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Range Environmental Vulnerability Assessment Periodic Review

Marine Corps Installations East-Marine Corps Base Camp Lejeune

March 2016

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Tables

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Appendices

Acronym	Definition
bgs	Below Ground Surface
BMP	Best Management
BZO	Battlesite Zero
CBC	Company Battle Course
CMP	Combat Marksmanship Range
CSM	Conceptual Site Model
DoD	Department of Defense
DoDIC	Department of Defense Identification Code
EOD	Explosive Ordnance Disposal
ETA	Engineer Training Area
HE	High Explosive
FY	Fiscal Year
GSRA	Greater Sandy Run Area
HMX	Cyclotetramethylene Tetranitramine
ID	Identification
$kg/m^2/yr$	Kilograms per Square Meter per Year
lb	Pounds
lb/yr	Pounds per Year
MAC	Military Operations in Urban Terrain Assault Course
MC	Munitions Constituents
MCB	Marine Corps Base
MCIEAST-MCB CAMLEJ	Marine Corps Installations EAST-Marine Corps Base Camp Lejeune
MOUT	Military Operations in Urban Terrain
RDX	Cyclotrimethylene Trinitramine
MDL	Method Detection Limit
mg/kg	Milligrams per Kilogram
NC	North Carolina
NTU	Nephelometric Turbidity Unit
ORC	Operational Range Clearance
PAH	Polyaromatic Hydrocarbons
REVA	Range Environmental Vulnerability Assessment
RFMSS	Range Facility Management Scheduling System
RUSLE	Revised Universal Soil Loss Equation
SAR	Small Arms Range
SARAP	Small Arms Range Assessment Protocol
SDZ	Surface Danger Zone
SR	Sandy Run
TNT	Trinitrotoluene
SOP	Standard Operating Procedure
TECOM	Training and Education Command
U.S.	United States

USEPA	United States Environmental Protection Agency
UXO	Unexploded Ordnance
μg/kg	Micrograms per Kilogram
μg/L	Micrograms per Liter

Executive Summary

Introduction

The United States (U.S.) Marine Corps (Marine Corps) Range Environmental Vulnerability Assessment (REVA) program meets the requirements of the Department of Defense (DoD) Instruction 4715.14 *Operational Range Assessments*.

The REVA program is a proactive and comprehensive program designed to support the Marine Corps' Range Sustainment Program. Operational ranges across the Marine Corps are assessed to identify areas and activities that are subject to possible impacts from external influences, as well as to determine whether a release or substantial threat of a release of munitions constituents (MC) from operational ranges to off-range areas creates an unacceptable risk to human health or the environment. This is accomplished through periodic assessments of operational range areas and, where applicable, the use of fate and transport modeling and analysis of the REVA indicator MC based on site-specific environmental conditions at the operational ranges and training areas. REVA indicator MC are evaluated to determine the potential for an off-range release of MC. These MC were selected because they are common constituents used in a wide variety of military munitions and because of their chemical stability in the environment. The indicator MC include cyclotetramethylene tetranitramine (HMX), cyclotrimethylene trinitramine (RDX), trinitrotoluene (TNT), perchlorate, and lead. HMX, RDX, TNT, and perchlorate are evaluated at ranges where high explosives are used, while lead is evaluated at small arms ranges (SARs).

This report presents the periodic review for Marine Corps Base (MCB) Camp Lejeune, Marine Corps Air Station New River, and Marine Corps Outlying Field Oak Grove, all located in southeastern North Carolina (NC). These areas are collectively referred to as Marine Corps Installations EAST-MCB Camp Lejeune (MCIEAST-MCB CAMLEJ). This report documents the review of munitions loading from 2011 through 2014, referred to as the periodic review period.

MCIEAST-MCB CAMLEJ is located in Onslow County, North Carolina and encompasses approximately 143,835 acres, with the majority of the installation (approximately 107,263 acres) designated for training purposes. The southeastern boundary of the installation is approximately 11.5 miles of the Atlantic Ocean beachfront. MCIEAST-MCB CAMLEJ is the Marine Corps' largest amphibious training base and home to the largest single concentration of Marines in the world (MCB Camp Lejeune, 2006).

Summary of Areas Assessed

The REVA periodic review installation visit was conducted in May 2014, and at that time, 222 operational range and training areas were identified within MCIEAST-MCB CAMLEJ. These areas were subdivided into 85 operational training areas, 3 operational impact areas, and 134 operational ranges.

MC loading areas are identified in REVA to describe where the majority of MC is deposited during training missions on a range or training area. These areas may encompass an entire range, target areas, or a portion of the range area. During this periodic review period, 37 MC loading areas were identified at MCIEAST-MCB CAMLEJ, as listed in **Table ES-1.**

Table ES-1: MC Loading Areas at MCIEAST-MCB CAMLEJ

MC Loading Areas		
Combat Town	F Ranges	K-504A/B
Devil Dog	F-6	K-505
EOD-1	G-6 (Company Battle Course [CBC])	K-510
EOD-2	G-7	L-5
EOD-3	G-10 Impact Area	Military Operations in Urban Terrain (MOUT) Assault Course (MAC)-3
ETA-1	G-10A	MOUT Complex
ETA-2	G-19 Ranges	N1/BT-3 Impact Area
ETA-3	K-2 Impact Area	SR-6
ETA-4	K-323	SR-7
ETA-5/5A	K-407	SR-10
ETA-7/7C	K-408	Stone Bay Area
ETA-9	K-500	
ETA-10	K-500A	

Forty-one SARs were qualitatively evaluated in this periodic review. SARs with similar characteristics in proximity to one another were grouped for the assessment, resulting in 29 SAR assessments, as presented in **Table ES-2**.

Table ES-2: SAR Assessment Groupings

SARs		
A-1	Hathcock Range	K-509
Alpha, Bravo, and Charlie	I-1	MAC-1, MAC-2, MAC-4, MAC-5, and MAC-6

SARs		
B-12	K-325	Mechanical Pistol
D-29A and D-29B	K-402 and K-402A	Multi-Purpose Range
D-30	K-406A and K-406B	R-100
Dodge City	K-501 and K-501A	Square Bay
F-4	K-503 and K-503A	SR-8
F-11A and F-11B	K-506	SR-11
F-18	K-507	Walk Down Pistol
G-21	K-508	

Average annual MC loading (mass per area per year) was estimated for TNT, RDX, HMX, and perchlorate for each MC loading area using expenditure data provided by the installation. Annual lead deposition (mass per year) was estimated for each MC loading area and SAR. These estimates were used in screening-level assessments to determine potential fate and transport of MC in surface water, sediment, and groundwater. Lead deposition estimates were used in the qualitative evaluation of SARs.

Screening-Level Assessment Results

Screening-level fate and transport assessments were conducted for 36 of the 37 identified MC loading areas at MCIEAST-MCB CAMLEJ to determine conservative estimates of MC concentrations in surface water, sediment, and groundwater at identified potential off-range receptor locations down gradient of MC loading areas at the installation boundary. The screening assessment was not conducted for the N1/BT-3 MC loading area because it was estimated to have low MC loading and is located in a tidally influenced area where MC are mixed with a large volume of water that is expected to provide significant dilution of any MC that may be present. If infiltrating precipitation reaches shallow groundwater, it is expected to discharge to the Atlantic Ocean where any potential MC would not be at detectable concentrations.

Surface Water and Sediment

The 36 MC loading areas assessed at MCIEAST-MCB CAMLEJ using the screening level model are located in 13 subwatersheds including the different segments of the New River and the Intracoastal Waterway, tributary streams of the New River and the Intracoastal Waterway, and two swamps located west of the New River. The identified down gradient off-range receptor locations are at the installation boundary within these subwatersheds. The primary surface water receptors identified are ecological receptors. Down gradient off range locations were selected as the modeled receptor locations in order to predict potential off-range releases at the installation boundary. Surface water at MCIEAST-MCB CAMLEJ is used for recreational purposes including fishing, swimming, and boating; however, it is not used as a drinking water source and does not represent a significant human exposure pathway.

The REVA screening-level surface water and sediment assessment at MCIEAST-MCB Camp Lejeune involved: 1) estimating the average annual MC concentrations in surface water runoff and sediment at the edge of each MC loading area, and 2) conducting a mixing calculation to determine the cumulative contribution of MC from individual MC loading areas draining to an off-range receptor location at the installation boundary.

Table ES-3 presents the 13 modeled receptor locations for surface water and sediment. The screening-level assessment predicted all sediment concentrations to be below detectable concentrations at the off-range downgradient receptor locations at the installation boundary. **Table ES-3** shows predicted MC concentrations in surface water at the modeled receptor locations. Detectable concentrations of RDX and TNT were predicted in the subwatersheds of New River between Town Creek and Stones Bay and in Bear Creek. The G-10 Impact Area MC loading area contributed 78% of the RDX mass and 98% of the TNT mass to the New River between Town Creek and Stones Bay and almost 100% of RDX and TNT mass to Bear Creek.

Table ES-3: Screening-Level Estimates of Annual Average MC Concentrations in Surface Water (including Runoff and Base Flow) Entering the Identified Downstream Off-Range Receptor Locations at the Installation Boundary

Downstream Off-Range Receptor Locations at the Installation Boundary Receiving Drainage from MC Loading Areas	Drainage Area (acres)	Estimated MC Concentration (µg/L)			
		HMX	RDX	TNT	Perchlorate
Shelter Swamp Creek	31,746	~0	~0	~0	~0
Juniper Swamp	20,127	~0	~0	~0	~0
Southwest Creek	28,830	~0	~0	~0	~0
Stones Creek	7,587	~0	~0	~0	0.002
New River at Stones Bay	12,294	~0	0.037	0.004	~0
New River between Stick Creek and Whitehurst Creek	14,544	~0	0.022	0.012	~0
New River between Town Creek and Stones Bay	21,123	0.004	**0.221**	**0.828**	~0
Wallace Creek	12,868	~0	0.021	0.009	~0
Intracoastal Waterway between Alligator Creek and Freeman Creek	11,749	~0	0.006	0.010	~0
New River between Stones Bay and Intracoastal Waterway	7,810	N/A	0.001	~0	~0
Bear Creek	6,886	0.002	**0.132**	**0.615**	~0
Intracoastal Waterway between Browns Inlet and Queen Creek	6,247	~0	0.014	0.013	~0

Downstream Off-Range Receptor Locations at the Installation Boundary Receiving Drainage from MC Loading Areas	Drainage Area (acres)	Estimated MC Concentration (µg/L)			
		HMX	RDX	TNT	Perchlorate
Freeman Creek	2,789	~0	0.020	0.012	~0
REVA median MDL for water		*0.077*	*0.097*	*0.108*	*0.06*

Note:
N/A = not modeled, as the MC loading rate was estimated to be negligible
Shading and bold indicate concentration exceeds the median MDL.

Groundwater

The groundwater screening-level assessment was conducted for the 36 MC loading areas identified at MCIEAST-MCB CAMLEJ. The REVA screening-level groundwater assessment at MCIEAST-MCB Camp Lejeune was a five-step process: 1) determine maximum MC concentrations in infiltrating water at each MC loading areas, 2) model the potential for MC to migrate from the MC loading areas vertically through the vadose zone to groundwater within the unconfined surficial aquifer, 3) model MC reaching the water table horizontally within the saturated zone in the surficial aquifer to potential receptor locations in surface water, 4) model vertical transport of MC that reaches the surficial aquifer to the semiconfined Castle Hayne aquifer, and 5) model horizontal transport of MC that reaches the Castle Hayne aquifer to potential groundwater receptors (drinking water wells). At each step of the process, the predicted MC concentrations were compared to median MDL values, and only the MC exceeding median MDLs were assessed in the next step. **Table ES-4** shows results of Step 5: receptor locations (i.e., wells) where detectable MC concentrations were predicted to reach.

Table ES-4: Model-Estimated MC Concentrations Potentially Reaching Groundwater Receptors

MC Loading Area	Well ID Where MC Exceeds Median MDL	Concentration at Nearest Perennial Stream (µg/L)			
		HMX	RDX	TNT	Perchlorate
G-10A	NPSW-2	NM	NM	NM	**0.161**
G-19 Ranges	PSW-2	NM	NM	NM	**0.141**
K-510	NPSW-1	N/A	NM	NM	**0.100**
L-5	Unknown [a]	NM	NM	NM	**0.340**
ETA-3	PSW-6	NM	NM	NM	**0.200**
EOD-2	None	NM	~0	NM	NM
Combat Town	PSW-1	NM	NM	NM	**0.185**
Mobile MOUT Complex	NPSW-4	NM	NM	NM	**0.344**
Stone Bay Area	None	NM	NM	NM	0.032

MC Loading Area	Well ID Where MC Exceeds Median MDL	Concentration at Nearest Perennial Stream (µg/L)			
		HMX	RDX	TNT	Perchlorate
REVA median MDL for water		*0.077*	*0.097*	*0.108*	*0.06*

Note:
N/A = not applicable - not modeled, as MC loading was estimated to be negligible
NM = not modeled because preceding steps in the groundwater screening assessment resulted in estimated concentrations below detectable limits.
Shading and bold indicate predicted concentration exceeds the median MDL.

[a] County well located off-installation. The well ID is unknown.

SAR Assessments

Forty-one SARs were identified at the installation and grouped for evaluation based on location and use, resulting in 29 SARs or groups of SARs. Qualitative evaluation of the SARs is based on the following factors:

- Range use
- Range design and layout
- Physical and chemical characteristics of the area
- Past and present operation and maintenance practices
- Lead migration pathways and receptors (groundwater, surface water, and sediment)

An overall ranking of minimal, moderate, or high is determined using the Small Arms Range Assessment Protocol (SARAP) for the surface water and groundwater migration pathways based on a scoring of these factors. A high ranking indicates the greatest potential for lead migration and receptor impact. Results of the SAR evaluations are provided in **Table ES-5**.

