 U		4.6 U	4.6 U		4.6 U
ARSENIC	50	5.3 U		5.3 U	5.3 U		5.3 U
COPPER	1000	5 U		5 U	5 U		5 U
LEAD	15	4.7 U		2.5 U	2.5 U		2.2 U
NICKEL	100	3.8		4.8	4.8		2.4
TIN	22000	16 U		16 U	16 U		16 U
ZINC	1050	21.5 U		28.3 U	28.3 U		19.9 U
Miscellaneous Parameters (ug/L)							
PERCHLORATE	15	0.19 J	0.17 J	0.08 U	0.08 U	0.08 U	0.19 J

APPENDIX E

DATA VALIDATION REPORTS

Tetra Tech NUS

INTERNAL CORRESPONDENCE

TO: R. BARRINGER **DATE:** JULY 8, 2009

FROM: ANN COGNETTI **COPIES:** DV FILE

SUBJECT: LIMITED INORGANIC DATA VALIDATION –TOTAL METALS, PERCENT SOLIDS
MCB CAMP LEJEUNE– CTO 163
SAMPLE DELIVERY GROUP (SDG) – H0859

SAMPLES: 21/Soils

FD05130901	MMRP64 SB005D 0204	MMRP64 SB007D 0002
MMRP64 SB009D 0002	MMRP64 SB009D 0406	MMRP64 SB010D 0002
MMRP64 SB021 0001	MMRP64 SB022 0001	MMRP64 SB023 0001
MMRP64-SB004D 0810	MMRP64-SB005D 0002	MMRP64-SB011D 0002
MMRP64-SS004C-0001	MMRP64-SS005C-0001	MMRP64-SS006C-0001
MMRP64-SS007C-0001	MMRP64-SS009C-0001	MMRP64-SS010C-0001
MMRP64-SS011C-0001	MMRP64-SS012C-0001	MMRP64-SS019C-0001

Overview

The sample set for MCB CAMP LEJEUNE-CTO 163 SDG H0859 contains twenty one (21) environmental soil samples. All samples were analyzed for selected metals (Sb, As, Cu, Pb, Ni, Sn and Zn) and percent solids. The samples were collected by Tetra Tech NUS on April 14 and 15, 2009 and analyzed by Mitkem Laboratories. Metals analyses were conducted using SW-846 method 6010B. Percent solids analyses were conducted using SM 19 2540B M. The field duplicate pair for this SDG is FD05130901 and MMRP64-SB005D 0002.

These data were evaluated based on the following parameters:

* • Data Completeness
* • Holding Times
* • Initial and Continuing Calibration Verification Results
• Blank Results
• Field Duplicate Results
* • Detection Limits

* - All quality control criteria were met for this parameter.

Blank Results

The following analytes were detected in the initial calibration blank, continuing calibration blank or preparation blank at the following maximum concentrations:

Analyte	Maximum Concentration (mg/kg)	Action Level (mg/kg)
Lead[1]	0.51	2.6
Tin[1]	1.5	7.5
Zinc[1]	0.40	2.0

[1] Maximum concentration present in preparation blank affecting all samples.

An action level of 5X the maximum contaminant level has been used to evaluate sample data for blank contamination. Sample aliquot, percent solids and dilution factors, if applicable, were taken into consideration when evaluating for blank contamination. Positive results less than the blank action level for lead, tin, and zinc were qualified (U) as a result of laboratory blank contamination.

Field Duplicate Results

Field duplicate imprecision (RPD>50%) was noted for antimony, copper, lead, and zinc in field duplicate pair (FD05130901 and MMRP64-SB005D 0002). Positive results reported for the analyte antimony, copper, lead and zinc were qualified as estimated "J" in the field duplicate pair since the difference in concentration between the two samples was greater than two times the reporting limit. No action was required for the other analytes since the difference in concentration between the two samples was less than two times the reporting limit.

Additional Comments

No data was provided for the Contract Required Quantitation Limit (CRQL) Check Standard (CRI).

Executive Summary

Laboratory Performance: Several analytes were present in the laboratory method / preparation blanks.

Other Factors Affecting Data Quality: Field duplicate non-compliances resulted in the qualification of some data.

The data for these analyses were reviewed with reference to the "National Functional Guidelines for Inorganic Review", October 2004, and the DOD document entitled "Quality System Manual (QSM) for Environmental Laboratories" (Jan 2006).

The text of this report has been formulated to address only those problem areas affecting data quality.

Ann Cognetti
Tetra Tech NUS
Ann Cognetti
Chemist/Data Validator

Edward Anthony/fer
Tetra Tech NUS
Joseph A. Samchuck
Quality Assurance Officer

Attachments:

1. Appendix A - Qualified Analytical Results
2. Appendix B - Results as reported by the Laboratory
3. Appendix C - Support Documentation

Tetra Tech NUS

INTERNAL CORRESPONDENCE

TO: R. BARRINGER **DATE:** JULY 8, 2009

FROM: ANN COGNETTI **COPIES:** DV FILE

SUBJECT: LIMITED INORGANIC DATA VALIDATION –TOTAL AND DISSOLVED METALS
MCB CAMP LEJEUNE– CTO 163
SAMPLE DELIVERY GROUP (SDG) – H0860

SAMPLES: 11/Aqueous

FD05140901	MMRP64 TW004	MMRP64 TW007
MMRP64 TW012	MMRP64 TW019	PW05150901
RB05130901	SB05130901	MMRP64 TW004F
MMRP64 TW012F	MMRP64 TW019F	

Overview

The sample set for MCB CAMP LEJEUNE-CTO 163, eleven (11) aqueous environmental samples. All samples were analyzed for select metals (Sb, As, Cu, Pb, Ni, Sn and Zn). Three samples, MMRP64 TW004F, MMRP64 TW012F, and MMRP64 TW019F were also analyzed for dissolved metals. The samples were collected by Tetra Tech NUS on April 14 and 15, 2009 and analyzed by Mitkem Laboratories. Metals analyses were conducted using SW-846 method 6010B. The field duplicate pair for this SDG is FD05140901 and MMRP64 TW012.

These data were evaluated based on the following parameters:

* • Data Completeness
* • Holding Times
* • Initial and Continuing Calibration Verification Results
• Blank Results
• Field Duplicate Results
* • Detection Limits

* - All quality control criteria were met for this parameter.

Blank Results

The following analytes were detected in the initial calibration blank, continuing calibration blank or preparation blank at the following maximum concentrations:

Analyte	Maximum Concentration (ug/L)	Action Level (ug/L)
Antimony	5.3	26.5
Lead[(1)]	3.2	16.0
Tin[(1)]	18.9	94.5
Zinc[(1)]	8.8	44.0

[(1)] Maximum concentration present in preparation blank affecting all samples.

An action level of 5X the maximum contaminant level has been used to evaluate sample data for blank contamination. Sample aliquot, percent solids and dilution factors, if applicable, were taken into consideration when evaluating for blank contamination. Positive results less than the blank action level for

lead, tin and zinc were qualified (U) as a result of laboratory blank contamination. Antimony was present in the continuing calibration blanks affecting samples MMRP64 TW004, MMRP64 TW007, MMRP64 TW012, MMRP64 TW019, MMRP64 TW004F and FD05140901. In these samples, all positive results less than the blank action level for antimony were qualified (U) as a result of laboratory contamination.

Field Duplicate Results

Field duplicate imprecision (RPD>50%) was noted for arsenic, copper, lead, nickel, and zinc in field duplicate pair (FD05140901 and MMRP64 TW012). Positive results reported for the aforementioned analyte zinc was qualified as estimated "J" for this field duplicate pair since the difference in concentration between the two samples was greater than two times the reporting limit. No action was required for the other analytes since the difference in concentration between the two samples was less than two times the reporting limit.

Additional Comments

No data was provided for the Contract Required Quantitation Limit (CRQL) Check Standard (CRI).

Executive Summary

Laboratory Performance: Several analytes were present in the laboratory method / preparation blanks.

Other Factors Affecting Data Quality: Field duplicate non-compliances resulted in the qualification of some data.

The data for these analyses were reviewed with reference to the "National Functional Guidelines for Inorganic Review", October 2004, and the DOD document entitled "Quality System Manual (QSM) for Environmental Laboratories" (Jan 2006).

The text of this report has been formulated to address only those problem areas affecting data quality.

Ann Cognetti

Tetra Tech NUS
Ann Cognetti
Chemist/Data Validator

Tetra Tech NUS
Joseph A. Samchuck
Quality Assurance Officer

Attachments:

1. Appendix A - Qualified Analytical Results
2. Appendix B - Results as reported by the Laboratory
3. Appendix C - Support Documentation

Tetra Tech NUS **INTERNAL CORRESPONDENCE**

TO: R. BARRINGER **DATE:** JULY 8, 2009

FROM: ANN COGNETTI **COPIES:** DV FILE

SUBJECT: **LIMITED PERCHLORATE DATA VALIDATION**
MCB CAMP LEJEUNE
SAMPLE DELIVERY GROUP (SDG) – R0902759

SAMPLES: 5/Aqueous

FD05140901	MMRP64-TW004	MMRP64-TW007
MMRP64-TW012	MMRP64-TW019	

Overview

The sample set for MCB CAMP LEJEUNE SDG R0902759 consists of five (5) aqueous environmental samples. All samples were analyzed for perchlorates. The field duplicate pair for this SDG is MMRP64-TW012 and FD05140901.

The samples were collected by Tetra Tech NUS on May 14 and 15, 2009 and analyzed by Columbia Analytical Services. All analyses were conducted in accordance with Naval Facilities Engineering Service Center (NFESC) Quality Assurance/Quality Control (QA/QC) criteria using SW-846 Methods 6850 analysis and reporting protocols. The data was evaluated based on the following parameters:

* • Data Completeness
* • Holding Times
* • Initial and Continuing Calibration Verification Results
* • Laboratory Method Blank Results
* • Field Duplicate Results
* • Detection Limits

* - All quality control criteria were met for this parameter.

Additional Comments

Positive results less than the reporting limit (RL) were qualified as estimated, J, due to uncertainty near the detection limit.

Executive Summary

Laboratory Performance: None.

Other Factors Affecting Data Quality: None.

The data for these analyses were reviewed with reference to the DOD document entitled "Quality System Manual (QSM) for Environmental Laboratories" (Jan 2006). The text of this report has been formulated to address only those problem areas affecting data quality.

Tetra Tech NUS
Ann Cognetti
Chemist/Data Validator

Tetra Tech NUS
Joseph A. Samchuck
Quality Assurance Officer

Attachments:

1. Appendix A - Qualified Analytical Results
2. Appendix B - Results as reported by the Laboratory
3. Appendix C - Support Documentation

APPENDIX F

ECOLOGICAL RISK SCREENING SUPPORTING DOCUMENTATION

APPENDIX F

FOOD-CHAIN MODEL RECEPTOR PROFILES

The following sections present the receptor profiles for the short-tailed shrew, American robin, meadow vole, northern bobwhite quail, mink, and green heron. The majority of the information for the profiles was obtained from the Wildlife Exposure Factors Handbook (USEPA, 1993). The data for the incidental soil ingestion rates were obtained from the Estimates of Soil Ingestion by Wildlife (Beyer, 1993) or the USEPA Ecological Soil Screening Guidance (USEPA, 2007).

The food and water ingestion rates are listed in g/g (of body weight)-day on a wet weight basis but were converted to dry weight for the ERA. The home ranges are presented in hectares in USEPA (1993) but were converted to acres by multiplying the number of hectares by 2.471. Also note that the estimated percent of soil in the diets are listed in dry weight. The attached table presents the calculation of the exposure parameters and how the calculations were done.

Short-Tailed Shrew (*Blarina brevicauda*)

Shrews inhabit a wide variety of habitats and are common in areas with abundant vegetative cover. They need cool, moist habitats because of their high metabolic and water-loss rates. The short-tailed shrew is primarily carnivorous, eating insects and gastropods such as earthworms, slugs, and snails.

The adult body weight for the short-tailed shrew in various habitats ranged from 0.015 to 0.01921 kilograms (kg) with an average of 0.0161 kg. The listed food ingestion rates for shrews are 0.49 and 0.62 grams per grams per day (g/g-day) (wet-weight). The water ingestion rate was listed as 0.223 g/g-day. The food and water ingestion rates in kg/day and liters per day (L/day), respectively, were calculated as shown in the attached table. The food ingestion rates were then multiplied by 0.16, which is the percent solids of worms (Sample et al., 1997) to convert the ingestion rate from a wet-weight value to a dry-weight value. The incidental soil ingestion rate was calculated by multiplying the ingestion rate by the percentage of soil that is incidentally ingested (assumed 3 percent for conservative food-chain model and 0.9 percent for the average food-chain model) from USEPA (2007). Three percent is the 90^{th} percentile value and 0.9 percent is the 50^{th} percentile value from USEPA (2007). The home range for the shrew (0. 9699 acres) was calculated using data from a tamarack bog in Manitoba (only value available).

American Robin (*Turdus migratorius*)

American robins' habitats include parks, lawns, moist forests, swamps, open woodlands, and orchards. Robins forage on the ground in open areas, along habitat edges, or the edges of streams. They also may forage above ground in shrubs and within the lower branches of trees. In the months preceding and during the breeding season, robins feed primarily on invertebrates and on some fruits. During the rest of the year their

diet consists primarily of fruits.

The adult body weight for the American robin in New York woodlands and forests and in Pennsylvania ranged from 0.0773 to 0.0862 kg with an average of 0.0804 kg. The only listed food ingestion rates were for robins in Kansas (1.52 g/g-day) and California (0.89 g/g-day), with an average of 1.205 g/g-day. Studies calculating ingestion rates for the robin included in the USEPA (December 1993) are based on a diet comprised of berries. Based on these studies, the food and water ingestion rates in kg/day and L/day, respectively, were calculated as shown in the attached table. The food ingestion rates were then multiplied by 0.23, which is the percent solids of fruit (Sample et al., 1997) to convert the ingestion rate from a wet-weight value to a dry-weight value. However, because it is assumed that the robin 100 percent of the robin's diet are worms for the food chain models, the ingestion rate for the robin was calculated using field metabolism scaling as presented on the attached table (Nagy et al., 1999). These are the values that will be used in the food chain model for this site.

The water ingestion rate was estimated as 0.14 g/g-day. The incidental soil ingestion rate was calculated by multiplying the ingestion rate by the percentage of soil that is incidentally ingested (assumed 16.4 percent for conservative food chain model and 6.4 percent for the average food chain model) from USEPA (2007). The 16.4 percent and 6.4 percent values are from the American woodcock since it is assumed that both the woodcock and robin are consuming 100 percent worms, and no incidental soil ingestion rate was available for the robin.

The home range for the robin was calculated using data from Tennessee and a New York dense conifer forest. The values ranged from 0.27 to 1.04 acres with an average home range of 0.6095 acres.

Meadow Vole (*Microtus pennsylvanicus*)

Meadow voles inhabit grassy fields, marshes, and bogs; however, they prefer fields with more grass, more cover, and fewer woody plants. They typically consume green succulent vegetation, sedges, seeds, roots, bark, fungi, insects, and animal matter. However, green succulent vegetation makes up the majority of their diet.

The adult body weight for the vole ranges from 0.017 to 0.0524 kg with an average of 0.0358 kg. The only listed food ingestion rates for voles range from 0.30 to 0.35 g/g-day (wet-weight), with an average of 0.325 g/g-day. The water ingestion rates are 0.14 (estimated) and 0.21 g/g-day, with an average of 0.175 g/g-day. The food and water ingestion rates in kg/day and L/day, respectively, were calculated as shown in the attached table. The food ingestion rates were then multiplied by 0.30, which is the percent solids of young grass (Sample et al., 1997) to convert the ingestion rate from a wet-weight value to a dry-weight value. Finally, the incidental soil ingestion rate is calculated by multiplying the ingestion rate by the percentage of soil that is incidentally ingested, which was 3.2 percent for conservative food chain model and 1.2 percent for the average

food chain model) from USEPA (2007). The home range for the meadow vole ranges from 0.000494 to 0.2051 acres with an average home range of 0.0659 acres.

Northern Bobwhite Quail (*Colinus virginianus*)

Quails inhabit grasslands, idle fields, pastures, and large clumps of grasses. Bobwhite quails forage in areas with open vegetation, some bare ground, and light litter. Seeds from weeds, woody plants, and grasses comprise the majority of an adult's diet, although green vegetation has been found to dominate the diet of this species in winter in the southern areas of the United States.

The adult body weight for the bobwhite quail ranges from 0.154 to 0.1939 kg with an average of 0.1751 kg. The listed food ingestion rates for quails range from 0.067 to 0.093 g/g-day (wet-weight), with an average of 0.078 g/g-day. The water ingestion rate is estimated as 0.10 and 0.11 g/g-day, and measured as 0.10 to 0.13 g/g-day, for an average water ingestion rate of 0.11 g/g-day. The food and water ingestion rates in kg/day and L/day, respectively, were calculated as shown in the attached table. The food ingestion rates were then multiplied by 0.30, which is the percent solids of young grass (Sample et al., 1997) to convert the ingestion rate from a wet-weight value to a dry-weight value. Finally, the incidental soil ingestion rate is calculated by multiplying the ingestion rate by the percentage of soil that is incidentally ingested, which was 13.9 percent for conservative food chain model and 6.1 percent for the average food chain model) from USEPA (2007) and was based on the mourning dove.

The home range for the quail ranges from 8.9 to 41.3 acres with an average home range of 18.8 acres.

References:

Beyer, N., E. Connor, and S. Gerould. 1994. Estimates of Soil Ingestion by Wildlife. Journal of Wildlife Management 58(2) pp. 375-382.

Nagy, K.A., I.A. Girard, and T.K. Brown. 1999. Energetics of Free-Ranging Mammals, Reptiles, and Birds. Annu. Rev. Nutr. 19. pp. 247-277.

Sample, B.E., M.S. Aplin, R.A. Efroymson, G.W. Suter II, and C.J.E. Welsh. 1997. Methods and Tools for Estimation of the Exposure of Terrestrial Wildlife to Contaminants. Oak Ridge National Laboratory. October. ORNL/TM-13391.

USEPA (U.S. Environmental Protection Agency), 1993. Wildlife Exposure Factors Handbook. U.S. Environmental Protection Agency. Office of Research and Development. Washington, D.C. December 1993. EPA/600/R-93/187a.

USEPA, 2007. Guidance for Developing Ecological Soil Screening Level, Attachment 4-1, Exposure Factors and Bioaccumulation Models for Derivation of Wildlife Eco-SSLs. Office of Solid Waste and Emergency and Response. OSWER Directive 9285.7-55. April.