Table ES-5: Summary of SARAP Results

SAR	Surface Water / Sediment Ranking	Groundwater Ranking
A-1	Minimal	Minimal
Alpha, Bravo, and Charlie	Moderate	Moderate
B-12	Minimal	Minimal
D-29A and D-29B	Minimal	Minimal
D-30	Moderate	Minimal
Dodge City	Moderate	Minimal
F-4	Minimal	Minimal
F-11A and F-11B	Minimal	Minimal
F-18	High	Moderate

SAR	Surface Water / Sediment Ranking	Groundwater Ranking
G-21	Moderate	Moderate
Hathcock Range	Moderate	Moderate
I-1	Minimal	Minimal
K-325	High	Moderate
K-402 and K-402A	Moderate	Minimal
K-406A and K-406B	High	Moderate
K-501 and K-501A	Moderate	Moderate
K-503 and K-503A	High	Moderate
K-506	Moderate	Minimal
K-507	Moderate	Minimal
K-508	High	Moderate
K-509	Moderate	Minimal
MAC-1, MAC-2, MAC-4, MAC-5, and MAC-6	Moderate	Minimal
Mechanical Pistol	Minimal	Minimal
Multi-Purpose Range	Minimal	Minimal
R-100	High	Minimal
Square Bay	Minimal	Minimal
SR-8	Moderate	Moderate
SR-11	Minimal	Minimal
Walk Down Pistol	Minimal	Minimal

Note:
NA = not assessed using SARAP based on the screening evaluation

Lead Loading in Subwatersheds

Although SARs are the largest contributors of lead at Marine Corps installations, some HE ranges also use significant quantities of lead. Subwatersheds where it was estimated that over 40,000 pounds of lead are loaded annually from use of both high explosive (HE) ranges and SARs are Shelter Swamp Creek, Stones Creek, New River at Stones Bay, and New River between Towns Creek and Stones Bay. Field sampling was conducted to evaluate these areas where high lead use was observed.

Field Sampling

Field sampling was completed in September 2014 as part of the periodic review. Sample locations were identified in the screening-level assessments, SARAPs, review of previously conducted annual monitoring, and a review of lead loading at a subwatershed level. A baseline evaluation of the R-100 skeet range was also completed.

Twelve surface water samples were collected from nine locations receiving drainage from range areas. Upper and lower depth intervals were collected at three of the nine locations. Samples analyzed for the following analytes:

- Five samples were analyzed for explosives and perchlorate
- Six samples were analyzed for total and dissolved lead and total hardness
- One sample was analyzed for explosives, perchlorate, total and dissolved lead, and total hardness

Upper and lower depth intervals were also sampled at a surface water reference location and analyzed for explosives, perchlorate, total and dissolved lead, and total hardness.

Ten groundwater samples were collected and analyzed for the following analytes:

- Seven samples were analyzed for perchlorate
- Two samples were analyzed for total and dissolved lead and total hardness
- One sample was analyzed for perchlorate, total and dissolved lead, and total hardness

Two surface water samples, four surface sediment samples, six surface soil samples, and six subsurface soil samples were collected and analyzed at the skeet range for lead and PAHs. Surface water was also analyzed for total hardness and dissolved lead, and soil and sediment were analyzed for pH. In order to better characterize soil/sediment for evaluating potential lead and PAH mobility, one sediment sample and four soil samples were analyzed for moisture content, sulfate, phosphate, total organic carbon, total inorganic carbon, cation exchange capacity, and particle size analysis.

Screening Criteria

Sampling was completed in September 2014. Appropriate surface water criteria were determined based on North Carolina classifications of surface water bodies. Screening criteria used were:

- Surface water: DoD screening values for ecological freshwater and ecological marine surface water systems (DoD, 2013) and North Carolina Protection Standards for protection of freshwater aquatic life, saltwater aquatic life, and human health (based on fish consumption only) (15A NCAC 02B, updated May 15, 2013).
- Groundwater: DoD Screening Values for human drinking water (DoD, 2013) and the most conservative of North Carolina Protection Standards for Groundwater Supply (15A NCAC 02L.0200, updated April 1, 2013), U.S. Environmental Protection Agency (USEPA) Maximum Contaminant Levels (MCLs), or USEPA tap water Regional Screening Levels (RSLs) (USEPA, November 2014).
- Sediment: DoD screening value for freshwater sediment (DoD, 2013) and North Carolina Federal Remediation Branch Soil Screening Levels (NCDENR, 2013).
- Soil: USEPA industrial and residential RSLs (USEPA, November 2014) and North Carolina Federal Remediation Branch Soil Screening Levels (NCDENR, 2013).

Surface Water Analytical Results

Three surface water sample locations are positioned around the K-2 Impact Area; three locations receive runoff from the G-10 Impact Area; one location is on the west side of the GSRA; one location is in Stones Bay; one location is in Wallace Creek; and one reference sample location is near the northern boundary of the installation in the New River. Total lead was detected at five of seven field samples and both reference samples, and all results were below the North Carolina Protection Standard of 25 µg/L for total lead. Dissolved lead was detected in three of seven field samples but neither reference sample, and all results were below screening criteria. Explosives and perchlorate were not detected in the six field samples analyzed or the reference sample.

Groundwater Analytical Results

Ten groundwater samples were collected from three potable supply wells, three non-potable supply wells, and four monitoring wells. Total lead was detected in three of the wells analyzed, and dissolved lead was detected in two wells and the duplicate of a third well. All detected concentrations were below the DoD and North Carolina standard of 15 µg/L for total and dissolved lead. Perchlorate was not detected in the eight wells sampled.

R-100 Skeet Range Analytical Results

A drainage ditch runs roughly parallel with the R-100 skeet range firing line flowing southeast to northwest. It was partially dry at the time of sampling, but a debris pile at the northwest extent of the ditch indicates that flow in this direction carries range debris including shotgun wads and deposits them in this area.

Two surface water samples plus one duplicate sample were collected from the drainage swale. Samples were analyzed for total and dissolved lead, PAHs, and hardness. The sample collected from the location farthest west (downgradient of the skeet range) in the swale contained a total lead concentration of 26 µg/L (duplicate result of 31 µg/L), exceeding the North Carolina freshwater ecological protection standard of 25 µg/L. The dissolved lead concentration in this sample was 22 µg/L (duplicate result of 23 µg/L), while the other surface water sample contained a dissolved lead concentration of 2.2 µg/L. Dissolved lead results exceeded the hardness-adjusted DoD screening criteria of 1.36 µg/L and 0.84 µg/L. PAHs were not detected in any sample collected.

Four surface sediment samples (0–6 inches bgs) were collected from the drainage swale. Lead was detected at all sample locations with a maximum concentration of 73 µg/kg in the sample farthest west (downgradient), which exceeded the DoD freshwater sediment screening value of 47 µg/kg and the USEPA Region 4 screening value of 30.2 µg/kg. All other lead concentrations in sediment were below screening benchmarks. Four PAHs were detected, but all detected concentrations were over an order of magnitude below USEPA Region 4 screening criteria.

Soil samples were collected from six locations at two depths: 0–6 inches below ground surface [bgs] and 18–24 inches bgs. Lead was detected in all 12 samples with a maximum concentration of 48 µg/kg, which is approximately an order of magnitude below the EPA residential RSL and North Carolina SSL. PAHs were detected at three locations, and all detected concentrations except one were an order of magnitude or greater below all screening criteria. Benzo(a)pyrene exceeded the USEPA residential RSL of 15 µg/kg in one surface soil sample with an estimated concentration of 29 µg/kg.

Soil and Sediment Characterization

Soil and sediment characteristics that can have a significant influence on mobility and availability of lead and PAHs in the environment include pH, phosphorus, sulfate, cation exchange capacity, and organic matter. Lead and many organic constituents, such as PAHs, are more mobile under acidic conditions where the pH is less than 6. Based on analyses for the soil and sediment samples, the soil characteristics are conducive to increasing mobility and availability of lead and PAHs. pH of both the soil and sediment is acidic, with 90% of the samples between 3.1 and 5.3. Phosphorus and sulfur concentrations are low and therefore unlikely to form insoluble lead minerals. The low cation exchange capacity and low organic matter content measured at the skeet range is characteristic of very sandy soils and are not expected to strongly bind lead or PAHs in the soil or sediment.

Summary

Screening level assessments and field sampling did not indicate off-installation releases of MC from operational ranges at MCIEAST-MCB CAMLEJ. However, detected lead concentrations minimally exceeded screening criteria for surface water and sediment at the R-100 skeet range; and benzo(a)pyrene was detected in surface soil at the skeet range slightly above its residential RSL. The installation boundary is up-gradient of these sample locations and these results do not indicate an off-installation release. Very few PAHs were detected at low concentrations and do not indicate that skeet range operations are resulting in significant PAH impacts.

Lead was detected at slightly elevated concentrations in surface water and sediment on the downgradient side of the skeet range, indicating that lead has potential to migrate off range. Wallace Creek is the downgradient receptor location from the skeet range, and lead was below detection levels in the sample collected and analyzed from the creek in September 2014. Surface water and sediment samples were collected in a stormwater drainage at the skeet range, and the pathway to human or ecological receptors for drinking water or recreation is not considered complete. Current concentrations are only slightly above conservative screening criteria and do not indicate an immediate threat to human health or the environment. Range management practices are being implemented to prevent future migration of lead, including lime soil amendments and removal of range debris from the range and stormwater ditch. Annual monitoring efforts will be conducted as needed to monitor concentrations, and a full reevaluation of all operational ranges will be conducted in the next periodic review cycle.

1. Introduction

1.1 Purpose

The United States (U.S.) Marine Corps (Marine Corps) Range Environmental Vulnerability Assessment (REVA) program meets the requirements of the Department of Defense (DoD) Instruction 4715.14 *Operational Range Assessments*.

The REVA program is a proactive and comprehensive program designed to support the Marine Corps' Range Sustainment Program. Operational ranges across the Marine Corps are assessed to identify areas and activities that are subject to possible impacts from external influences, as well as to determine whether a release or substantial threat of a release of munitions constituents (MC) from operational ranges to off-range areas creates an unacceptable risk to human health or the environment. This is accomplished through periodic assessments of operational range areas and, where applicable, the use of fate and transport modeling and analysis of the REVA indicator MC based on site-specific environmental conditions at the operational ranges and training areas.

This report presents the periodic review for Marine Corps Base (MCB) Camp Lejeune, Marine Corps Air Station New River, and Marine Corps Outlying Field Oak Grove, all located in southeastern North Carolina (NC). These areas are collectively referred to as Marine Corps Installations EAST-MCB Camp Lejeune (MCIEAST-MCB CAMLEJ) throughout the remainder of this report. This report documents the review of munitions loading from 2011 through 2014, referred to as the periodic review period. The results of the prior REVA reviews are provided in the REVA, Marine Corps Base Camp Lejeune, NC and the REVA Five-Year Review Report, Marine Corps Base Camp Lejeune, NC (Malcolm Pirnie, 2009; ARCADIS/Malcolm Pirnie, 2012).

1.2 Scope and Applicability

The scope of the REVA program includes Marine Corps operational ranges located within the United States and overseas. Operational ranges (as defined in 10 United States Code 101 (e)(3)) include, but are not limited to, HE ranges, live-fire maneuver areas, small arms ranges (SARs), buffer areas, and training areas where military munitions are known or suspected to have been currently or historically used.

The indicator MC evaluated in the REVA program include cyclotetramethylene tetranitramine (HMX), cyclotrimethylene trinitramine (RDX), trinitrotoluene (TNT), perchlorate, and lead. HMX, RDX, and TNT were selected because they are common high explosives (HEs) used in a wide variety of military munitions and because of their chemical stability in the environment. Perchlorate is a component of the solid propellants used in some military munitions; it is highly soluble and has low sorption potential and a low natural degradation rate that make the compound highly mobile in the environment. Lead is the most prevalent potentially hazardous constituent in small arms ammunition and is used as an indicator to identify potential impacts of training related to small arms usage. Additional information pertaining to the physical and chemical characteristics of the REVA indicator compounds is provided in the *REVA Reference Manual* (HQMC, 2009).

1.3 Installation Overview

MCIEAST-MCB CAMLEJ is located in Onslow County, NC and encompasses approximately 143,835 acres, with the majority of the installation (approximately 107,263 acres) designated for training purposes. The southeastern boundary of the installation is approximately 11.5 miles of the Atlantic Ocean beachfront. A site location map is provided as **Figure 1-1**. MCIEAST-MCB CAMLEJ is the Marine Corps' largest amphibious training base and home to the largest single concentration of Marines in the world (MCB Camp Lejeune, 2006). The installation provides specialized training for those serving in U.S. Marine Forces Command and is also home to the Marine Corps Engineer School, the U.S. Coast Guard's Special Missions Training Center, the Marine Special Operations Command, the School of Infantry-East, the II Marine Expeditionary Force, and other Training and Education Command formal schools.