APPENDIX F

DRY WEIGHT BAFS FOR PLANTS AND EARTHWORMS
D-6, SMALL ARMS RANGE
MCB CAMP LEJEUNE
ONSLOW COUNTY, NORTH CAROLINA

Chemicals	Plant BAFs[1,3]		Earthworm BAFs[2,3]	
	Conservative[5]	Average[5]	Conservative[5]	Average[5]
Inorganics				
Antimony	1.14E-02	1.02E-02	1.00E+00	1.00E+00
Lead	Eco-SSL	Eco-SSL	Eco-SSL	Eco-SSL
Zinc	Eco-SSL	Eco-SSL	Eco-SSL	Eco-SSL

Notes:

BAF - Bioaccumulation Factor

BSAF - Biota Sediment Accumulation Factor

1 - Sample et al., (1997) for inorganics; conservative value is 90th percentile; average value is median value.

2 - ORNL (September, 1998) for all chemicals; conservative value is 90th percentile; average value is median value.

3 - Where "Eco-SSL" is given, values were calculated using equations from USEPA (2007), Attachment 4-1, Table 4a (for inorganics).

4 - Conservative and average refers to the exposure scenarios for which the uptake factors are used

Default value of 1 is assigned to parameters without uptake factors

APPENDIX F

DRY WEIGHT DERIVATION OF BODY WEIGHT, FOOD INTAKE, AND WATER INTAKE FACTORS FOR TERRESTRIAL FOOD CHAIN MODELS
1 of 2

Data from US EPA (1993) except where noted				Derivation of Factors for Modeling		
Species/Factor	Age/Sex/ Cond./Seas.	Value	Study Average	Calculation of Values		Notes
American Robin						
Body Weight (g)	A B	77.3	77.3	Minimum Value	0.0773 kg	
				Maximum Value	0.0862 kg	
	A M nonbreeding	86.2		Overall Study Average	0.0804 kg	
	A F nonbreeding	83.6	84.9			
	A M breeding	77.4				
	A F breeding	80.6	79			
Food Ingestion Rate (g/g-day)	B B free-living	0.89		*Based on Metabolic Scaling*		
				Conservative value:	0.01247 kg/day	Used maximum body weight in below equation
	- B free-living	1.52				
				Average value	0.01188 kg/day	Used average body weight in below equation
						Food ingestion rates were calculated from Nagy et al., (1999) for insectivores as follows:
	Overall Study Average		1.21			FI = $(9.7*BW(g)^{0.705})/18kJ/g/1000$
Water Ingestion Rate (g/g-day)	A B	0.14		Conservative value:	0.0121 L/day	Ingestion rate * Maximum Body weight
				Average value	0.0113 L/day	Ingestion rate * Average Body weight
Short-Tailed Shrew						
Body Weight (g)	A B	15	15	Minimum Value	0.0150 kg	
				Maximum Value	0.01921 kg	
	M summer	19.21	17.27	Overall Study Average	0.01613 kg	
	F summer	17.4				
	M fall	16.87				
	M fall	15.58				
Food Ingestion Rate (g/g-day)	A B	0.49		Conservative value:	0.0016 kg/day	Maximum ingestion rate * Average Body weight * 0.16[1]
	A B	0.62		Average value	0.00143 kg/day	Average ingestion rate * Average Body weight * 0.16[1]
	Overall Study Average		0.555			[1] - 0.16 = percent solids in earthworms to convert to a dry weight ingestion rate
Water Ingestion Rate (g/g-day)	A B	0.223		Conservative value:	0.00428 L/day	Ingestion rate * Maximum Body weight
				Average value	0.00360 L/day	Ingestion rate * Average Body weight

APPENDIX F

DRY WEIGHT DERIVATION OF BODY WEIGHT, FOOD INTAKE, AND WATER INTAKE FACTORS FOR TERRESTRIAL FOOD CHAIN MODELS
2 of 2

Data from US EPA (1993) except where noted				Derivation of Factors for Modeling		
Species/Factor	Age/Sex/ Cond./Seas.	Value	Study Average	Calculation of Values		Notes
Meadow Vole						
Body Weight (g)	A M summer	40	36.7	Minimum Value	0.017 kg	
	A F summer	33.4		Maximum Value	0.052 kg	
				Overall Study Average	0.0358 kg	
	A M spring	52.4	48.0			
	A F spring	43.5				
	A B spring	26	21.2			
	A B summer	24.3				
	A B fall	17				
	A B winter	17.5				
	A M	35.5	37.3			
	A F	39				
Food Ingestion Rate (g/g-day)		0.3	0.33	Conservative value:	0.003756 kg/day	Maximum ingestion rate * Average Body weight * 0.3 [1]
		0.35		Average value	0.003488 kg/day	Average ingestion rate * Average Body weight * 0.3[1]
						[1] - 0.30 = percent solids in grass to convert to a dry weight ingestion rate
Water Ingestion Rate	A B	0.21	0.18	Conservative value:	0.007513 L/day	Maximum ingestion rate * Average Body weight
	A B	0.14		Average value	0.006261 L/day	Average ingestion rate * Average Body weight
Northern Bobwhite Quail						
Body Weight (g)	A B fall	189.9	191	Minimum Value	0.154 kg	
	A B winter	193.9		Maximum Value	0.194 kg	
	A B spring	190		Overall Study Average	0.1751 kg	
	A M winter	181	177			
	A M summer	163				
	A F winter	183				
	A F summer	180				
	A M winter	161	157			
	A M summer	154				
	A F winter	157				
	A F summer	157				
Food Ingestion Rate (g/g-day)	A B winter	0.093	0.078	Conservative value:	0.00488 kg/day	Maximum ingestion rate * Average Body weight * 0.3[1]
	A B spring	0.067				
	A B summer	0.079		Average value	0.00408 kg/day	Average ingestion rate * Average Body weight * 0.3[1]
	A B fall	0.072				
						[1] - 0.30 = percent solids in grass to convert to a dry weight ingestion rate
Water Ingestion Rate (g/g-day)	A M summer	0.1	0.11	Conservative value:	0.0227616 L/day	Maximum ingestion rate * Average Body weight
	A F summer	0.13				
	A M summer	0.11		Average value	0.0192598 L/day	Average ingestion rate * Average Body weight
	A F summer	0.1				

APPENDIX F

CHEMICAL CONCENTRATIONS IN SURFACE SOIL AND TISSUE
D-6, SMALL ARMS RANGE
MCB CAMP LEJEUNE
ONSLOW COUNTY, NORTH CAROLINA

Chemical	Average Surface Soil Concentration (mg/kg)	Average Ground Water Concentration (mg/L)	Average Earthworm Bioaccumulation Factors	Average Earthworm Concentrations (mg/kg)	Average Invertebrate Bioaccumulation Factors	Average Invertebrate Concentrations (mg/kg)	Average Plant Bioaccumulation Factors	Average Plant Concentrations (mg/kg)
Inorganics								
ANTIMONY	4.28E+01	0.00E+00	1.00E+00	4.28E+01	1.00E+00	4.28E+01	1.02E-02	4.36E-01
LEAD	6.18E+03	4.72E+01	Regressionfrom Eco SSL	9.21E+02	7.10E-02	4.38E+02	Regression from Eco SSL	3.55E+01
ZINC	5.34E+01	1.29E+02	Regression from Eco SSL	3.15E+02	1.94E+00	1.03E+02	Regression from Eco SSL	4.38E+01

1 - If the average of all value is the greater than the maximum detection, the average of the positive detections was used as the average value.

APPENDIX F

BOBWHITE QUAIL- AVERAGE INPUTS
TERRESTRIAL WILDLIFE MODEL HAZARD QUOTIENT CALCULATION
D-6, SMALL ARMS RANGE
MCB CAMP LEJEUNE, ONSLOW COUNTY, NORTH CAROLINA

Chemical	Avg Soil Conc. (mg/kg)	Avg GW Conc. (mg/L)	Vegetation Conc.[1] (mg/kg)	Dose (mg/kg/d) from:			Total Dose (mg/kg/d)	NOAEL (mg/kg/d)	LOAEL (mg/kg/d)	Hazard Quotients	
				Soil	Ground Water	Veg.				NOAEL	LOAEL
Inorganics											
ANTIMONY	4.49E+00	2.24E-03	4.04E+00	6.38E-03	2.47E-04	9.41E-02	1.01E-01	NV	NV	#VALUE!	#VALUE!
LEAD	6.18E+03	4.72E+01	4.38E+02	8.78E+00	5.19E+00	1.02E+01	2.42E+01	1.63E+00	4.46E+01	1.5E+01	5.4E-01
ZINC	5.34E+01	1.29E+02	1.03E+02	7.59E-02	1.42E+01	2.41E+00	1.67E+01	6.61E+01	1.71E+02	2.5E-01	9.8E-02

Body Weight = (BW)	1.75E-01	kg
Food Ingestion Rate = (If)	4.08E-03	kg/day
Water Ingestion Rate = (Iw)	1.93E-02	L/day
Soil Ingestion Rate = (Is)	2.49E-04	kg/day
Home Range = (HR)	3.00E-01	acres
Contaminated Area = (CA)	Assume equal to home range	

Cells are shaded if the hazard quotient is greater than 1.0

Dose (soil) = (Cs * Is)(H)/BW
Dose (vegetation) = (Cv * If)(H)/BW
Dose (water) = (Cw * Iw)(H)/BW
Cv = Contaminant concentration in vegetation
Cs = Contaminant concentration in soil
Cw = Contaminant concentration in water
Total Dose = Dose (soil) + Dose (vegetation) + Dose (water)
H=CA/HR (Assume = to 1)

Conc = Concentration
LOAEL = Lowest Observed Adverse Effects Concentratio
NOAEL = No Observed Adverse Effects Concentration
GW = Ground Water
NV = No value available
#VALUE! = value not able to be calculated

APPENDIX F

AMERICAN ROBIN - AVERAGE INPUTS
TERRESTRIAL WILDLIFE MODEL ECOLOGICAL EFFECTS QUOTIENT CALCULATION
D-6, SMALL ARMS RANGE
MCB CAMP LEJEUNE, ONSLOW COUNTY, NORTH CAROLINA

Chemical	Avg Soil Conc. (mg/kg)	Avg GW Conc. (mg/L)	Invertebrate Conc. (mg/kg)	Dose (mg/kg/d) from:			Total Dose (mg/kg/d)	NOAEL (mg/kg/d)	LOAEL (mg/kg/d)	Hazard Quotients	
				Soil	Surface Water	Invert.				NOAEL	LOAEL
Inorganics											
ANTIMONY	4.28E+01	0.00E+00	4.28E+01	4.04E-01	0.00E+00	6.32E+00	6.72E+00	NV	NV	#VALUE!	#VALUE!
LEAD	6.18E+03	4.72E+01	9.21E+02	5.84E+01	6.66E+00	1.36E+02	2.01E+02	1.63E+00	4.46E+01	1.2E+02	4.5E+00
ZINC	5.34E+01	1.29E+02	3.15E+02	5.05E-01	1.83E+01	4.66E+01	6.53E+01	6.61E+01	1.71E+02	9.9E-01	3.8E-01

Cells are shaded if the value is greater than 1.0

Body Weight = (BW)	8.04E-02	kg
Food Ingestion Rate = (If)	1.19E-02	kg/day
Water Ingestion Rate = (Iw)	1.13E-02	L/day
Soil Ingestion Rate = (Is)	7.60E-04	kg/day
Home Range = (HR)	6.10E-01	acres
Contaminated Area = (CA)	Assume equal to home range	

Dose (soil) = (Cs * Is)(H)/BW
Dose (invertebrate) = (Ci * If)(H)/BW
Dose (water) = (Cw * Iw)(H)/BW
Ci = Contaminant concentration in invertebrate
Cs = Contaminant concentration in soil
Cw = Contaminant concentration in water
Total Dose = Dose (soil) + Dose (invertebrate) + Dose (water)
H=CA/HR (Assume = to 1)

Conc = Concentration
LOAEL = Lowest Observed Adverse Effects Concentration
NOAEL = No Observed Adverse Effects Concentration
GW = Ground Water
NV = No value available
#VALUE! = value not able to be calculated

APPENDIX F

SHORT-TAILED SHREW - AVERAGE INPUTS
TERRESTRIAL WILDLIFE MODEL ECOLOGICAL EFFECTS QUOTIENT CALCULATION
D-6, SMALL ARMS RANGE
MCB CAMP LEJEUNE, ONSLOW COUNTY, NORTH CAROLINA

Chemical	Avg Soil Conc. (mg/kg)	Avg GW Conc. (mg/L)	Invertebrate Conc. (mg/kg)	Dose (mg/kg/d) from: Soil	Ground Water	Invert.	Total Dose (mg/kg/d)	NOAEL (mg/kg/d)	LOAEL (mg/kg/d)	Hazard Quotients NOAEL	LOAEL
Inorganics											
ANTIMONY	4.28E+01	0.00E+00	4.28E+01	3.42E-02	0.00E+00	3.80E+00	3.84E+00	5.90E-02	2.76E+00	6.5E+01	1.4E+00
LEAD	6.18E+03	4.72E+01	9.21E+02	4.95E+00	1.06E+01	8.20E+01	9.75E+01	4.70E+00	1.86E+02	2.1E+01	5.2E-01
ZINC	5.34E+01	1.29E+02	3.15E+02	4.28E-02	2.89E+01	2.81E+01	5.70E+01	7.54E+01	2.98E+02	7.6E-01	1.91E-01

Cells are shaded if the value is greater than 1.0

Body Weight = (BW)	1.61E-02	kg
Food Ingestion Rate = (If)	1.43E-03	kg/day
Water Ingestion Rate = (Iw)	3.60E-03	L/day
Soil Ingestion Rate = (Is)	1.29E-05	kg/day
Home Range = (HR)	9.70E-01	acres
Contaminated Area = (CA)	Assume equal to home range	

Dose (soil) = (Cs * Is)(H)/BW
Dose (invertebrate) = (Ci * If)(H)/BW
Dose (water) = (Cw * Iw)(H)/BW
Ci = Contaminant concentration in invertebrate
Cs = Contaminant concentration in soil
Cw = Contaminant concentration in water
Total Dose = Dose (soil) + Dose (invertebrate) + Dose (water)
H=CA/HR (Assume = to 1)

Conc = Concentration
LOAEL = Lowest Observed Adverse Effects Concentration
NOAEL = No Observed Adverse Effects Concentration
GW = Ground Water

APPENDIX F

SOURCES AND ENDPOINTS FOR NOAELS AND LOAELS FOR TERRESTRIAL WILDLIFE
D-6, SMALL ARMS RANGE
MCB CAMP LEJEUNE
ONSLOW COUNTY, NORTH CAROLINA

Parameters	Concentration (mg/kg-day)	Endpoint	Effect	Chronic/ Subchronic	Species	Primary Reference	Source of Reference
Inorganics							
Antimony	0.059	NOAEL	reproduction & growth	chronic	mammals	USEPA, 2005	
Antimony	2.76	LOAEL	reproduction & growth	chronic	mammals	USEPA, 2006	
Lead	1.63	NOAEL	reproduction & growth	chronic	birds	USEPA, 2005	
Lead	44.6	LOAEL	reproduction & growth	chronic	birds	USEPA, 2005	
Lead	4.7	NOAEL	reproduction & growth	chronic	mammals	USEPA, 2005	
Lead	186.4	LOAEL	reproduction & growth	chronic	mammals	USEPA, 2005	
Zinc	75.4	NOAEL	reproduction & growth	chronic	mammals	USEPA, 2007	
Zinc	297.58	LOAEL	reproduction & growth	chronic	mammals	USEPA, 2007	
Zinc	66.1	NOAEL	reproduction & growth	chronic	birds	USEPA, 2007	
Zinc	171.44	LOAEL	reproduction & growth	chronic	birds	USEPA, 2007	

Notes:

NOAEL = No Observed Adverse Effects Level

LOAEL = Lowest Observed Adverse Effects Level

The LOAELs used for several metals were calculated as the geometric mean of growth and reproduction data from the Ecological Soil Screening Levels (U.S. EPA, 2005, 2006, 2007).

References for the NOAELS and LOAELs are presented in this Attachment and Titled "TRV Source and Endpoint References".

APPENDIX F

WILDLIFE TOXICITY REFERENCE VALUES
D-6, SMALL ARMS RANGE
MCB CAMP LEJEUNE
ONSLOW COUNTY, NORTH CAROLINA

PARAMETER	Mammal		Bird	
	NOAEL	LOAEL	NOAEL	LOAEL
INORGANICS				
Antimony	0.059	2.76	NV	NV
Lead	4.7	186.4	1.63	44.63
Zinc	75.4	298	66.1	171.44

Notes:

The sources of these NOAELS and LOAELS are presented in the table titled "Sources and Endpoints for NOAELS and LOAELS for Terrestrial Wildlife" in this appendix.

The NOAELS and LOAELS in the source table were divided by 10 if a subchronic study was the basis for the value. Also, if only a NOAEL was available, the value was multiplied by 10 to estimate the LOAEL. If only a LOAEL was available, the value was divided by 10 to estimate the NOAEL.

APPENDIX F

MEADOW VOLE - AVERAGE INPUTS
TERRESTRIAL WILDLIFE MODEL HAZARD QUOTIENT CALCULATION
D-6, SMALL ARMS RANGE
MCB CAMP LEJEUNE, ONSLOW COUNTY, NORTH CAROLINA

Chemical	Avg Soil Conc. (mg/kg)	Avg GW Conc. (mg/L)	Vegetation Conc.[1] (mg/kg)	Dose (mg/kg/d) from:			Total Dose (mg/kg/d)	NOAEL (mg/kg/d)	LOAEL (mg/kg/d)	Hazard Quotients	
				Soil	Ground Water	Veg.				NOAEL	LOAEL
Inorganics											
ANTIMONY	4.49E+00	2.24E-03	4.04E+00	5.25E-03	3.92E-04	3.94E-01	3.99E-01	5.90E-02	2.76E+00	6.8E+00	1.4E-01
LEAD	6.18E+03	4.72E+01	4.38E+02	7.22E+00	8.26E+00	4.27E+01	5.82E+01	4.70E+00	1.86E+02	1.2E+01	3.1E-01
ZINC	5.34E+01	1.29E+02	1.03E+02	6.24E-02	2.26E+01	1.01E+01	3.28E+01	7.54E+01	2.98E+02	4.3E-01	1.1E-01

Body Weight = (BW)	3.58E-02	kg
Food Ingestion Rate = (If)	3.49E-03	kg/day
Water Ingestion Rate = (Iw)	6.26E-03	L/day
Soil Ingestion Rate = (Is)	4.19E-05	kg/day
Home Range = (HR)	6.590E-02	acres
Contaminated Area = (CA)	Assume equal to home range	

Cells are shaded if the hazard quotient is greater than 1.0

Dose (soil) = (Cs * Is)(H)/BW
Dose (vegetation) = (Cv * If)(H)/BW
Dose (water) = (Cw * Iw)(H)/BW
Cv = Contaminant concentration in vegetation
Cs = Contaminant concentration in soil
Cw = Contaminant concentration in water
Total Dose = Dose (soil) + Dose (vegetation) + Dose (water)
H=CA/HR (Assume = to 1)

Conc = Concentration
LOAEL = Lowest Observed Adverse Effects Concentration
NOAEL = No Observed Adverse Effects Concentration
GW = Ground Water

APPENDIX F

TRV SOURCE AND ENDPOINT REFERENCES

USEPA, 2005. Ecological Soil Screening Level for Antimony, Interim Final. Office of Emergency and Remedial Response. OSWER Directive 9285.7-61. February.