The REVA periodic review installation visit was conducted in May 2014, and at that time, 222 operational range and training areas were identified within MCIEAST-MCB CAMLEJ. These areas were subdivided into 85 operational training areas, 3 operational impact areas, and 134 operational ranges. All ranges, training areas, and corresponding details are provided in **Appendix A.**

Ten fixed ranges that use HE and/or perchlorate were constructed during the periodic review period. One of the 10 ranges is located in the Greater Sandy Run Area (GSRA): SR-12, an improvised explosives device course, is located in training area ST in the GSRA. Five of the 10 ranges are explosive ordnance disposal (EOD) or engineering training areas (ETAs), which were constructed in a central part of the installation to replace inactive ranges EOD-1 and ETA-3:

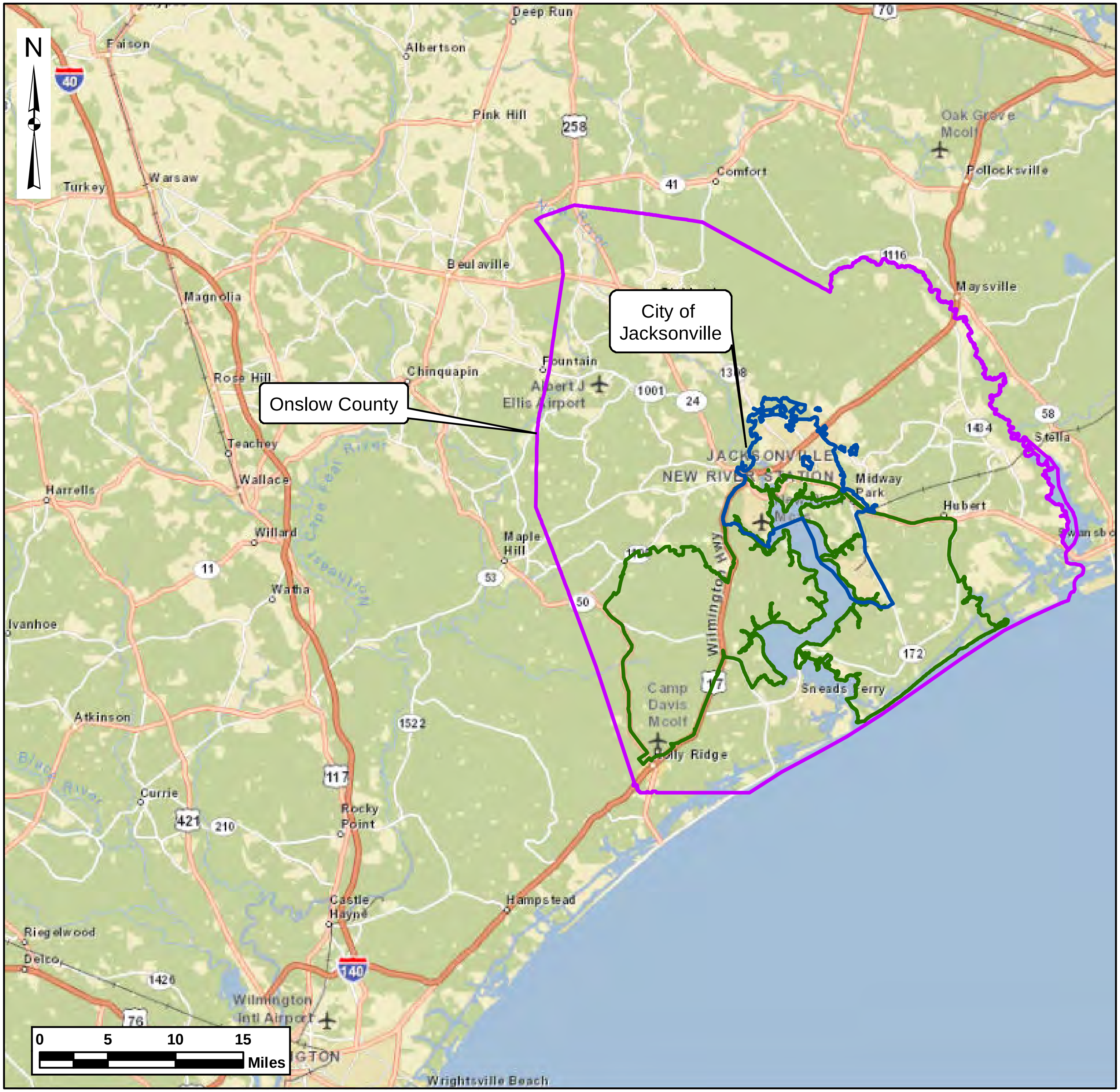
- EOD-3
- ETA-7
- ETA-8
- ETA-9
- ETA-10

Four of the 10 new ranges constructed are located in the K-2 Impact Area. During the periodic review period, ranges with surface danger zones (SDZs) within the K-2 Impact Area were reviewed at Headquarters Marine Corps. Several SDZs were made inactive and replaced or realigned based on an analysis of range and weapons system use. The four new fixed ranges at the K-2 Impact Area were constructed over the footprints of recently inactivated ranges. K-323 was the only range in the K-2 Impact Area that became inactive and did not have a new range constructed in its footprint. The four ranges are:

- K-500 Mortar Range (constructed in part of K-211 footprint) – activated in 2011
- K-500A MK-19 Range (constructed in part of K-212 footprint) – activated in 2011
- K-502 Rocket Range (constructed in part of K-302 footprint) – activated in 2011
- K-505 Rocket Range (constructed in part of K-309 footprint) – activated in 2013

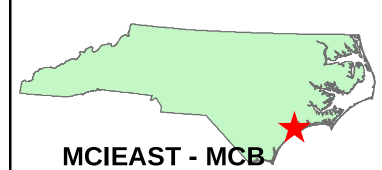
FIGURE 1-1
MCIEAST-MCB CAMLEJ
SITE LOCATION

REVA
MCIEAST-MCB CAMLEJ



Legend

- Installation Boundary
- County Boundary
- City Boundary



Coordinate System: UTM
Zone: 18N
Datum: NAD83
Units: Meters

Date: June 2015

Sounce: Aerial - ESRI
MCB/NREA GIS Office 2014
Onslow County, NC GIS Office 2014

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Expenditure data indicated that range K-502 was not used during the periodic review period; therefore, this range was not further evaluated.

Two ranges were under construction during the May 2014 REVA site visit. G-27 in the G-10 Impact Area and SR-9 in the GSRA were scheduled to become active during the fall of 2014. These ranges were not evaluated in this review because they were not used during the periodic review period; however, will be evaluated in the next periodic review cycle or earlier as needed.

Six SARs were constructed during the periodic review period. Four of the new SARs were constructed in the K-2 Impact Area over the footprints of recently deactivated ranges:

- K-506 Day/Night and Combat Field Firing Range (constructed in part of K-315 footprint) – activated in 2013
- K-507 Close Combat and Combat Marksmanship Range (CMP) Range (constructed in part of K-317 footprint) – activated in 2013
- K-508 Battlesite Zero (BZO)/Live-Fire Maneuver Range (constructed in part of K-319 footprint) – activated in 2013
- K-509 Live-Fire Maneuver Range (constructed in part of K-321/321A footprint) – activated in 2013

The other two SARs constructed during the periodic review period were G-21 and R-100. G-21 was constructed in the G-10 Impact Area and became active in 2012. The D-9 Skeet Range was closed in July 2011 and is now managed under a different regulatory program. The R-100 Skeet/Trap Range opened in August 2012 to replace D-9 and is located approximately 2.5 miles northeast of its former location.

1.4 Summary of Areas Addressed in the Periodic Review

MC loading areas are identified in REVA to describe where the majority of MC is deposited during training missions on a range or training area. These areas may encompass an entire range, target areas, or a portion of the range area. During this periodic review period, 37 MC loading areas were identified at MCIEAST-MCB CAMLEJ. These MC loading areas are distributed throughout the installation as shown in **Figure 1-2**, and they are listed below.

- Combat Town
- Devil Dog
- EOD-1
- EOD-2
- EOD-3
- ETA-1
- ETA-2
- ETA-3
- ETA-4
- ETA-5/5A
- ETA-7/7C
- ETA-9
- ETA-10
- F Ranges

- F-6
- G-6 (Company Battle Course [CBC])
- G-7
- G-10 Impact Area
- G-10A
- G-19 Ranges
- K-2 Impact Area
- K-323
- K-407
- K-408
- K-500
- K-500A
- K-504A/B
- K-505
- K-510
- L-5
- Military Operations in Urban Terrain (MOUT) Assault Course (MAC)-3
- MOUT Complex
- N1/BT-3 Impact Area
- SR-6
- SR-7
- SR-10
- Stone Bay Area

Some of these MC loading areas aggregate expenditure data from multiple ranges. A summary of these MC loading areas and the ranges listed in the Range Facility Management Scheduling System (RFMSS) expenditure data that contributed to these MC loading areas is presented in **Table 1-1**.

Table 1-1: Summary of Ranges Contributing to MC Loading Areas

MC Loading Area	Contributing Ranges
G-10 Impact Area	G-3, G-10 UCAS, G-10 Convoy Site 3, G-29A, G-29B, Naval Gunfire, all Gun Positions, all Mortar Positions
K-2 Impact Area	K-2A, Gun Position 16K
N1/BT-3 Impact Area	BT-3, H-1
F-Ranges	F-2, F-5
Mobile MOUT Complex	MOUT-Lejeune; Live Fire Buildings 2, 24, 36, 40, 67; MOUT-Mobile Farm House; MOUT-Mobile Non-Live Fire; MOUT-Sniper Tower
Stone Bay Area	Non-Lethal Weapons Grenade 1, Urban Training Facility Breacher Pit

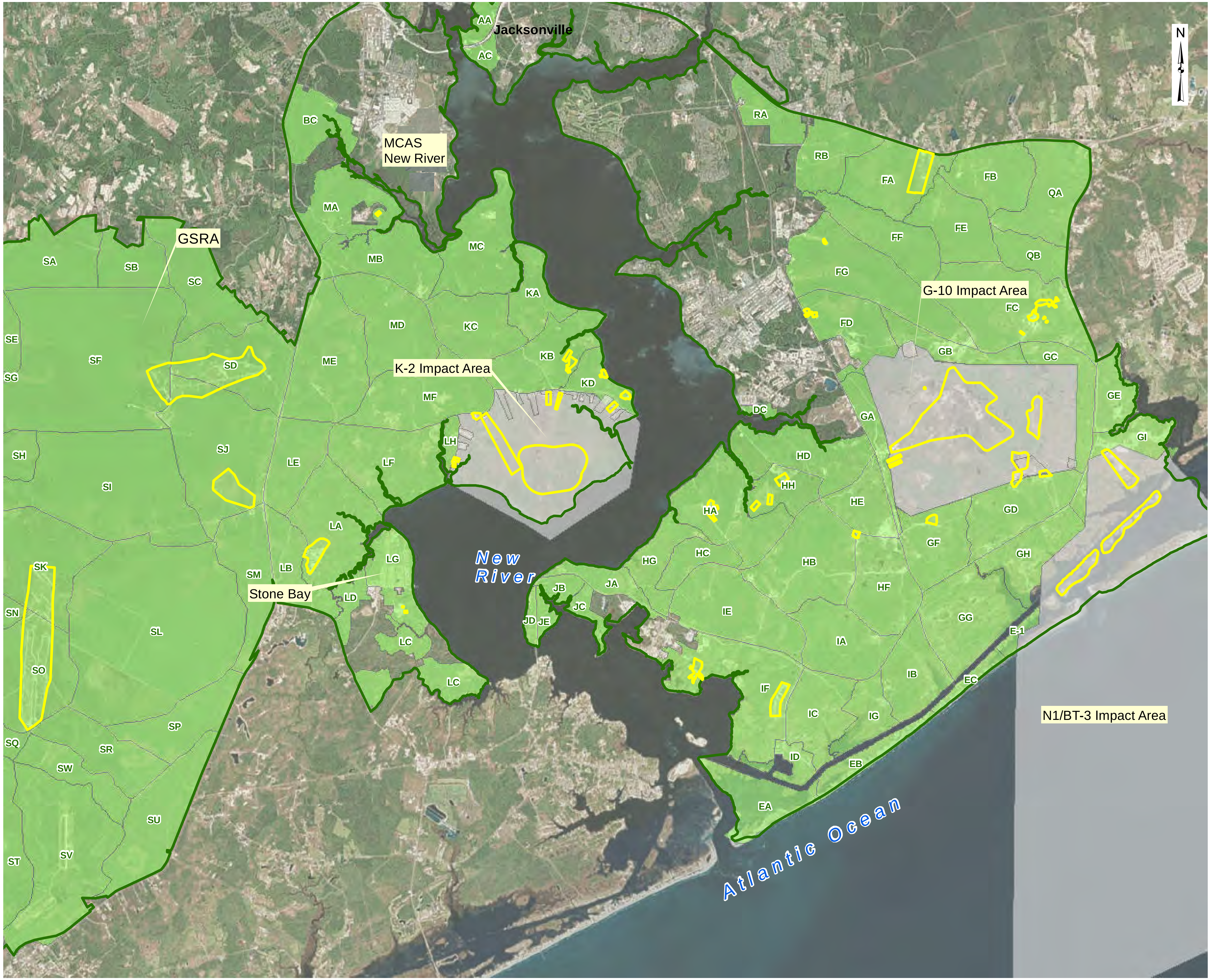


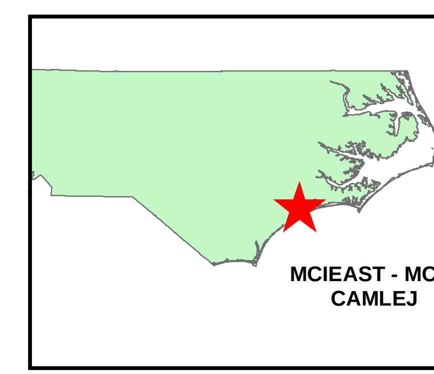
FIGURE 1-2
MCIEAST-MCB CAMLEJ
MC LOADING AREAS

REVA
MCIEAST - MCB CAMLEJ

Legend

- Installation Boundary
- Training Area
- Impact Area
- MC Loading Area

Note:
GSRA - Greater Sandy Run Area
- MC loading areas are shown in yellow text.



0 0.4 0.8 1.6 2.4
Miles

Coordinate System: UTM
Zone: 18N
Datum: NAD83
Units: Meters

Date: June 2015

Source: Aerial - ESRI
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Thirty-one MC loading areas were evaluated during the previous five-year review (completed in 2012), and all but six of these MC loading areas were included in the periodic review (G-5, G-8 and G-9, K-211/212, K-301, K-303 to 305, and K-405). Of ranges included in these six MC loading areas, G-5 was the only range used during the periodic review period, and only a small amount of small arms ammunition was used at the range; therefore, it was not evaluated as an MC loading area. The remaining five ranges were made inactive prior to the periodic review period.