USEPA, 2005. Ecological Soil Screening Level for Lead, Interim Final. Office of Emergency and Remedial Response. OSWER Directive 9285.7-70. March.

USEPA, 2007. Ecological Soil Screening Level for Zinc, Interim Final. Office of Emergency and Remedial Response. OSWER Directive 9285.7-73. November.

APPENDIX B

AREA AND VOLUME CALCULATIONS FOR ALTERNATIVES 2, 3, AND 4

TETRA TECH NUS, INC. **CALCULATION SHEET**

CLIENT:	MCB CAMP LEJEUNE D-6, SMALL ARMS RANGE	JOB NUMBER:	112G01716.0000.0901
SUBJECT:	OU2 - Removal Action Limits		
BASED ON:	Figure 4-1	DRAWING NUMBER:	
BY: TJR Date: 03-30-2010	CHECKED BY: CRM Date: 03-30-2010	APPROVED BY: CRM	DATE: 04-05-201

CALCULATIONS AND ASSUMPTIONS

Alternative 2: Excavation, Off-Site Disposal, and Restoration

Excavation is for three different depths: 4.0' (subsurface soil), and 2.0' & 1.0' (surface soil). Areas to be excavated to 4.0 feet are shown in orange, pink areas will be excavated to 2.0 feet, and blue areas will be excavated to 1.0 feet. Refer to Figure 4-1.

Areas for 4.0' excavation:
- 15 foot squares around SB007 and SB005 (shown in orange)

Areas for 2.0' excavation:
- Pink shaded area (SB009)

Areas for 1.0' excavation:
- Blue shaded areas (SB004, SB006, SB008, SB010, and SB011)

Areas were provided by GIS technician who created Figure 4-1

Areas provided by GIS

Pink Areas	Area (sq ft)
Orange Areas	450
Pink Area	523
Blue Areas	3,993

Volumes

AREA	Length (ft)	Width (ft)	Area (sq ft)	Excavation Depth (ft)	Volume (cu ft)	Volume (cu yd)
Orange Areas			450	4	1,800	66.7
Pink Area			520	2	1,040	38.5
Blue Areas			3,993	1	3,993	147.9
Totals			4,963		6,833	253

Area 4,963 sq ft

Volume 253 cu yd or 380 tons @ 1.5 tons per cu yd

Restoration
Backfill with common fill and seed.

Seed Area
Seed all areas: assume seed area twice the excavated area

Seed area	4,963	sq ft or
	5.0	msf
	2	times
	10	msf

TETRA TECH NUS, INC. **CALCULATION SHEET**

CLIENT:	MCB CAMP LEJEUNE D-6, SMALL ARMS RANGE		JOB NUMBER: 112G01716.0000.0901
SUBJECT:	OU2 - Removal Action Limits		
BASED ON:	Figure 4-1		DRAWING NUMBER:
BY: TJR Date: 03-30-2010	CHECKED BY: CRM Date: 03-30-2010		APPROVED BY: CRM DATE: 04-05-201

Annual Cost

Sampling

Labor & Materials, collect 5 groundwater samples per round

Assume 2 days to sample with 2 people, local plus 1 day of preparations

2 people @ $70.00 per hour for 10 hours per for 3 days =	$4,200
car for 3 days =	$300
report @ $65.00 per hour for 20 hours =	$1,300
IDW disposal =	$250
Misc supplies, copying, etc. =	$400
	$6,450

Analytical, per round

Analysis water samples for lead

type	cost each	number	total
Lead	$65	5	$325
			$325
40% QA/QC & Data Validation			$130
			$455

Sampling report assume $1,500 per round $1,500

Alternative 4: Soil Washing

Excavation volume same as Alternative 2

Assume: Soil washing takes 10 days to complete including excavation
Cost to wash is $150 per cubic yard
20% of washed material is to be disposed off-site as hazardous

253 cu yd
20%
51 cu yd or 76 tons @ 1.5 tons per cu yd

Return remaining material to excavation

Restoration

Purchase 51 cu yd of common fill and seed.

Seed Area

Same as Alternative 2

Annual Cost

Same as Alternative 2

TETRA TECH NUS, INC. **CALCULATION SHEET**

CLIENT:	**MCB CAMP LEJEUNE D-6, SMALL ARMS RANGE**	JOB NUMBER:	**112G01716.0000.0901**
SUBJECT:	**OU2 - Removal Action Limits**		
BASED ON:	Figure 4-1	DRAWING NUMBER:	
BY: TJR Date: 03-30-2010	CHECKED BY: CRM Date: 03-30-2010	APPROVED BY: CRM	DATE: 04-05-201

APPENDIX C

COST ESTIMATES

C-1 EXCAVATION AND DISPOSAL

C-2 PHYTOREMEDIATION

C-3 SOIL WASHING

C-1 EXCAVATION AND DISPOSAL

MARINE CORPS BASE CAMP LEJEUNE
Onslow County, North Carolina
D-6, Small Arms Range
Alternative 2: Excavation, Off-Site Disposal, and Restoration
Capital Cost

4/8/2010 9:29 AM

Item	Quantity	Unit	Unit Cost Subcontract	Unit Cost Material	Unit Cost Labor	Unit Cost Equipment	Extended Cost Subcontract	Extended Cost Material	Extended Cost Labor	Extended Cost Equipment	Subtotal
1 PROJECT PLANNING & DOCUMENTS											
1.1 Prepare Construction/Work Plans	300	hr			$37.00		$0	$0	$11,100	$0	$11,100
2 MOBILIZATION, DEMOBILIZATION AND FIELD SUPPORT											
2.1 Underground Utility Clearances	1	ls	$7,350.00				$7,350	$0	$0	$0	$7,350
2.2 Construction Survey Support	1	day	$1,075.00				$1,075	$0	$0	$0	$1,075
2.3 Equipment Mobilization/Demobilization	2	ea			$177.00	$610.00	$0	$0	$354	$1,220	$1,574
2.4 Site Superintendent	6	day		$116.00	$384.64		$0	$696	$2,308	$0	$3,004
3 DECONTAMINATION											
3.1 Decontamination Services	1	ls		$1,250.00	$2,350.00	$1,550.00	$0	$1,250	$2,350	$1,550	$5,150
3.2 Equipment Decon Pad	1	ls		$4,500.00	$3,000.00	$725.00	$0	$4,500	$3,000	$725	$8,225
3.3 Disposal of Decon Waste (liquid & solid)	1	ls	$500.00				$500	$0	$0	$0	$500
4 PRE EXCAVATION SAMPLING											
4.1 Laboratory Samples, lead	20	ea	$60.00	$10.00			$1,200	$200	$0	$0	$1,400
4.2 XRF rental	1	wk				$1,500.00	$0	$0	$0	$1,500	$1,500
4.3 Site Superintendent	4	day		$116.00	$384.64		$0	$464	$1,539	$0	$2,003
4.4 Site Labor, (1 laborer)	4	day			$264.80		$0	$0	$1,059	$0	$1,059
5 EXCAVATION AND DISPOSAL											
5.1 Backhoe/Loader, 86 hp	4	day			$343.60	$387.60	$0	$0	$1,374	$1,550	$2,925
5.2 XRF rental	1	wk				$1,500.00	$0	$0	$0	$1,500	$1,500
5.3 Site Labor, (3 laborers)	12	day			$264.80		$0	$0	$3,178	$0	$3,178
5.4 Verification Samples, lead	5	ea	$150.00	$10.00			$750	$50	$0	$0	$800
5.5 Non-Hazardous Soil Transportation & Disposal	380	ton	$58.00				$22,040	$0	$0	$0	$22,040
5.6 Waste Disposal Characterization / Analytical	1	ea	$850.00	$30.00	$50.00	$30.00	$850	$30	$50	$30	$960
6 SITE RESTORATION											
6.1 Backfill, common fill	253	cy		$15.20			$0	$3,846	$0	$0	$3,846
6.2 Seed	10.0	msf	$77.50				$775	$0	$0	$0	$775
6.3 Backhoe/Loader, 86 hp	2	day			$343.60	$387.60	$0	$0	$687	$775	$1,462
6.4 Site Labor, (3 laborers)	6	day			$264.80		$0	$0	$1,589	$0	$1,589
7 MONITORING WELLS											
7.1 DPT Mobilization/Demobilization	1	ea	$2,000.00				$2,000	$0	$0	$0	$2,000
7.2 Install Monitoring Wells, 2" PVC, 5 wells, 15' deep	75	lf	$55.00				$4,125	$0	$0	$0	$4,125
7.3 Monitoring Well Head	5	ea	$500.00				$2,500	$0	$0	$0	$2,500
7.4 IDW Disposal	5	drum	$165.00				$825	$0	$0	$0	$825
8 POST CONSTRUCTION COST											
8.1 Contractor Completion Report	150	hr			$37.00		$0	$0	$5,550	$0	$5,550
8.2 Remedial Action Closeout Report	200	hr			$37.00		$0	$0	$7,400	$0	$7,400
Subtotal							$43,990	$11,036	$41,538	$8,851	$105,414
Overhead on Labor Cost @ 30%									$12,461		$12,461
G & A on Labor, Material, Equipment, & Subs Cost @ 10%							$4,399	$1,104	$4,154	$885	$10,541
Tax on Materials and Equipment Cost @ 4.5%								$497		$398	$895
Total Direct Cost							$48,389	$12,636	$58,153	$10,134	$129,311
Indirects on Total Direct Cost @ 30%											$38,793
Profit on Total Direct Cost @ 10%											$12,931
Subtotal											$181,036
Health & Safety Monitoring @ 2%											$3,621
Total Field Cost											$184,657