Forty-one SARs were qualitatively evaluated in this periodic review, and 10 of these 41 SARs were constructed during the periodic review period (G-21, K-501, K-501A, K-503, K-503A, K-506, K-507, K-508, K-509, R-100). SARs with similar characteristics in proximity to one another were grouped for the assessment, resulting in 29 SAR assessments:

- A-1
- Alpha, Bravo, and Charlie
- B-12
- D-29A and D-29B
- D-30
- Dodge City
- F-4
- F-11A and F-11B
- F-18
- G-21
- Hathcock Range
- I-1
- K-325
- K-402 and K-402A
- K-406A and K-406B
- K-501 and K-501A
- K-503 and K-503A
- K-506
- K-507
- K-508
- K-509
- MAC-1, MAC-2, MAC-4, MAC-5, and MAC-6
- Mechanical Pistol
- Multi-Purpose Range
- R-100
- Square Bay
- SR-8
- SR-11
- Walk Down Pistol

<u>Comparison to 5-Year Review</u>

Thirty-seven SARs were evaluated during the previous five-year review (completed in 2012), and all but six were included in the periodic review. These six SARs (K-309, K-315, K-317, K-319, K-321, and K-321A) were located in the K-2 Impact Area and became inactive during or before 2011. SARs with similar characteristics in proximity to one another were grouped together for the assessment, resulting in 27 SAR assessments during the five-year review.

2. Assessment Methods and Results

MCIEAST-MCB CAMLEJ was assessed qualitatively through the development of a site-specific conceptual site model (CSM) and quantitatively through screening-level transport assessments. This section presents the MC deposition estimates, the site-specific CSM, and the screening-level modeling results.

2.1 Conceptual Site Model

A CSM is used to characterize the dynamics that may affect off-range migration of MC, including potential exposure pathways and receptors. The site-specific CSM for MCIEAST-MCB CAMLEJ builds on and updates the installation CSM developed as part of the baseline and five-year REVAs (Malcolm Pirnie, 2009; ARCADIS/Malcolm Pirnie, 2012).

2.1.1 Operational Range Clearance

Operational range clearance (ORC) is conducted by the Training and Education Command (TECOM) as a safety measure to reduce the explosive hazard to Marines during training and minimize risks during construction activities. REVA benefits from the ORC program through reducing the MC present on operational ranges thereby reducing potential for MC migration from impact areas. Since the REVA 5-Year Review, ORC activities were conducted in the G-10 Impact Area (ORC completed in 2013), Camp Geiger (completed in 2014), Range F-5 (completed in 2013), and the K-2 Impact Area (on-going). Clearance activities in these areas included surface sweeps with some subsurface clearances to 2 feet below ground surface (bgs). Range Control personnel provided descriptions of the clearance work completed, and using this information, ORC was factored into the MC loading estimations to account for reduced MC loads for affected ranges. This adjustment to the MC loading approach is discussed in **Section 2.1.2.2**.

2.1.2 Estimated Munitions Constituents Loading

2.1.2.1 Munitions Constituents Loading Approach

The MC loading of HE and perchlorate was estimated based on mass-loading principles using military munitions expenditure data and estimated dud / high order / low order detonation rates. Studies have shown that MC are deposited on the operational range through low and high order detonations and may leach from corroded UXO. These processes are represented in the equation:

Total MC loading = MC (low orders) + MC (high orders) + MC (UXO)

Note:

1. MC (low orders) is the amount of MC deposited as a result of low order detonations.
2. MC (high orders) is the amount of MC deposited as a result of high order detonations.
3. MC (UXO) is the amount of MC deposited as a result of UXO with breached casings.

The REVA process accounts for MC contributed from all three of these potential sources, but MC remaining from low order detonations are the most significant contributors to MC loading. MC loading rates for low order detonations, high order detonations, and UXO were estimated for each MC loading area using the following equations:

> MC (low order) = (number of military munitions expended) x (low order rate) x (amount of residual remaining from a low order detonation)
>
> MC (high order) = (number of military munitions expended) x (high order rate) x (amount of residual remaining from a high order detonation)
>
> MC (UXO) = (number of military munitions expended) x (dud rate) x (amount of residual exposed as a result of damage to UXO casing)

MC loading areas were defined based on known history and current training activities in order to estimate MC loading rates, which is the MC loading input in the screening-level models. These areas represent locations at which significant MC loading is occurring or suspected to have occurred from training with munitions containing HE (TNT, RDX, and HMX), illumination rounds, or other munitions containing solid propellants (perchlorate) and metals (lead). MC loading areas were adjusted for the periodic review to reflect updated information about locations of range facilities, known targets, SDZs, aerial imagery, information from range personnel, visual notes from the site visit, and munitions use data. Training-specific information for some ranges and training areas indicated minimal use or use of munitions that result in negligible MC loading since the REVA five-year review. Therefore, MC loading areas were not defined at these ranges.

MC loading was estimated using the REVA MC Loading Rate Calculator (described in the REVA 5-Year Review Manual) and modified to account for standard management practices at demolition and EOD ranges and for ORC activities that occurred during the periodic review period. These modifications are described in **Section 2.1.2.2.** Total lead deposition at impact areas and HE ranges was estimated using the lead content in each munition and the number of ordnance items used. Given the nature of lead deposition, deposition estimates assume no lead consumption from impact and that all of the lead contained within the munition is deposited in the MC loading area. Similarly, lead deposition estimates at SARs were also based on the total number of cartridges expended at the range and the amount of lead in each cartridge. MC loading areas are shown in **Figure 1-2.**

2.1.2.2 Munitions Constituents Loading Assumptions

MC loading is based primarily on munitions expenditure data obtained from the TECOM, which covers the period from fiscal year (FY) 2011 through March 2014 (3 years and 6 months). The expenditure data were used to develop annual averages of expenditures for each MC loading area identified. These averages then were used in the MC loading calculator to generate estimated MC loading rates for each MC loading area. Some assumptions were made that affected how the data were used:

- The primary expenditure data provided by TECOM were RFMSS data. According to range personnel, these data capture expenditure use for all training and EOD operations at MCIEAST-MCB CAMLEJ. The RFMSS data provided were broken out by year and range. Annual average expenditure totals were calculated for each munition type based on a period of 365 days. Exceptions follow:

    - There were five ranges (K-309, K-315, K-319, K-321, K-321A) that were active for less than a year during the beginning of FY 2011 before becoming inactive. The expenditure counts from FY2011 were used to complete loading estimates, rather than calculating average annual use during the entire periodic review period.
    - There were some expenditures listed where DoD Identification Codes (DoDICs) did not correspond with documented range use, and the DoDIC appeared to be a typing error. Range personnel confirmed these occurrences were due to incorrect entry into RFMSS. The expenditure counts of the entries in question were proportionally distributed among the other DoDICs listed for the same range within that year.
    - There were occurrences where munitions listed in the expenditure data were not expected to be used at the specific ranges listed. If the munitions were limited quantities and did not represent a significant deposition of MC, they were not incorporated into the calculations. If the munitions were significant quantities, they were attributed to the closest range where those munitions are used.
- MCIEAST-MCB CAMLEJ constructed eight new ranges on footprints of ranges that had become inactive early during the periodic review period. The expenditures from both the inactive and active ranges were combined and attributed to a single MC loading area.
- The expenditure summaries contain some DoDICs for which information on MC content was not available in Munitions Items Disposition Action System (MIDAS) or other inventories. These entries were managed using one of the two following methods:
    - In some of these instances, general descriptions of the munitions associated with these DoDICs were provided, either as part of the installation data or in other readily available sources. These descriptions were considered in relation to the range design and use, and a surrogate DoDIC with the most similar description was selected from available data sources for use in the MC loading calculations.
    - Where no descriptions of the munitions were provided, the associated expenditures for the unknown DoDICs were proportionally distributed among other DoDICs used at the same range that year.
- Range personnel confirmed that all donor charges and destroyed items associated with EOD operations were tracked in RFMSS; therefore, EOD commitment sheet data were not incorporated into MC loading calculations.
- MC loading areas affected by ORC activities at MCIEAST-MCB CAMLEJ during the periodic review period included the G-10 impact area and Range F-5. Based on the date of completion provided by Range Control personnel, a percentage of the munitions expenditures were adjusted to reflect assumed 100% high order detonations to account for the clearance activities. ORC was ongoing at the K-2 Impact Area during the periodic review site visit, but information regarding activities was not available; therefore, ORC was not factored into MC loading estimates at the K-2 Impact Area.
- Expenditures associated with EOD and demolition activities were adjusted to reflect an assumed 100% high order detonation for the MC loading calculations. Lead deposition associated with EOD and demolition activities was conservatively reduced to 5% of potential deposition in these instances to account for standard operating procedures (SOPs) where munitions debris is collected and removed from the range.

RFMSS data provided by the installation included dud/UXO rates for some expenditures. These rates were not used to replace the standard dud assumptions in the REVA MC Loading Rate Calculator because these data were not reported for a long enough period to develop meaningful dud rates. As such, the REVA standard dud rate assumptions were used.

The MC loading rates and lead deposition estimates generated by the MC loading rate calculator are listed in **Appendix B**, along with the calculated lead deposition at each SAR. Additional details regarding the MC loading methods are outlined in the REVA Reference Manual and REVA 5-Year Review Manual (HQMC, 2009; HQMC, 2010).

2.1.3 Potential Pathways and Receptors

Exposure pathways identified at MCIEAST-MCB CAMLEJ for off-range human and ecological receptors are surface water, sediment, and/or groundwater. Potential transport pathways are shown in **Figure 2-1.**

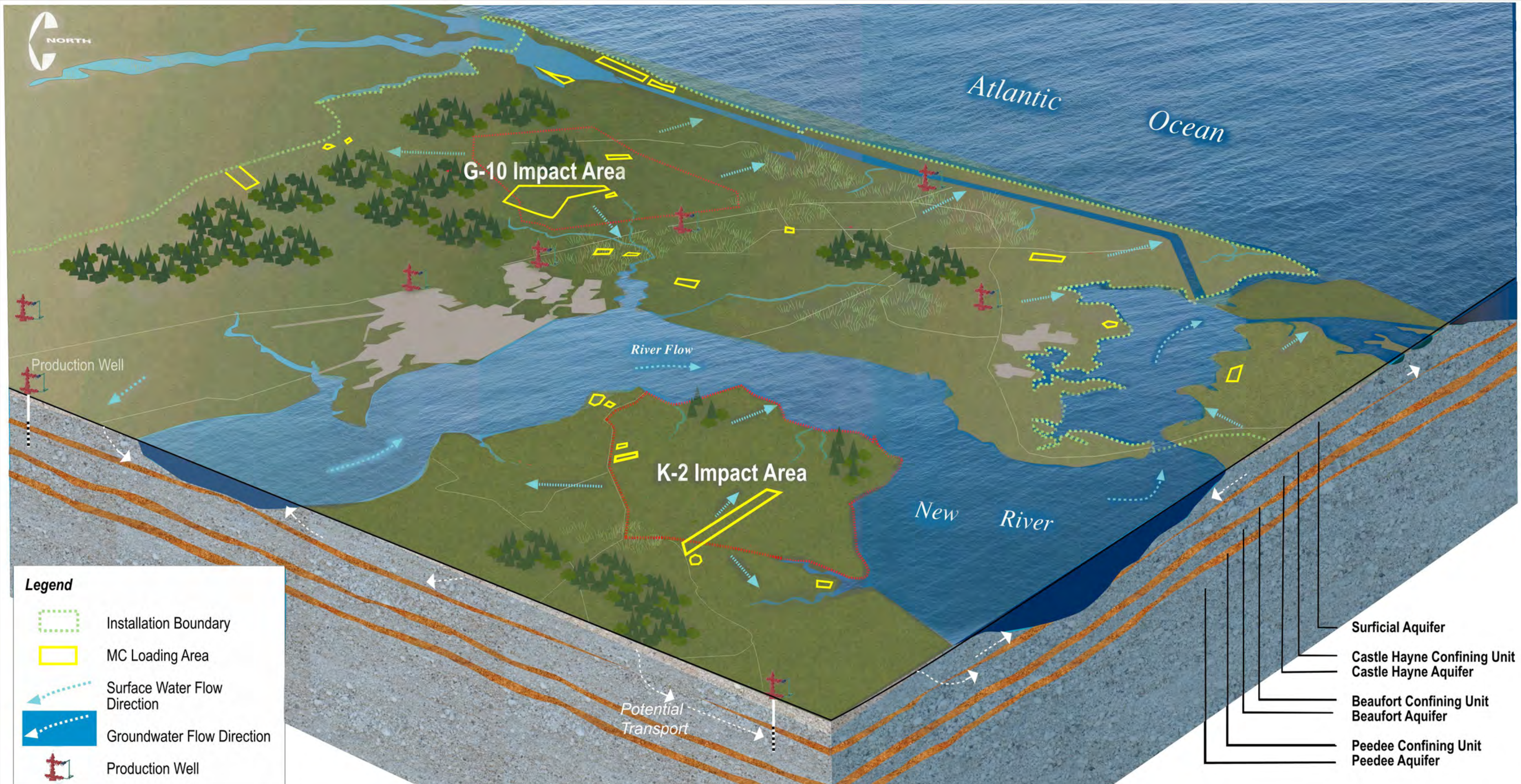
2.1.3.1 Surface Water and Sediments

MC loading areas identified in this periodic review are located in 14 subwatersheds, which have been delineated within the MCIEAST-MCB CAMLEJ installation boundary at a 10-digit hydrologic unit code level. These are the subwatersheds of the different segments and tributaries of the New River, the Intracoastal Waterway, and two swamps located west of the New River (**Figure 2-2**).

Based on the estimated surface water runoff rate at the identified MC loading areas, there is a high potential for MC to migrate via surface water runoff from the MC loading areas. The high estimated surface water runoff rate at all the MC loading areas is attributed to the high precipitation (average of 56 inches per year), the sparse vegetation cover at many of the loading areas, and soil types at several of the MC loading areas.