Item	Quantity	Unit	Unit Cost Subcontract	Unit Cost Material	Unit Cost Labor	Unit Cost Equipment	Extended Cost Subcontract	Extended Cost Material	Extended Cost Labor	Extended Cost Equipment	Subtotal
Contingency on Total Field Costs @ 30%											$55,397
Engineering on Total Field Cost @ 20%											$36,931
TOTAL CAPITAL COST											**$276,985**

MARINE CORPS BASE CAMP LEJEUNE
Onslow County, North Carolina
D-6, Small Arms Range
Alternative 2: Excavation, Off-Site Disposal, and Restoration
Annual Cost

Item	Item Cost first year	Notes
Sampling	$25,800	Labor and supplies to collect samples using a crew of two, four times a year for year 1.
Analysis/Groundwater	$1,820	Analyze samples for lead.
Sampling Report	$6,000	
Subtotal	$33,620	
Contingency @ 10%	$3,362	
TOTAL	**$36,982**	

MARINE CORPS BASE CAMP LEJEUNE
Onslow County, North Carolina
D-6, Small Arms Range
Alternative 2: Excavation, Off-Site Disposal, and Restoration
Present Worth Analysis

Year	Capital Cost	Annual Cost	Total Year Cost	Annual Discount Rate at 7%	Present Worth
0	$276,985		$276,985	1.000	$276,985
1		$36,982	$36,982	0.935	$34,578
			TOTAL PRESENT WORTH		**$311,563**

C-2 PHYTOREMEDIATION

Phase WBS - ECES Report (with Markups)

System:

RACER Version: 10.3.0
Database Location: C:\Documents and Settings\charles.metz\Application Data\AECOM\RACER 10.3\Alternative 3 - Phytoremediation.mdb

Folder:

Folder Name: Camp Lejeune

Project:

Project ID: 112g01716
Project Name: D-6, Small Arms Range
Project Category: None

Location
State / Country: NORTH CAROLINA
City: CAMP LEJEUNE AREA

Location Modifier	Default	User
	0.914	0.914

Options
Database: System Costs
Cost Database Date: 2010
Report Option: Fiscal

Description

This alternative would involve the phytoremediation of D-6, Small Arms Range contaminated soil identified on Figure 4-1. Site preparation would require a limited amount of excavation as phytoremedaiton is limited by plant root depth (assumed to be 6 inches). Therefore, the depth of lead contaminated soil would need to be adjusted to 6 inches across the site. The areas depicted on Figure 4 1 would need to be excavated and spread out over the site to allow for plant root interaction. It is assumed that the most of the site would be used to implement phytoremediation. Following excavation, an irrigation system would be installed followed by the planting of plant species (e.g., Indian mustard) known to hyperaccumulate lead. The plant biomass would be periodically harvested for off site disposal. Monitoring would occur to document the removal of lead from the soil and to determine when the RAO had been met.

Phase WBS - ECES Report
(with Markups)

Site:

Site ID: 112G01716
Site Name: D-6, Small Arms Range
Site Type: None

Media/Waste Type
Primary: Soil
Secondary: Groundwater

Contaminant
Primary: Metals
Secondary: None

Phase Names
Pre-Study: ☐
EE/CA: ☑
Design: ☐
Removal Action: ☑
Remedial Action: ☐
Operations & Maintenance: ☐
Long Term Monitoring: ☐
Site Closeout: ☐

Documentation
Description: NA
Support Team: Documentation of personnel used to provide support for estimator and preparation of the estimate.
References: Documentation of reference sources used in the preparation of the estimate.

Estimator Information
Estimator Name: Charles Metz
Estimator Title: Project Engineer
Agency/Org./Office: Tetra Tech NUS, Inc.
Business Address: 661 Andersen Drive, Foster Plaza 7
Pittsburgh, PA 15220
Telephone Number: 412-921-8214
Email Address: charles.metz@tetratech.com
Estimate Prepared Date: 04/02/2010

Estimator Signature: CRM **Date:** 04-05-2010

Reviewer Information
Reviewer Name: Tom Riley
Reviewer Title:
Agency/Org./Office: Tetra Tech NUS, Inc.

Phase WBS - ECES Report (with Markups)

Business Address: 661 Andersen Drive, Foster Plaza 7
Pittsburgh, PA 15220

Telephone Number: 412-921-7237

Email Address: tom.riley@tetratech.com

Date Reviewed: 04/05/2010

Reviewer Signature: TJR **Date:** 04-05-2010

Phase Cost Summary Report
(with Markups)

Technology	Direct Cost	Markups	Total Cost
Excavation	$5,473	$3,183	$8,656
Phytoremediation	$39,772	$19,562	$59,334
Groundwater Monitoring Well	$10,071	$5,726	$15,797
Residual Waste Management	$1,947	$410	$2,357
Natural Attenuation	$193,015	$196,824	$389,839
Total Capital Cost	$250,278	$225,705	$475,983

	Direct Cost	Markups	Total Cost
Total Phase Cost	$250,278	$225,705	$475,983

Print Date: 4/5/2010 10:21:04 AM

Phase Cost Over Time Report
(with Markups)

Technology	2011	2012	2013	2014	2015	2016
Excavation	$8,656	$0	$0	$0	$0	$0
Phytoremediation	$59,334	$0	$0	$0	$0	$0
Groundwater Monitoring Well	$15,797	$0	$0	$0	$0	$0
Residual Waste Management	$2,357	$0	$0	$0	$0	$0
Natural Attenuation	$83,069	$34,086	$34,086	$34,086	$34,086	$34,086
Total Phase Cost	$169,212	$34,086	$34,086	$34,086	$34,086	$34,086

Phase Cost Over Time Report
(with Markups)

Technology	2017	2018	2019	2020	Total
Excavation	$0	$0	$0	$0	$8,656
Phytoremediation	$0	$0	$0	$0	$59,334
Groundwater Monitoring Well	$0	$0	$0	$0	$15,797
Residual Waste Management	$0	$0	$0	$0	$2,357
Natural Attenuation	$34,086	$34,086	$34,086	$34,086	$389,839
Total Phase Cost	$34,086	$34,086	$34,086	$34,086	$475,983

Print Date: 4/5/2010 12:48:38 PM

MARINE CORPS BASE CAMP LEJEUNE
Onslow County, North Carolina
D-6, Small Arms Range
Altnertive 3: Phytoremediation
Present Worth Analysis

4/5/2010 12:56 PM

Year	Capital Cost	Annual Cost	Total Year Cost	Annual Discount Rate 7.0%	Present Worth
0	$169,212		$169,212	1.000	$169,212
1		$34,086	$34,086	0.935	$31,856
2		$34,086	$34,086	0.873	$29,772
3		$34,086	$34,086	0.816	$27,824
4		$34,086	$34,086	0.763	$26,004
5		$34,086	$34,086	0.713	$24,303
6		$34,086	$34,086	0.666	$22,713
7		$34,086	$34,086	0.623	$21,227
8		$34,086	$34,086	0.582	$19,838
9		$34,086	$34,086	0.544	$18,541
10		$34,086	$34,086	0.508	$17,328
				TOTAL PRESENT WORTH	**$408,618**