MC sorbed to sediment can be released from loading areas at MCB Camp Lejeune through eroded soils carried in surface water runoff that drain to intermittent and perennial streams before discharging into larger surface water bodies. The New River embayment and its tributaries, the Intracoastal Waterway and its tributaries, and the Atlantic Ocean are used for recreational purposes, including fishing, swimming, and boating; however, surface water does not represent a significant human exposure pathway since it is not a drinking water source. Special status ecological species habitat areas and restricted zones are found within the 14 subwatersheds. Surface water-related ecological receptor locations include streams, tidal creeks, swamps, wetlands, and near shore marine environments (such as the New River and Onslow Bay) that support ecological receptors, potentially including threatened and endangered and other special status species, such as the red cockaded woodpecker, loggerhead sea turtle, and the bald eagle. The special status species are described in more detail in the *REVA Five-Year Review MCB Camp Lejeune* (ARCADIS/Malcolm Pirnie, 2012).

Erosion characteristics of the MC loading areas, as quantified in the Revised Universal Soil Loss Equation (RUSLE), indicate low to high potential for soil erosion. Low soil erosion potential was estimated for 2 MC loading areas, moderate soil erosion potential was estimated for 31 MC loading areas, and high soil erosion potential was estimated for 4 MC loading areas. The moderate or high soil erosion potential at 35 of the 37 identified MC loading areas is attributable to the relatively high rainfall erosivity for the region



Notes:

Surface features shown are not intended to be exact locations but rather are representative of those present on the installation.

Possible MC Migration Pathways:

- Most surface water drains into the New River either directly or via its tributaries, with some southern areas draining into the Intracoastal Waterway before discharging into the Atlantic Ocean.
- Potential transport from the surficial aquifer to the Castle Hayne Aquifer in areas where the Castle Hayne Confining Unit is thinned or not present.
- Shallow groundwater discharges to the New River, all its tributaries (including swamps, wetlands, and streams), and the Atlantic Ocean.
- Surface water is used for fishing, boating, swimming, training, and ecological habitat.
- The Castle Hayne Aquifer is a drinking water source.
- T&E species present in surface waters at the installation include the Atlantic Loggerhead sea turtle, the green sea turtle, and the American alligator.

Not to Scale

FIGURE 2-1
Graphical Conceptual Site Model of MCIEAST-MCB Camp Lejeune

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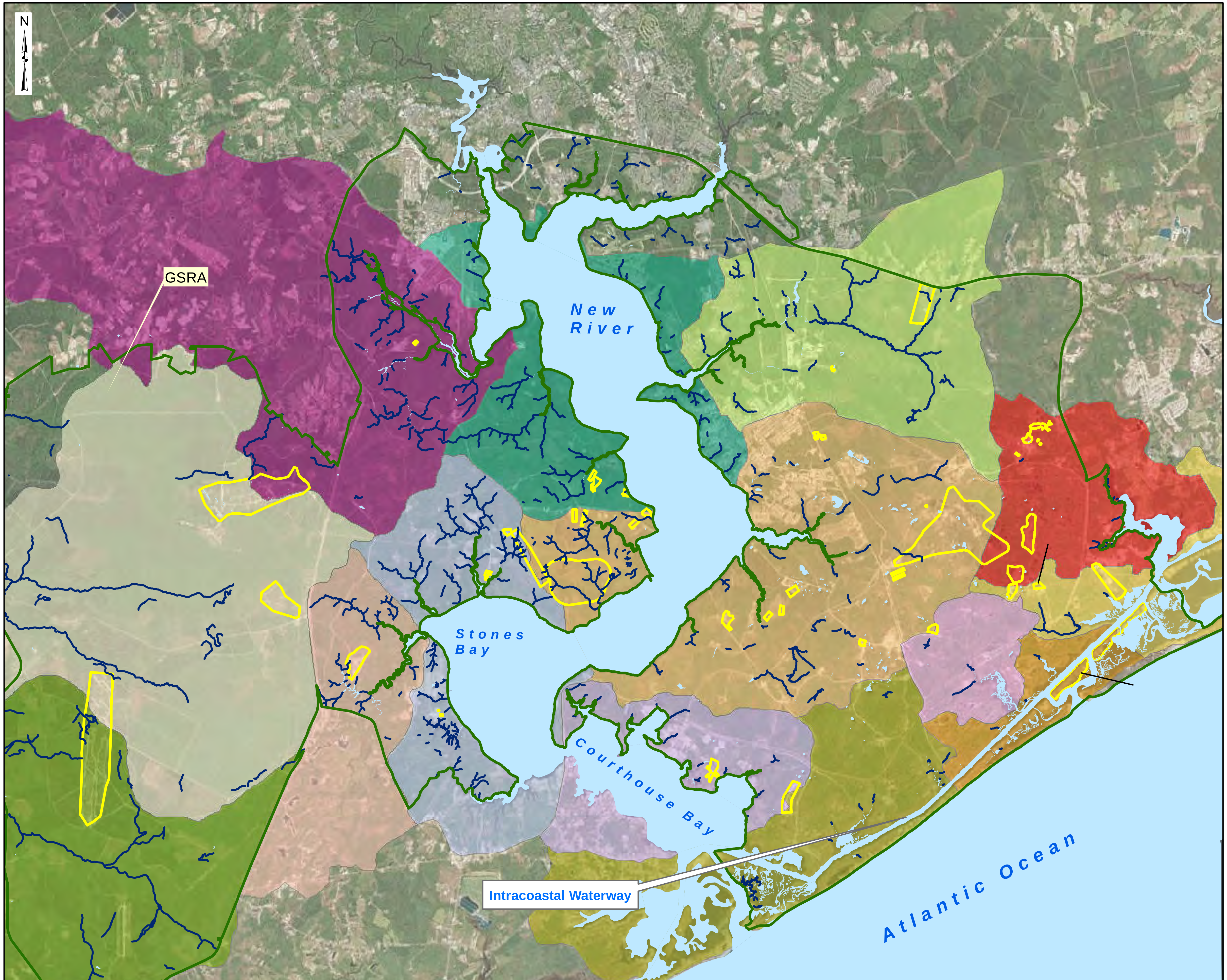

FIGURE 2-2
MCIEAST-MCB CAMLEJ
SURFACE WATER FEATURES

REVA
MCIEAST - MCB CAMLEJ

Legend

Installation Boundary
MC Loading Area

Stream

Dry
Intermittent
Permanent
Surface Water

Subwatershed Area

Bear Creek
Freeman Creek
Intracoastal Waterway between Browns Inlet and Queen Creek
Intracoastal Waterway between Alligator Creek and Freeman Creek
Intracoastal Waterway between Gillete Creek and Browns Creek
Juniper Swamp
New River at Stones Bay
New River between Stick Creek and Whitehurst Creek
New River between Town Creek and Stones Bay
New River between Stones Bay and Intracoastal Waterway
Shelter Swamp Creek
Southwest Creek
Stones Creek
Wallace Creek

0 0.45 0.9 1.8 2.7
Miles

Coordinate System: UTM
Zone: 18N
Datum: NAD83
Units: Meters

Date: June 2015

Source: Aerial - ESRI
MCB/NREA GIS Office 2014

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and the sparse vegetation cover at many of the MC loading areas. MC loading areas that were estimated to have high soil erosion potential have steeper topographic slopes (ranging from 8% to 13%), whereas the two MC loading areas that were estimated to have low soil erosion potential are gently sloping (slopes less than 3%). The moderate or high soil erosion potential that may occur at most of the identified MC loading areas makes soil erosion an important mechanism for MC mobilization in surface water.

2.1.3.2 Groundwater

MC may migrate to the water table after dissolution into infiltrating rainwater due to the shallow water table and the presence of sandy soils, which result in a relatively high recharge rate (ranging from approximately 5 to 21 inches per year [Heath, 1989]). Other factors affecting migration of MC to the water table include mass loading at the surface, aqueous solubility, and retardation of the MC due to soil characteristics. Shallow groundwater in the surficial aquifer generally flows toward streams and other surface water features. Potential ecological receptors are in the surface water where shallow groundwater discharges. There are no known shallow groundwater drinking water users within or outside of MCIEAST- MCB CAMLEJ. It is not anticipated that there are off-installation receptors of shallow groundwater, but a comprehensive investigation to identify individual domestic wells or irrigation wells outside the installation boundary has not been conducted.

Shallow groundwater from the surficial aquifer recharges the underlying confined aquifers, including the underlying Castle Hayne aquifer. Over most of the installation, a confining unit reduces the rate of flow to the Castle Hayne aquifer; however, this confining unit is absent in some areas, allowing for a direct connection between the surficial and Castle Hayne aquifers (shown in **Figure 2-1**). The semi-confined Castle Hayne aquifer at MCIEAST-MCB CAMLEJ provides the drinking water source for the installation, for areas just outside the installation, and for the City of Jacksonville, NC. At the time of the REVA site visit, installation personnel indicated there were 60 active potable wells within the boundaries of MCIEAST-MCB CAMLEJ, all screened within the Castle Hayne aquifer. Four of the 60 active wells were added after the REVA five-year review was completed for MCIEAST-MCB CAMLEJ. These four wells are located west of the G-10 Impact MC loading area. Based on information obtained from MCIEAST-MCB CAMLEJ personnel, three additional wells will become operational within the next 4 years. MC loading areas and the potentiometric map for the Castle Hayne aquifer are presented in **Figure 2-3**.

Significant withdrawals by the installation and adjacent county water supply wells have induced strong localized hydraulic gradient toward the water supply wells. Because the Castle Hayne aquifer is semiconfined at MCIEAST-MCB CAMLEJ and the confining unit is absent in some locations, potential MC loads from the upper surficial aquifer may migrate down to the Castle Hayne aquifer where it could be transported to drinking water supply wells.

The Castle Hayne aquifer is a human receptor exposure point because this aquifer provides the public water supply for MCIEAST-MCB CAMLEJ within the installation and the city of Jacksonville, Onslow County, and private domestic supplies nearby outside the installation. No direct ecological receptors were identified for groundwater, but groundwater contributions to surface water are evaluated through the surface water pathway.

2.2 Screening-Level Assessment Results

The average annual MC concentrations in surface water, sediment, and groundwater were estimated based on the average annual MC loaded for each MC at each loading area (**Appendix B**) and were conducted for the period 2011–2014. Screening-level fate and transport assessments were conducted for 36 of the 37 identified MC loading areas at MCIEAST-MCB CAMLEJ to determine conservative estimates of MC concentrations in surface water, sediment, and groundwater at identified potential off-range receptor locations down gradient of MC loading areas at the installation boundary. The procedures used are presented in the REVA 5-Year Review Manual (HQMC, 2010). The MC loading areas assessed were selected for quantitative screening-level assessments based on range use and their potential for MC migration to off-range receptor locations at the installation boundary. MC modeled for each MC loading area were determined by munitions used at each area and are summarized in **Appendix C**.

The screening assessment was not conducted for one of the identified MC loading areas (N1/BT-3 MC loading area) because it was estimated to have low MC loading and is located in a tidally influenced area where MC are mixed with a large volume of water that is expected to provide significant dilution of MC that may be present. Further, shallow groundwater is only expected to flow to the Atlantic Ocean and is not expected to reach the Castle Hayne aquifer due to the absence of vertical gradient near the MC loading area. Additionally, the closest well is more than 2 miles away from the MC loading area. Therefore, based on the estimated loading and the physical location of the N1/BT-3 MC loading area, off-range MC migration is expected to be minimal and screening-level assessments for the MC loading area were not conducted at this time.

The average annual MC concentrations in surface water, sediment, and groundwater were estimated based on the average annual MC loaded for each MC at each loading area. The following ranges were not active during this entire time period and were assessed using the fate and transport models for the period MC loading was known to have occurred:

- K-323 (became inactive in 2011, assessment conducted only for 2011)
- K-505, EOD-3, ETA-9, and ETA-10 (active in 2013, assessment conducted for the period 2013–2014)
- EOD-1 (became inactive 2012, assessment conducted for period 2011–2012)
- ETA-3 (limited use from 2011 to 2013; assessment conducted for the period 2011–2013)

Although 36 MC loading areas were identified for modeling, not all areas used munitions containing all REVA indicator MC. Because of negligible loading for some MC, the following MC loading areas were modeled for each of the four REVA MC:

- 24 of the 36 assessed MC loading areas were modeled for HMX
- 34 of the 36 assessed MC loading areas were modeled for RDX
- 35 of the 36 assessed MC loading areas were modeled for TNT
- 34 of the 36 assessed MC loading areas were modeled for perchlorate