Phase Assembly Level Data Report

Phase Name	Technology Name	Assembly Description	Qty	UOM	Materials	Labor	Equipment	SubBid	Extended Cost
Alternative 3 - Phytoremediation	Excavation	Excavate and load, bank measure, medium material, 3/4 C.Y. bucket, hydraulic excavator	497	BCY	0.00	2.58	0.84	0.00	1,700.52
Alternative 3 - Phytoremediation	Excavation	Seeding, Vegetative Cover	0.140000001	ACR	2,647.16	375.92	161.93	0.00	445.90
Alternative 3 - Phytoremediation	Excavation	Disposable Materials per Sample	40	EA	7.85	0.00	0.00	0.00	313.84
Alternative 3 - Phytoremediation	Excavation	Testing, TAL metals (6010/7000s)	10	EA	0.00	0.00	0.00	215.40	2,153.97
Alternative 3 - Phytoremediation	Excavation	Project Manager	5	HR	0.00	58.09	0.00	0.00	290.44
Alternative 3 - Phytoremediation	Excavation	Project Scientist	7	HR	0.00	58.85	0.00	0.00	411.92
Alternative 3 - Phytoremediation	Excavation	QA/QC Officer	1	HR	0.00	58.29	0.00	0.00	58.29
Alternative 3 - Phytoremediation	Excavation	Field Technician	1	HR	0.00	34.85	0.00	0.00	34.85
Alternative 3 - Phytoremediation	Excavation	Word Processing/Clerical	1	HR	0.00	29.96	0.00	0.00	29.96
Alternative 3 - Phytoremediation	Excavation	Draftsman/CADD	1	HR	0.00	32.88	0.00	0.00	32.88
									5,472.57
Alternative 3 - Phytoremediation	Phytoremediation	6' Galvanized Chain-link Fence	800	LF	33.36	2.13	0.46	0.00	28,768.23
Alternative 3 - Phytoremediation	Phytoremediation	Full Circle Sprinkler Head, 30' Diameter	4	EA	11.20	21.99	0.00	0.00	132.76
Alternative 3 - Phytoremediation	Phytoremediation	1,000 Gallon Nalgene Horizontal XLPE Tank without legs	1	EA	1,206.10	212.15	55.15	0.00	1,473.40
Alternative 3 - Phytoremediation	Phytoremediation	Truck, 2 Axle, Highway, 21,700 GVW, 4 x 2, 2 Axle	1	DAY	0.00	0.00	237.15	0.00	237.15
Alternative 3 - Phytoremediation	Phytoremediation	Mobilization Equipment (Soils)	1	LS	0.00	1,396.11	1,484.36	0.00	2,880.47
Alternative 3 - Phytoremediation	Phytoremediation	Demobilize Equipment (Soils)	1	LS	0.00	1,396.11	1,484.36	0.00	2,880.47
Alternative 3 - Phytoremediation	Phytoremediation	Per Diem (per person)	1	DAY	0.00	0.00	0.00	109.00	109.00
Alternative 3 - Phytoremediation	Phytoremediation	Portable Water Pump, 2", 10,000 GPH, Gas Powered, with Wheels	1	EA	1,854.51	325.26	0.00	0.00	2,179.77
Alternative 3 - Phytoremediation	Phytoremediation	Utilities Hook-up Fee	1	EA	0.00	0.00	0.00	703.78	703.78
Alternative 3 - Phytoremediation	Phytoremediation	Phytoremediation Grass (General Cost)	1520	SY	0.15	0.02	0.00	0.00	248.40
Alternative 3 - Phytoremediation	Phytoremediation	2" Polyethylene, flexible piping, SDR15, 125 psi	158	LF	1.01	0.00	0.00	0.00	158.85
									39,772.29
Alternative 3 - Phytoremediation	Groundwater Monitoring Well	Mobilize/DeMobilize Drilling Rig & Crew	1	LS	0.00	1,111.60	650.53	0.00	1,762.13
Alternative 3 - Phytoremediation	Groundwater Monitoring Well	Organic Vapor Analyzer Rental, per Day	1	DAY	0.00	0.00	0.00	31.55	31.55
Alternative 3 - Phytoremediation	Groundwater Monitoring Well	Decontaminate Rig, Augers, Screen (Rental Equipment)	1	DAY	18.96	444.57	0.00	0.00	463.53

Alternative 3 - Phytoremediation	Groundwater Monitoring Well	Field Technician	16	HR	0.00	34.85	0.00	0.00	557.57
Alternative 3 - Phytoremediation	Groundwater Monitoring Well	2" PVC, Schedule 40, Well Casing	50	LF	0.94	3.71	3.96	0.00	430.19
Alternative 3 - Phytoremediation	Groundwater Monitoring Well	2" PVC, Schedule 40, Well Screen	25	LF	3.13	3.71	3.96	0.00	269.71
Alternative 3 - Phytoremediation	Groundwater Monitoring Well	2" PVC, Well Plug	5	EA	10.15	11.12	11.87	0.00	165.66
Alternative 3 - Phytoremediation	Groundwater Monitoring Well	Hollow Stem Auger, 8" Dia Borehole, Depth <= 100 ft	80	LF	0.00	12.51	20.87	0.00	2,670.55
Alternative 3 - Phytoremediation	Groundwater Monitoring Well	Move Rig/Equipment Around Site	4	EA	69.37	159.79	93.51	0.00	1,290.72
Alternative 3 - Phytoremediation	Groundwater Monitoring Well	DOT steel drums, 55 gal., open, 17C	4	EA	87.01	0.00	0.00	0.00	348.02
Alternative 3 - Phytoremediation	Groundwater Monitoring Well	2" Screen, Filter Pack	35	LF	6.91	2.86	3.05	0.00	449.06
Alternative 3 - Phytoremediation	Groundwater Monitoring Well	Surface Pad, Concrete, 2' x 2' x 4"	5	EA	43.19	12.42	0.15	0.00	278.80
Alternative 3 - Phytoremediation	Groundwater Monitoring Well	2" Well, Portland Cement Grout	35	LF	0.90	0.00	0.00	0.00	31.60
Alternative 3 - Phytoremediation	Groundwater Monitoring Well	2" Well, Bentonite Seal	5	EA	111.51	73.91	78.93	0.00	1,321.74
									10,070.84
Alternative 3 - Phytoremediation	Residual Waste Management	Load Drums on Disposal Vehicle	14	EA	0.00	4.21	1.30	0.00	77.17
Alternative 3 -	Residual Waste Management	Transport 55 Gallon Drums of Hazardous Waste, Max 80 drums (per Mile)	50	MI	0.00	0.00	0.00	1.75	87.74
Alternative 3 - Phytoremediation	Residual Waste Management	Waste Stream Evaluation Fee, Not Including 50% Rebate on 1st Shipment	1	EA	0.00	0.00	0.00	438.36	438.36
Alternative 3 - Phytoremediation	Residual Waste Management	Landfill Nonhazardous Solid Waste, 55 Gallon Drum	14	EA	0.00	0.00	0.00	95.97	1,343.58
									1,946.86
Alternative 3 - Phytoremediation	Natural Attenuation	Sample collection, vehicle mileage charge, car or van	920	MI	0.00	0.00	0.00	0.58	533.60
Alternative 3 - Phytoremediation	Natural Attenuation	Per Diem (per person)	8	DAY	0.00	0.00	0.00	109.00	872.00
Alternative 3 - Phytoremediation	Natural Attenuation	Disposable Materials per Sample	21	EA	7.85	0.00	0.00	0.00	164.76
Alternative 3 - Phytoremediation	Natural Attenuation	Decontamination Materials per Sample	21	EA	10.24	0.00	0.00	0.00	215.04
Alternative 3 - Phytoremediation	Natural Attenuation	Oxygen/reduction potential meter rental	2	DAY	0.00	0.00	0.00	52.89	105.79
Alternative 3 - Phytoremediation	Natural Attenuation	Surface Soil Sampling Equipment	1	EA	422.90	0.00	0.00	0.00	422.90
Alternative 3 - Phytoremediation	Natural Attenuation	Power Auger Rental	1	DAY	0.00	0.00	25.45	0.00	25.45
Alternative 3 - Phytoremediation	Natural Attenuation	Monitor well sampling equipment, rental, water quality testing parameter device rental	1	WK	0.00	0.00	0.00	274.20	274.20
Alternative 3 - Phytoremediation	Natural Attenuation	Testing, soil & sediment analysis, pH, electrometric (9045)	21	EA	0.00	0.00	0.00	10.92	229.37
Alternative 3 - Phytoremediation	Natural Attenuation	Testing, dissolved solids	21	EA	0.00	0.00	0.00	15.89	333.78
Alternative 3 - Phytoremediation	Natural Attenuation	Testing, nitrogen, nitrate/nitrite	21	EA	0.00	0.00	0.00	27.48	577.16

Alternative 3 - Phytoremediation	Natural Attenuation	Testing, acidity/alkalinity	21	EA	0.00	0.00	0.00	13.92	292.32
Alternative 3 - Phytoremediation	Natural Attenuation	Testing, TAL metals (6010/7000s)	21	EA	0.00	0.00	0.00	195.82	4,112.12
Alternative 3 - Phytoremediation	Natural Attenuation	Testing, dissolved oxygen (DO)	21	EA	0.00	0.00	0.00	13.02	273.32
Alternative 3 - Phytoremediation	Natural Attenuation	Testing, sulfur: sulfate, sulfide, sulfite	21	EA	0.00	0.00	0.00	28.27	593.67
Alternative 3 - Phytoremediation	Natural Attenuation	Testing, TAL metals (6010/7000s)	22	EA	0.00	0.00	0.00	195.82	4,307.94
Alternative 3 - Phytoremediation	Natural Attenuation	Testing, TAL metals (6010/7000s)	22	EA	0.00	0.00	0.00	195.82	4,307.94
Alternative 3 - Phytoremediation	Natural Attenuation	Project Manager	4	HR	0.00	58.09	0.00	0.00	232.36
Alternative 3 - Phytoremediation	Natural Attenuation	Project Engineer	30	HR	0.00	51.71	0.00	0.00	1,551.43
Alternative 3 - Phytoremediation	Natural Attenuation	Project Scientist	187	HR	0.00	58.85	0.00	0.00	11,004.16
Alternative 3 - Phytoremediation	Natural Attenuation	Staff Scientist	80	HR	0.00	33.63	0.00	0.00	2,690.09
Alternative 3 - Phytoremediation	Natural Attenuation	Field Technician	97	HR	0.00	34.85	0.00	0.00	3,380.25
Alternative 3 - Phytoremediation	Natural Attenuation	Word Processing/Clerical	45	HR	0.00	29.96	0.00	0.00	1,348.23
Alternative 3 - Phytoremediation	Natural Attenuation	Draftsman/CADD	41	HR	0.00	32.88	0.00	0.00	1,348.18
Alternative 3 - Phytoremediation	Natural Attenuation	DOT steel drums, 55 gal., open, 17C	10	EA	87.01	0.00	0.00	0.00	870.06
Alternative 3 - Phytoremediation	Natural Attenuation	Well Development Equipment Rental (weekly)	1	WK	0.00	0.00	0.00	540.48	540.48
Alternative 3 - Phytoremediation	Natural Attenuation	PVC bailers, disposable polyethylene, 1.50" OD x 36"	10	EA	3.43	0.00	0.00	0.00	34.27
									40,640.89
									97,903.45

C-3 SOIL WASHING

MARINE CORPS BASE CAMP LEJEUNE
Onslow County, North Carolina
D-6, Small Arms Range
Alternative 4: Soil Washing
Capital Cost