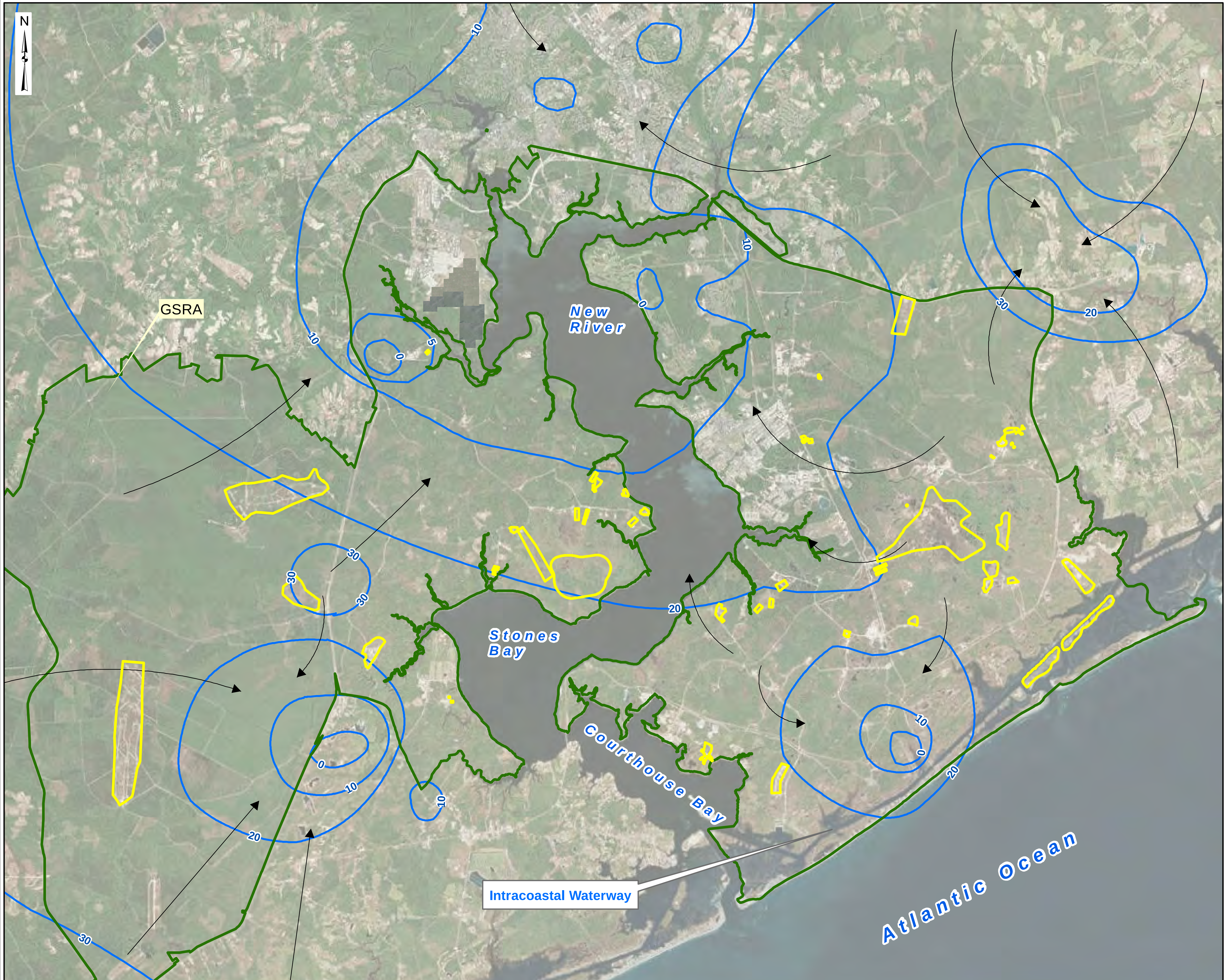

FIGURE 2-3
MCIEAST-MCB CAMLEJ
GROUNDWATER FEATURES

REVA
MCIEAST - MCB CAMLEJ

Legend

- Installation Boundary
- MC Loading Area
- Castle Hayne Flow Direction
- Groundwater Elevation for Castle Hayne Aquifer (2013)

Note:
- Groundwater contour was developed based on water level data published by United States Geological Survey (2013).

MCIEAST - MCB CAMPLEJ

0 0.5 1 2 3
Miles

Coordinate System: UTM
Zone: 18N
Datum: NAD83
Units: Meters

Date: June 2015

Source: Aerial - ESRI
MCB/NREA GIS Office 2014

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Summaries of the results of surface water, sediment, and groundwater screening-level assessment are presented in the following sections. Results were compared to REVA median method detection limits (MDLs) to evaluate the potential for MC releases to off-range receptors. The median values were determined using MDLs from several laboratories to establish a set of comparison values to identify next steps in the REVA process. MDLs do not represent a regulatory action level but are used only within REVA to determine if the predicted concentrations of REVA MC generated from the fate and transport models are detectable. Parameter values used in the screening assessment are presented in **Appendix C**. Technical memorandums describing the surface water, sediment, and groundwater screening-level assessments are also provided in **Appendix C**.

2.2.1 Surface Water Screening-Level Results

The 36 MC loading areas assessed at MCIEAST-MCB CAMLEJ using the screening level model are located in 13 subwatersheds shown in **Figure 2-2**. The identified down gradient off-range receptor locations are at the installation boundary within these subwatersheds and include the different segments of the New River and the Intracoastal Waterway, tributary streams of the New River and the Intracoastal Waterway, and two swamps located west of the New River (**Figure 2-4)**. The primary receptors identified for surface water at MCIEAST-MCB CAMLEJ are potential ecological receptors. Although streams near the MC loading areas may represent the closest potential ecological receptor locations, down gradient off range locations were selected as the modeled receptor locations in order to predict potential off-range releases at the installation boundary. Surface water at MCIEAST-MCB CAMLEJ is used for recreational purposes including fishing, swimming, and boating; however, it is not used as a drinking water source. Surface water does not represent a significant human exposure pathway.

The REVA screening-level surface water assessment at MCIEAST-MCB Camp Lejeune involved: 1) estimating the average annual MC concentrations in surface water runoff at the edge of each MC loading area, and 2) conducting a mixing calculation to determine the cumulative contribution of MC from individual MC loading areas draining to an off-range receptor location at the installation boundary. A technical memorandum detailing the assessment and results is provided in **Appendix C**.

MC concentrations in surface water entering downstream off-range receptor locations at the installation boundary were based on the edge-of-loading area predicted MC concentrations and shallow groundwater discharge to surface water (baseflow) combined from MC loading areas located within the same subwatersheds. **Appendix C** contains a table showing the proportion of each MC loading area draining to multiple receptor locations, and a table showing the percent mass of each MC contributed by individual MC loading areas to the downstream receptor locations.

Receptor locations with a predicted MC concentration above the median MDL are bold and highlighted pink in **Table 2-1** and highlighted green in **Figure 2-4**. The following are based on the screening assessment:

- HMX and perchlorate concentrations were predicted to be below median MDLs at all of the surface water downstream off-range receptor locations at the installation boundary.
- RDX and TNT concentrations were predicted to be above median MDLs in the Bear Creek and the segment of the New River between Town Creek and Stones Bay.

- The G-10 Impact MC loading area was predicted to contribute 78% of the RDX mass and 98% of the TNT mass to the New River between Town Creek and Stones Bay and almost 100% of RDX and TNT mass to Bear Creek.
- RDX and TNT concentrations were predicted to be below median MDLs in surface water at all other downstream off-range receptor locations at the installation boundary.

Table 2-1: Screening-Level Estimates of Annual Average MC Concentrations in Surface Water (including Runoff and Base Flow) Entering the Identified Downstream Off-Range Receptor Locations at the Installation Boundary

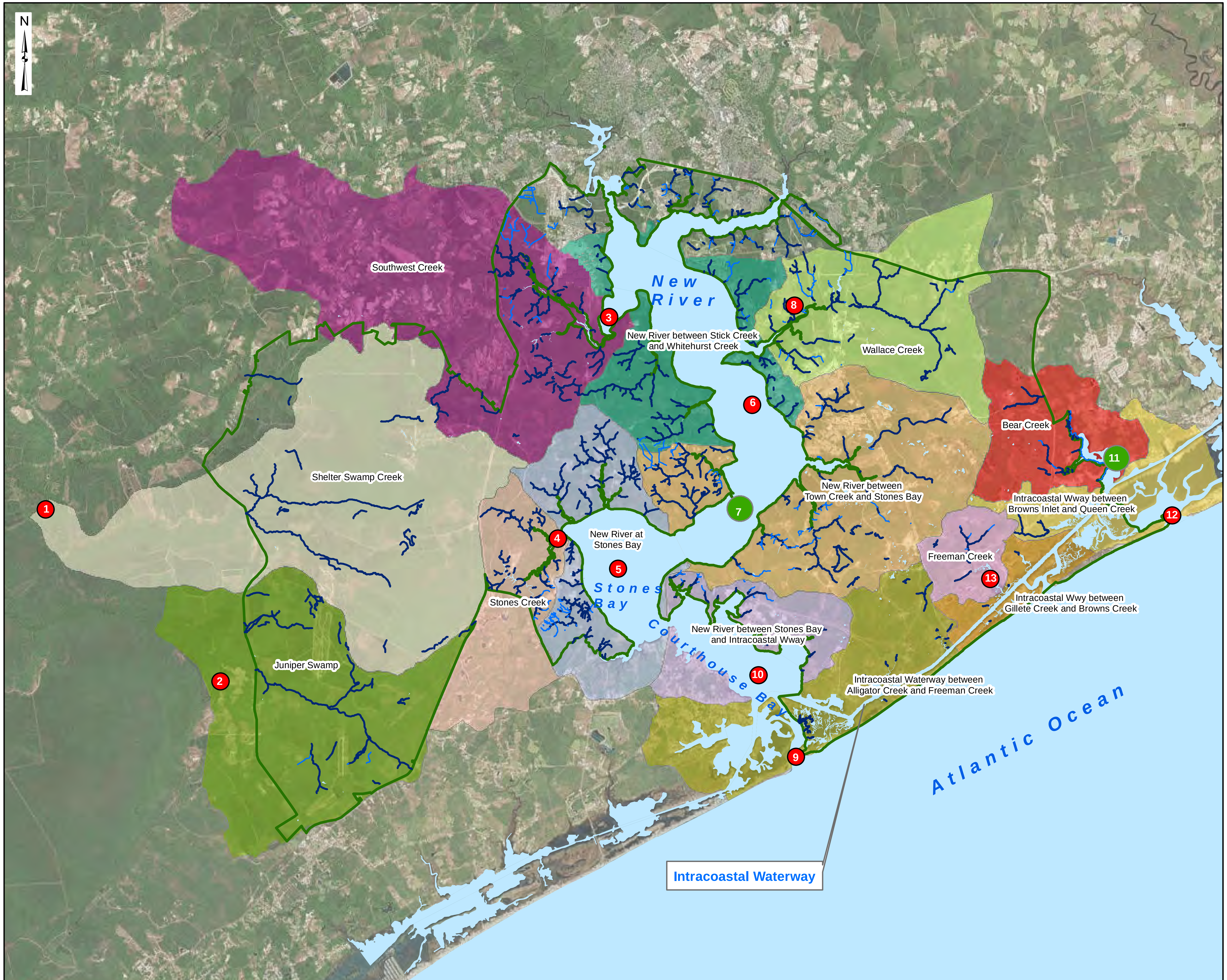
Downstream Off-Range Receptor Locations at the Installation Boundary Receiving Drainage from MC Loading Areas	Drainage Area (acres)	Estimated MC Concentration (µg/L)			
		HMX	RDX	TNT	Perchlorate
Shelter Swamp Creek (1)	31,746	~0	~0	~0	~0
Juniper Swamp (2)	20,127	~0	~0	~0	~0
Southwest Creek (3)	28,830	~0	~0	~0	~0
Stones Creek (4)	7,587	~0	~0	~0	0.002
New River at Stones Bay (5)	12,294	~0	0.037	0.004	~0
New River between Stick Creek and Whitehurst Creek (6)	14,544	~0	0.022	0.012	~0
New River between Town Creek and Stones Bay (7)	21,123	0.004	**0.221**	**0.828**	~0
Wallace Creek (8)	12,868	~0	0.021	0.009	~0
Intracoastal Waterway between Alligator Creek and Freeman Creek (9)	11,749	~0	0.006	0.010	~0
New River between Stones Bay and Intracoastal Waterway (10)	7,810	N/A	0.001	~0	~0
Bear Creek (11)	6,886	0.002	**0.132**	**0.615**	~0
Intracoastal Waterway between Browns Inlet and Queen Creek (12)	6,247	~0	0.014	0.013	~0
Freeman Creek (13)	2,789	~0	0.020	0.012	~0
REVA median MDL for water		*0.077*	*0.097*	*0.108*	*0.06*

Note:
N/A = not modeled, as the MC loading rate was estimated to be negligible
Numbers in parentheses beside receptor locations correspond to circled numbers in **Figure 2-4.**
Shading and bold indicate concentration exceeds the median MDL.

Based on the predicted detectable MC concentrations in surface water entering two downstream off-range receptor locations at the installation boundary, field data collection activities (surface water sampling) were conducted within the subwatersheds of Bear Creek and the segment of the New River between Town Creek

FIGURE 2-4
MCIEAST-MCB CAMLEJ MODEL PREDICTIONS AT SURFACE WATER RECEPTOR LOCATIONS

REVA
MCIEAST - MCB CAMLEJ



Legend

- Installation Boundary
- SW Receptor Locations with no Predicted Detections
- SW Receptor Locations with Predicted Detections

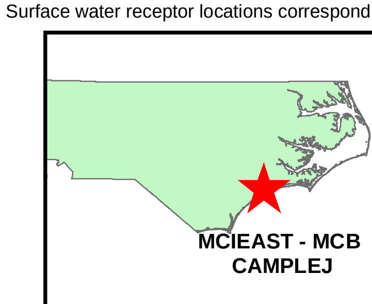
Stream

- Non-Permanent
- Permanent
- Surface Water

Subwatershed Area

- Bear Creek
- Freeman Creek
- Intracoastal Waterway between Browns Inlet and Queen Creek
- Intracoastal Waterway between Alligator Creek and Freeman Creek
- Intracoastal Waterway between Gillete Creek and Browns Creek
- Juniper Swamp
- New River at Stones Bay
- New River between Stick Creek and Whitehurst Creek
- New River between Town Creek and Stones Bay
- New River between Stones Bay and Intracoastal Waterway
- Shelter Swamp Creek
- Southwest Creek
- Stones Creek
- Wallace Creek

Note:
- Surface water receptor locations correspond to Table 2-7.



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Miles

Coordinate System: UTM
Zone: 18N
Datum: NAD83
Units: Meters

Date: June 2015

Source: Aerial - ESRI
MCB/NREA GIS Office 2014

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and Stones Bay in September 2014. The results and findings of these activities are discussed in **Section 2.5**.