4/8/2010 9:29 AM

Item	Quantity	Unit	Unit Cost Subcontract	Unit Cost Material	Unit Cost Labor	Unit Cost Equipment	Extended Cost Subcontract	Extended Cost Material	Extended Cost Labor	Extended Cost Equipment	Subtotal
1 PROJECT PLANNING & DOCUMENTS											
1.1 Prepare Construction/Work Plans	300	hr			$37.00		$0	$0	$11,100	$0	$11,100
2 MOBILIZATION, DEMOBILIZATION AND FIELD SUPPORT											
2.1 Underground Utility Clearances	1	ls	$7,350.00				$7,350	$0	$0	$0	$7,350
2.2 Construction Survey Support	1	day	$1,075.00				$1,075	$0	$0	$0	$1,075
2.3 Equipment Mobilization/Demobilization	3	ea			$177.00	$610.00	$0	$0	$531	$1,830	$2,361
2.4 Site Superintendent	12	day		$116.00	$384.64		$0	$1,392	$4,616	$0	$6,008
3 DECONTAMINATION											
3.1 Decontamination Services	1	ls		$1,250.00	$2,350.00	$1,550.00	$0	$1,250	$2,350	$1,550	$5,150
3.2 Equipment Decon Pad	1	ls		$4,500.00	$3,000.00	$725.00	$0	$4,500	$3,000	$725	$8,225
3.3 Disposal of Decon Waste (liquid & solid)	1	ls	$500.00				$500	$0	$0	$0	$500
4 PRE EXCAVATION SAMPLING											
4.1 Laboratory Samples, lead	20	ea	$60.00	$10.00			$1,200	$200	$0	$0	$1,400
4.2 XRF rental	1	wk				$1,500.00	$0	$0	$0	$1,500	$1,500
4.3 Site Superintendent	4	day		$116.00	$384.64		$0	$464	$1,539	$0	$2,003
4.4 Site Labor, (1 laborer)	4	day			$264.80		$0	$0	$1,059	$0	$1,059
5 EXCAVATION AND SOIL WASHING											
5.1 Backhoe/Loader, 86 hp	10	day			$343.60	$387.60	$0	$0	$3,436	$3,876	$7,312
5.2 XRF rental	2	wk				$1,500.00	$0	$0	$0	$3,000	$3,000
5.3 Site Labor, (3 laborers)	30	day			$264.80		$0	$0	$7,944	$0	$7,944
5.4 Verification Samples, lead	5	ea	$150.00	$10.00			$750	$50	$0	$0	$800
5.5 Soil Washing	253	cy	$150.00				$37,950	$0	$0	$0	$37,950
5.6 Hazardous Soil Transportation & Disposal	76	ton	$285.00				$21,660	$0	$0	$0	$21,660
5.7 Waste Disposal Characterization / Analytical	1	ea	$850.00	$30.00	$50.00	$30.00	$850	$30	$50	$30	$960
6 SITE RESTORATION											
6.1 Backfill, common fill	51	cy		$15.20			$0	$775	$0	$0	$775
6.2 Seed	10.0	msf	$77.50				$775	$0	$0	$0	$775
6.3 Backhoe/Loader, 86 hp	2	day			$343.60	$387.60	$0	$0	$687	$775	$1,462
6.4 Site Labor, (3 laborers)	6	day			$264.80		$0	$0	$1,589	$0	$1,589
7 MONITORING WELLS											
7.1 DPT Mobilization/Demobilization	1	ea	$2,000.00				$2,000	$0	$0	$0	$2,000
7.2 Install Monitoring Wells, 2" PVC, 5 wells, 15' deep	75	lf	$55.00				$4,125	$0	$0	$0	$4,125
7.3 Monitoring Well Head	5	ea	$500.00				$2,500	$0	$0	$0	$2,500
7.4 IDW Disposal	5	drum	$165.00				$825	$0	$0	$0	$825
8 POST CONSTRUCTION COST											
8.1 Contractor Completion Report	150	hr			$37.00		$0	$0	$5,550	$0	$5,550
8.2 Remedial Action Closeout Report	200	hr			$37.00		$0	$0	$7,400	$0	$7,400
Subtotal							$81,560	$8,661	$50,850	$13,286	$154,358
Overhead on Labor Cost @ 30%									$15,255		$15,255
G & A on Labor, Material, Equipment, & Subs Cost @ 10%							$8,156	$866	$5,085	$1,329	$15,436
Tax on Materials and Equipment Cost @ 4.5%								$390		$598	$988
Total Direct Cost							$89,716	$9,917	$71,191	$15,213	$186,036
Indirects on Total Direct Cost @ 35%											$65,113
Profit on Total Direct Cost @ 10%											$18,604
Subtotal											$269,753
Health & Safety Monitoring @ 2%											$5,395
Total Field Cost											$275,148

Item	Quantity	Unit	Unit Cost Subcontract	Unit Cost Material	Unit Cost Labor	Unit Cost Equipment	Extended Cost Subcontract	Extended Cost Material	Extended Cost Labor	Extended Cost Equipment	Subtotal
Contingency on Total Field Costs @ 30%											$82,544
Engineering on Total Field Cost @ 25%											$68,787
TOTAL CAPITAL COST											**$426,479**

MARINE CORPS BASE CAMP LEJEUNE
Onslow County, North Carolina
D-6, Small Arms Range
Alternative 4: Soil Washing
Annual Cost

Item	Item Cost first year	Notes
Sampling	$25,800	Labor and supplies to collect samples using a crew of two, four times a year for year 1.
Analysis/Soil & Sediment	$1,820	Analyze samples for lead.
Sampling Report	$6,000	
Subtotal	$33,620	
Contingency @ 10%	$3,362	
TOTAL	**$36,982**	

MARINE CORPS BASE CAMP LEJEUNE
Onslow County, North Carolina
D-6, Small Arms Range
Alternative 4: Soil Washing
Present Worth Analysis

Year	Capital Cost	Annual Cost	Total Year Cost	Annual Discount Rate at 7%	Present Worth
0	$426,479		$426,479	1.000	$426,479
1		$36,982	$36,982	0.935	$34,578
			TOTAL PRESENT WORTH		**$461,057**

APPENDIX D

RESPONSES TO COMMENTS

D-1 RESPONSES TO REGULATOR COMMENTS

REVIEW COMMENTS		PROJECT: DOCUMENT:	Investigation of Former Indoor Small Arms Firing Range April 2010, Engineering Evaluation/Cost Analysis for Not-Time Critical Removal Action D-6, 50-Foot Indoor Rifle and Pistol Range – UXO-01 (Former Building 451)	
		Date: Reviewer: Phone: Date: Reviewer: Phone:	10/05/10 Stacey Haire, USEPA– Legal Counsel (404) 562-8960 10/05/10 Ms. Gena Townsend, USEPA, Reg. 4 (404) 562-8538	Action on comments taken by: Rick Barringer and Charles Metz
Item No.	**Page, Section, Paragraph**	**Comments**	**Response**	**Response Acceptance (A-agree) (D-disagree)**
EPA -1	Section 3.1	Remove the words "and guidance" from the first sentence of Section 3.1.	The words "and guidance" were removed from the first sentence of Section 3.1.	A
EPA -2	Section 3.3.2	The NC soil remediation goals table that I found seemed to set the antimony soil level at 6.3 rather than 6.2. Please check.	The PRG for antimony was changed to 6.3 mg/kg to reflect the current North Carolina SRG table (updated October 2010).	A
EPA -3	Sections 4 and 5	The post excavation groundwater sampling should be increased from "two" to "four" consecutive events.	The post excavation groundwater sampling component of each alternative was changed in Sections 4.1.2, 4.1.3, and 4.1.4 to state that a minimum of 4 consecutive events would be conducted. Specifically, it now states: "*Post-excavation groundwater monitoring (lead only) would be conducted quarterly for one year to potentially support a no further action determination for groundwater.*" In addition, the following sentence was changed in the last bullet of Section 5.0 to reflect that 4 quarters of sampling must occur: "*If lead concentrations do not exceed the PRG in an individual well for four consecutive quarters, that well will be removed from the monitoring program.*"	A

Metz, Charles

From: Beck, Bryan K CIV NAVFAC MidLant [bryan.k.beck@navy.mil]
Sent: Monday, May 24, 2010 10:04 AM
To: Morgan, Martha; robert.a.lowder@usmc.mil; Cleland, David T CIV NAVFAC MIDLANT; townsend.gena@epa.gov; Barringer, Rick
Cc: Mcelveen, Randy
Subject: RE: NCDENR Comments on EE/CA for UXO-01, Former Indoor Rifle and Pistol Range

Thanks Marti

-----Original Message-----
From: Morgan, Martha [mailto:martha.morgan@ncdenr.gov]
Sent: Monday, May 24, 2010 9:54
To: robert.a.lowder@usmc.mil; Cleland, David T CIV NAVFAC MIDLANT; Beck, Bryan K CIV NAVFAC MidLant; townsend.gena@epa.gov; Rick.Barringer@tetratech.com
Cc: Mcelveen, Randy
Subject: NCDENR Comments on EE/CA for UXO-01, Former Indoor Rifle and Pistol Range

Hey there,

We have finished review of the Engineering Evaluation/Cost Analysis for Non-Time Critical Removal Action at the D-6, 50-Foot Indoor Rifle and Pistol Range, UXO-01, Former Building 451 and concur with the recommendations made in Section 5 of the EE/CA. Thanks and let me know if you need anything else on this.

Marti

D-2 RESPONSES TO PUBLIC COMMENTS