2.2.2 Sediment Screening-Level Results

The soil types at the MC loading areas identified at MCIEAST-MCB CAMLEJ are primarily fine sand and loamy fine sand and have low inherent soil erodibility. Based on the predicted soil loss value at the MC loading areas, the overall soil erosion potential at the MC loading areas ranges from low to high, with the majority of the MC loading areas (30 of the 36 modeled) having a moderate soil erosion potential (**Appendix C**). Similar to the surface water screening-level assessment, average annual MC concentrations in sediment were estimated at the edge of the MC loading areas and then potentially entering the identified downstream off-range surface water receptor locations at the installation boundary. A technical memorandum detailing the sediment assessment and results is included in **Appendix C**.

The TNT concentrations in sediment from three MC loading areas (G-Impact Area, G-10A, and EOD-3) were estimated to be at detectable concentrations at the edge of loading areas. These three MC loading areas drain to two downstream receptor locations: 1) the segment of the New River between Town Creek and Stones Bay and 2) Bear Creek. These areas were further assessed, and TNT concentrations in sediment were predicted to be below the median MDL at downstream receptor locations at the installation boundary. These results are presented in **Table 2-2**. Based on the sediment screening-level assessment results, no additional assessment is recommended at this time for sediment for the MC loading areas at MCIEAST-MCB CAMLEJ.

Table 2-2: Screening-Level Estimates of Annual Average MC Concentrations in Sediment Entering the Downstream Off-Range Receptor Locations at the Installation Boundary

Downstream Receptor Locations at the Installation Boundary	Drainage Area (acres)	Estimated MC Concentration (µg/kg)			
		HMX	RDX	TNT	Perchlorate
New River between Town Creek and Stones Bay (7)	21,123	~0	0.013	2.69	~0
Bear Creek (11)	6,886	~0	0.008	2.41	~0
REVA median MDL for water		*77.9*	*78*	*63.1*	*0.213*

Note:
Subwatersheds that were not modeled because MC was eliminated from further assessment based on the concentration predicted at the edge of the MC loading area, are not shown on the table.

Numbers in parentheses beside receptor locations correspond to circled numbers in **Figure 2-4**.

2.2.3 Groundwater Screening-Level Results

The groundwater screening-level assessment was conducted for the 36 MC loading areas identified at MCIEAST-MCB CAMLEJ. The REVA screening-level groundwater assessment at MCIEAST-MCB Camp Lejeune was a five-step process: 1) determine maximum MC concentrations in infiltrating water at each MC loading areas, 2) model the potential for MC to migrate from the MC loading areas vertically through the vadose zone to groundwater within the unconfined surficial aquifer, 3) model MC reaching the water table horizontally within the saturated zone in the surficial aquifer to potential receptor locations in surface water,

4) model vertical transport of MC that reaches the surficial aquifer to the semiconfined Castle Hayne aquifer, and 5) model horizontal transport of MC that reaches the Castle Hayne aquifer to potential groundwater receptors (drinking water wells). At each step of the process, the predicted MC concentrations were compared to median MDL values, and only the MC exceeding median MDLs were assessed in the next step. The assessment methods of the four-step process are described in detail in the REVA Five-Year Review Manual (HQMC, 2010). A technical memorandum detailing the groundwater assessment and results is provided in **Appendix C**.

Based on results of the first four steps of the screening-level assessment, RDX at one MC loading area and perchlorate at eight MC loading areas were modeled for movement through the Castle Hayne aquifer to drinking water supply wells. **Table 2-3** presents the predicted MC concentrations potentially reaching the nearest drinking water supply wells from the MC loading areas modeled. The model predicted the following:

- The RDX concentration potentially reaching the closest water supply well from the EOD-2 MC loading area is below the median MDL.
- Perchlorate reaching the nearest water supply wells from seven of the eight MC loading areas modeled for perchlorate is at a concentration above the median MDL (detectable concentrations), as identified in bold and pink highlighting in **Table 2-3**.

Table 2-3: Model-Estimated MC Concentrations Potentially Reaching Groundwater Receptors

MC Loading Area	Well ID Where MC Exceeds Median MDL	Concentration at Nearest Perennial Stream (µg/L)			
		HMX	RDX	TNT	Perchlorate
G-10A	NPSW-2	NM	NM	NM	**0.161**
G-19 Ranges	PSW-2	NM	NM	NM	**0.141**
K-510	NPSW-1	N/A	NM	NM	**0.100**
L-5	Unknown [a]	NM	NM	NM	**0.340**
ETA-3	PSW-6	NM	NM	NM	**0.200**
EOD-2	None	NM	~0	NM	NM
Combat Town	PSW-1	NM	NM	NM	**0.185**
Mobile MOUT Complex	NPSW-4	NM	NM	NM	**0.344**
Stone Bay Area	None	NM	NM	NM	0.032
REVA median MDL for water		*0.077*	*0.097*	*0.108*	*0.06*

Note:
N/A = not modeled, as MC loading was estimated to be negligible
NM = not modeled because MC was eliminated for further assessment based on the previous step of the assessment
Shading and bold indicate predicted concentration exceeds the median MDL.

[a] County well located off-installation. The well ID is unknown.

Based on the predicted detectable MC concentrations in groundwater potentially reaching the seven down gradient public supply wells (**Table 2-3**), groundwater sampling for MC in three potable supply wells, three non-potable supply wells, and one monitoring well was conducted in September 2014. The results and findings of these sampling activities are discussed in **Section 2.5**.

2.3 Small Arms Range Assessment Results

Ranges that use small arms ammunition at MCIEAST-MCB CAMLEJ are qualitatively assessed under the REVA program. The REVA indicator MC for SARs is lead because it is the most prevalent potentially hazardous constituent associated with small arms ammunition. Forty-one SARs were identified and are shown on **Figure 2-5**. SARs with similar characteristics located adjacent to one another were grouped for the assessment resulting in completion of 29 SAR assessments. Twenty-one of these 29 SARs or grouped SARs were previously evaluated in the five-year review.

These previously evaluated SARs were first analyzed with the SAR screening evaluation tool to identify those SARs with a limited risk of lead migration to a receptor. Conditions indicating limited risk of migration include: ranges previously ranked minimal with no significant changes since the last review; low lead loading and no nearby receptors; or ranges with bullet traps effective in minimizing lead exposure to the environment. These limited risk SARs identified through the screening evaluation demonstrate very low potential impacts for human health or the environment and are recommended for re-evaluation in the next REVA review. Any new SARs are evaluated using the SARAP as a baseline.

Screening evaluations were completed for all SARs assessed in the five-year review, and this resulted in low risk (minimal) rankings for 11 SARs for surface water and 12 SARs for groundwater. These SARs and pathways are recommended for re-evaluation in the next periodic review. The summary of the screening evaluation results indicating those ranges and pathways requiring a SARAP evaluation are in **Appendix D**.

The SARAP is applied to SARs where there is a perceived potential risk of lead migration and receptor impact and evaluates the migration potential of lead at an individual SAR based several factors, including the following:

- Range use
- Range design and layout
- Physical and chemical characteristics of the area
- Past and present operation and maintenance practices
- Lead migration pathways and receptors (groundwater, surface water, and sediment)

An overall ranking of minimal, moderate, or high is determined for the surface water and groundwater migration pathways based on a scoring of these factors. A high ranking indicates the greatest potential for lead migration and receptor impact.

Eighteen SARs or groups of SARs were evaluated with the SARAP based on results of the screening evaluation. The SARAP evaluations are provided in **Appendix D**, and **Table 2-16** provides a summary of SARAP results.

Table 2-4: Summary of SARAP Results

SAR	Surface Water / Sediment Ranking (Score)	Groundwater Ranking (Score)
Alpha, Bravo, and Charlie	Moderate (44)	Moderate (36)
D-30	Moderate (41)	NA
Dodge City	Moderate (40)	Minimal (32)
F-18	High (46)	Moderate (37)
G-21	Moderate (40)	Moderate (34)
Hathcock Range	Moderate (42)	Moderate (34)
K-325	High (48)	Moderate (35)
K-402 and K-402A	Moderate (44)	Minimal (31)
K-406A and K-406B	High (51)	Moderate (40)
K-501 and K-501A	Moderate (44)	Moderate (39)
K-503 and K-503A	High (48)	Moderate (39)
K-506	Moderate (40)	Minimal (27)
K-507	Moderate (37)	Minimal (24)
K-508	High (47)	Moderate (36)
K-509	Moderate (34)	Minimal (25)
MAC-1, MAC-2, MAC-4, MAC-5, and MAC-6	Moderate (39)	Minimal (29)
R-100	High (27)[a]	Minimal (28)
SR-8	Moderate (41)	Moderate (39)

Note:
NA = not assessed using SARAP based on the screening evaluation
High ranking range: 45–65
Moderate ranking range: 33–44
Minimal ranking range: 0–32

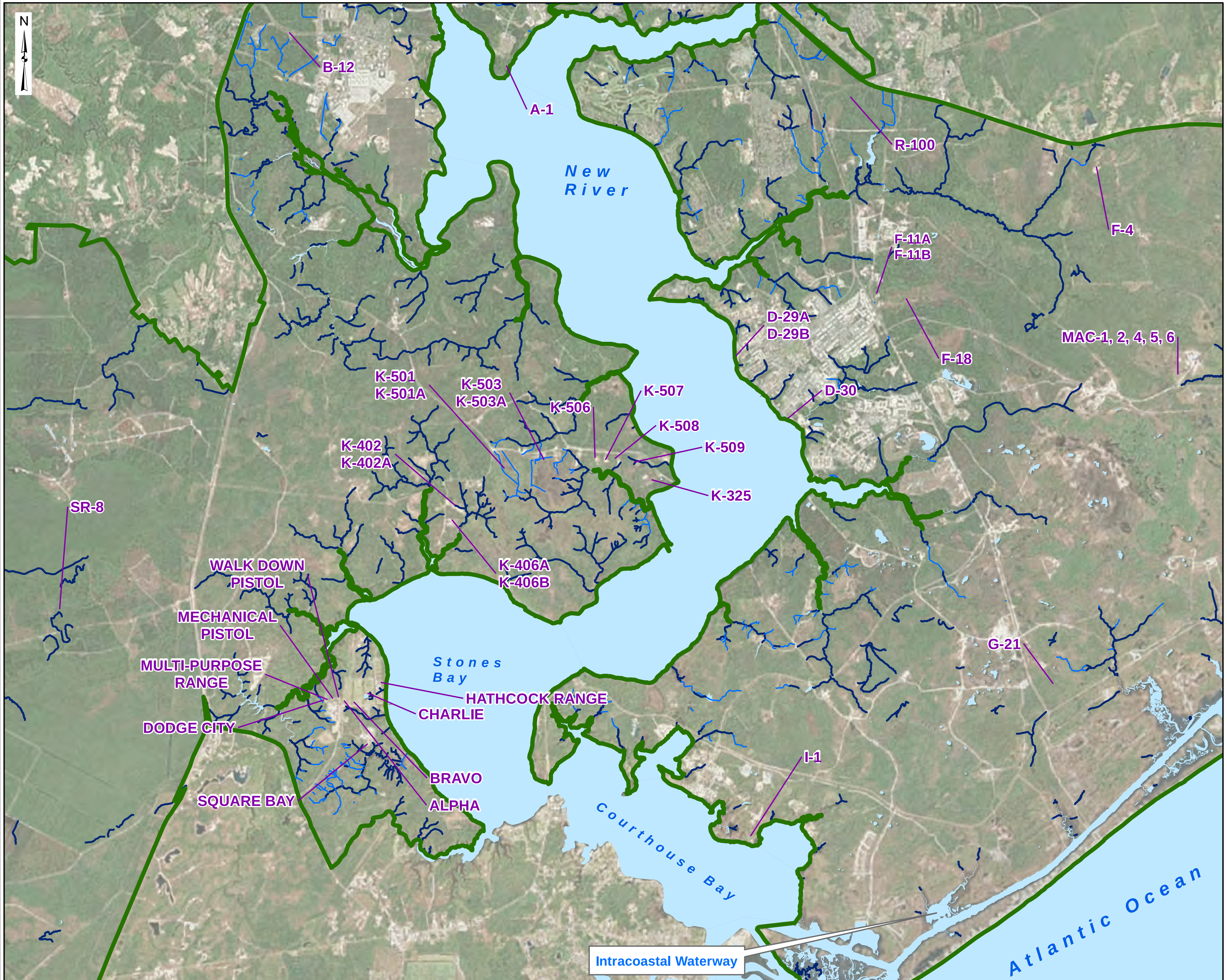
a Modified ranking based on sample results

Six SARs received high rankings, 12 received moderate rankings, and none received a minimal ranking for surface water/sediment through the SARAP. A high ranking indicates there is greater potential for lead migration from the SAR. Range R-100 scored a minimal ranking; however, the ranking was modified to high based on sample results, as discussed in **Section 2.5**. Four of the SARs or groups of SARs with the highest score for surface water are located in the K-2 Impact Area: K-325, K-406A and K-406B, K-503 and K-503A, and K-508. The high surface water and sediment rankings at these SARs are attributed to the following:

- High MC loading rates (greater than 4,000 lb/yr)
- No impact berm, therefore, projectiles are scattered throughout SDZ
- No recent lead removal activities
- High rate of precipitation

FIGURE 2-5
MCIEAST-MCB CAMLEJ
SMALL ARMS RANGES

REVA
MCIEAST - MCB CAMLEJ



Legend

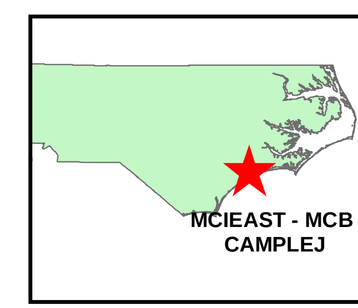
Installation Boundary

Stream

Non-Permanent

Permanent

Surface Water



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Miles

Coordinate System: UTM
Zone: 18N
Datum: NAD83
Units: Meters

Date: June 2015

Source: Aerial - ESRI
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- Limited vegetative cover
- No engineering controls or best management practices (BMPs) to control surface water runoff or erosion
- Surface water body located nearby

Range F-18 received a high ranking for surface water, partially attributed to high loading, high precipitation, and nearby surface water. A surface water sample was collected down gradient of this SAR as a result of the high ranking. Sampling results are discussed in **Section 2.5**.

R-100 received a modified high ranking based on the results of the sampling effort conducted at the skeet range. Samples were collected to target potential migration pathways around the range including surface water drainages, sediment, and soil around the range boundaries. Results of this effort are summarized in **Section 2.5**.

Seventeen SARs were evaluated for groundwater using the SARAP. No SARs received a high ranking, 10 received moderate rankings, and 7 received minimal rankings. The moderate ranking indicates some factors are present that contribute to the potential for lead migration off range, but there is likely no immediate threat to human health via intake from water supply wells or to the environment.

2.4 Lead Loading in Subwatersheds

Lead is not modeled within REVA because the site-specific information needed for reasonable prediction is not available. Although SARs are the largest contributors of lead at Marine Corps installations, some HE ranges also use significant quantities of lead. Total lead loading within each subwatershed was calculated by combining average annual lead loading from SARs and MC loading areas. Subwatershed lead loading is presented in **Appendix B**.

Lead loading is significantly higher within the subwatersheds of Shelter Swamp Creek, Stones Creek, New River at Stones Bay, and New River between Town Creek and Stones Bay. Ranges within these subwatersheds use over 40,000 pounds of lead annually, as presented in **Table 2-5**. Other subwatersheds receive 0 to 14,000 pounds of lead annually. Potential lead migration typically is evaluated in REVA by a qualitative assessment and field sampling. Sampling is discussed in **Section 2.5**.

Table 2-5: Highest Lead Loading in Subwatersheds at MCIEAST-MCB CAMLEJ

Subwatershed	MC Loading Areas	SARs	Total Lead (lb/yr)
Shelter Swamp Creek	SR-6, SR-7, SR-10	SR-8	54,604
Stones Creek	L-5	Mechanical Pistol, Multi-Purpose, Walk Down, Dodge City, Alpha	41,891
New River at Stones Bay	Stones Bay Area, K-407, K-408, K-500A, K-500	Bravo, Charlie, Hathcock, K-402, K-406A/B	45,951

Subwatershed	MC Loading Areas	SARs	Total Lead (lb/yr)
New River between Town Creek and Stones Bay	K-500, K-2 Impact, K-504A/B, K-505, K-323, ETA-5/5A, ETA-7/7C, ETA-9, ETA-10, EOD-3, Combat Town, ETA-4, G-19 Ranges, G-10 Impact Area, G-10A, F-6	K-501/501A (60%), K-503/503A, K-309, K-315, K-319, K-321/321A, K-325, K-506, K-508,K-509, G-21	59,857

2.5 Summary of Field Sampling

Field sampling was completed in September 2014 as part of the periodic review. Sample locations were identified in the screening-level assessments, SARAPs, review of previously conducted annual monitoring, and a review of lead loading at a subwatershed level. A baseline evaluation of the R-100 skeet range was also completed. This range opened in August 2012, and the baseline results will be used for future evaluation of the effectiveness of the SOPs and BMPs at the range. This section summarizes the sampling results.

2.5.1 Samples

Surface water samples were collected from 10 locations: 9 locations receiving drainage from range areas plus one reference location in the northern extent of the installation in the New River. Sample locations were identified through the screening-level model, SAR evaluation, subwatershed lead leading evaluation, and/or annual monitoring. Four locations were identified only through the model; one location was identified only through the SAR evaluation; one location was identified only through the subwatershed lead loading evaluation; three locations were identified through a combination of two or three of these evaluations; and one location was a reference sample north of the ranges. Two depth interval samples were collected from four of the locations, resulting in a total of 12 field samples and two reference samples. Three of the 10 surface water sample locations were around the K-2 Impact Area where one sample was analyzed for total and dissolved lead and hardness; one sample was analyzed for explosives and perchlorate; and one sample was analyzed for total and dissolved lead, hardness explosives, and perchlorate. Three of the 10 sample locations were downstream of the G-10 Impact Area and analyzed for explosives and perchlorate. The other three sample locations included Wallace Creek, Stones Bay, and the GSRA where one sample was collected from each location and analyzed for total and dissolved lead and hardness. The reference location was north of the ranges in the New River; two depth intervals were sampled and analyzed for total and dissolved lead, hardness, explosives, and perchlorate.

Groundwater samples were collected from 4 monitoring wells, 3 potable supply wells, and 3 non-potable supply wells for a total of 10 sampled wells. Six of these locations were identified through the screening level model, and four locations were identified through the annual monitoring. One additional monitoring well (identified through annual monitoring) and one potable supply well (identified through the model and annual monitoring) were identified for sampling; however, they were not sampled due to accessibility during the sampling event. One sample was analyzed for total and dissolved lead, hardness and perchlorate; two samples were analyzed only for total and dissolved lead and hardness; and seven samples were analyzed only for perchlorate. .

A baseline study was completed at the skeet range (R-100), which became active in August 2012. Constituents of concern at skeet ranges include lead, which is the main component of the shotgun ammunition, and polyaromatic hydrocarbons (PAHs), which are used to bind the clay pigeons used as targets. This field study included collection of two surface water samples, four surface sediment samples (0-6 inches below ground surface [bgs]), six surface soil samples (0-6 inches bgs), and six subsurface soil samples (18-24 inches bgs). All samples were analyzed for lead and PAHs. Additionally, in order to better characterize the environment for understanding MC mobility, one surface sediment sample, two surface soil samples, and two subsurface soil samples were analyzed for pH, sulfate, phosphorus, total organic carbon, total inorganic carbon, cation exchange capacity, and particle size analysis.

2.5.2 Screening Criteria

Results were screened against DoD screening values and applicable North Carolina criteria. Surface water was compared to DoD screening values for ecological freshwater and ecological marine surface water systems (DoD, 2013) and to North Carolina Protection Standards for protection of freshwater aquatic life, saltwater aquatic life, and human health (based on fish consumption only) (15A NCAC 02B, updated May 15, 2013). Appropriate criteria were determined based on North Carolina classifications of surface water bodies.

Groundwater was screened against DoD Screening Values for human drinking water (DoD, 2013) and the most conservative of North Carolina Protection Standards for Groundwater Supply (15A NCAC 02L.0200, updated April 1, 2013), maximum contaminant levels (MCLs), or USEPA regional screening levels (RSLs) (USEPA, 2014). Sediment sample results associated with the skeet range were compared to the DoD screening value for freshwater sediment (DoD, 2013) and North Carolina Federal Remediation Branch Soil Screening Levels (NCDENR, 2013). The State of North Carolina does not have sediment standards, so soil criteria were used for comparison. Soil sample results associated with the skeet range were compared to USEPA residential and industrial RSLs (USEPA, 2014) and North Carolina Federal Remediation Branch Soil Screening Levels (NCDENR, 2013).

2.5.3 Results

Samples were analyzed by RTI Laboratories in Livonia, Michigan. Results summaries are presented in **Tables 2-6** through **2-10**. Brief summaries are provided in the following sections.

2.5.3.1 Surface Water

Fourteen surface water samples (plus one duplicate sample) were collected from 10 locations. Upper and lower profile samples were analyzed at four locations where the water depth was greater than 4 feet; no significant differences were observed in the results from the two depth intervals. Sample results are presented in **Table 2-6**.

Total lead was detected in five of seven field samples with a maximum detected concentration of 7.7 µg/L in the GSRA sample (GSRA_SW-01). All results were below the North Carolina Protection Standard of 25 µg/L for total lead. Total lead was detected in both reference samples with concentrations of 0.86 µg/L and 0.36 µg/L in upper and lower depth intervals, respectively. Dissolved lead was detected in three of seven field samples with a maximum detected concentration of 2.5 µg/L in the Stones Bay lower interval sample (SB_SW-01) and one of the samples near the K-2 Impact Area (K2_SW-02). Dissolved lead was not detected in either reference sample. All detected concentrations from locations classified as saltwater were below the DoD ecological marine surface water screening value of 8.1 µg/L for dissolved lead. Dissolved lead was not detected in the location classified as freshwater (GSRA_SW-01), and explosives and perchlorate were not detected at the six field samples or two reference samples analyzed.

Surface water pH was near neutral at all locations except for the GSRA. Sample GSRA_SW-01 on the west side of GSRA had a field-measured pH of 4.11, while all other sample pHs ranged from 6.8 to 7.97. The lower pH may promote dissolution of lead and subsequent mobilization; however, dissolved lead was not detected at this location.

2.5.3.2 Groundwater

Ten groundwater samples were collected from three potable supply wells, three non-potable supply wells, and four monitoring wells. Two duplicate samples were also collected. Sample results are presented in **Table 2-7**. Total lead was detected in three of the wells (plus a duplicate) analyzed with a maximum detected concentration of 1.7 µg/L. Dissolved lead was detected in two wells and the duplicate of a third well with a maximum detected concentration of 1.5 µg/L. All detected concentrations were below the DoD and North Carolina standard of 15 µg/L for total and dissolved lead. Perchlorate was not detected in the eight wells analyzed for perchlorate.

2.5.3.3 Skeet Range Results

Skeet Range Surface Water

Two surface water samples plus one duplicate sample were collected from a drainage swale located behind the firing line at skeet range R-100. Samples were analyzed for total and dissolved lead, PAHs, and hardness. Sample results are presented in **Table 2-8**.

The sample collected from the location farthest west in the swale (R100_SW-01) contained a total lead concentration of 26 µg/L (duplicate result of 31 µg/L), exceeding the North Carolina freshwater ecological protection standard of 25 µg/L. The eastern surface water sample (R100_SW-04) contained a total lead concentration of 3.3 µg/L, which is below the ecological protection standard. Dissolved lead concentrations at R100_SW-01 and R100_SW-04 were 22 µg/L (duplicate result of 23 µg/L) and 2.2 µg/L, respectively. The dissolved lead result for R100_SW-01 exceeded the chronic and acute hardness-adjusted DoD screening criteria of 0.21 and 5.47 µg/L, respectively. The dissolved lead result for R100_SW-04 exceeded the chronic hardness-adjusted screening criterion of 0.11 µg/L but not the acute hardness-adjusted screening criterion of 2.89 µg/L. PAHs were not detected in any sample collected.

The results indicate that most of the lead observed in the total sample is in dissolved form. The swale drains toward sample location R100_SW-01, and the sample was taken on the down gradient side of a debris pile that contained wads and other range debris. The field measured surface water pH at R100_SW-01 and R100_SW-04 were 7.19 and 4.85, respectively. Field measured turbidities were 1.38 and 2.27 nephelometric turbidity units (NTU).

Skeet Range Sediment

A drainage ditch runs roughly parallel with the firing line flowing southeast to northwest. It was partially dry at the time of sampling, but a debris pile at the northwest extent of the ditch indicates that flow in this direction carries range debris including shotgun wads and deposits them in this area. Four surface sediment samples (0–6 inches bgs) plus one duplicate sample were collected from the drainage swale located behind the firing line at skeet range R-100. Sample results are presented in **Table 2-9**. Lead was detected at all sample locations with a maximum concentration of 73 µg/kg in sample R100_SW-01, which exceeded the DoD freshwater sediment screening value of 47 µg/kg. All other concentrations ranged from 7.1 to 24 µg/kg. Four PAHs were detected (estimated concentrations below the reporting limit) in R100_SW-02 with total PAHs equaling 60 µg/kg. All detected concentrations were over an order of magnitude below USEPA Region 4 screening criteria. DoD does not have sediment screening values for PAHs. Sample R100_SW-02 is located in the drainage swale behind the firing line. Lab measured pHs ranged from 3.32 to 4.09, indicating acidic soil that may promote mobilization of lead into surface water.

Skeet Range Soil

Twelve soil samples plus one duplicate sample were collected from six locations. Samples were collected from two depths: (0–6 inches bgs and 18–24 inches bgs) at each location. Sample results are summarized in **Table 2-10**. Lead was detected in all 12 samples at concentrations ranging from 5.9 to 48 µg/kg. All detected concentrations are at least one order of magnitude below screening criteria. One surface sample contained PAHs but only an estimated concentration of benzo(a)pyrene (29 µg/kg) exceeded the residential RSL (15 µg/kg). The two subsurface samples each contained one PAH, and both detections were far below screening criteria. The sporadic PAH detections at low concentrations indicate that skeet range activities are not adversely impacting soil with PAHs.

The pH of the deep sample at location R100_SB-01 was near neutral at 7.06; however, all other sample results indicated acidic conditions with pHs ranging from 2.88 to 4.64, which is consistent with the field measurements. These acidic soils may promote lead mobilization into stormwater runoff.

Qualitative Risk Evaluation

Surface water and sediment samples were collected from a stormwater drainage swale that only flows during precipitation events. Any exposure of human or ecological receptors to constituents in soils from the drainage swales or in stormwater runoff must be considered based on potential contact with stormwater rather than a perennial surface water body used as a potable supply or as a fishery. The drinking water pathway for humans is incomplete for stormwater. While incidental contact by skeet range users is possible, whole and partial body contact under a recreational exposure scenario to stormwater in drainages during precipitation events is also considered incomplete.

Wallace Creek is the downgradient water body receiving stormwater runoff from the site. A sample was collected in September 2014 from Wallace Creek and analyzed for total and dissolved lead. Concentrations of total and dissolved lead were below the limit of detection (0.50 µg/L) in this sample. The potential exposure to lead in surface water by site workers and recreational users at Wallace Creek will not lead to adverse health effects.

Similar to human health, ecological screening criteria are developed based on ecological endpoints in intermittent water bodies based on acute water quality criteria and perennial water bodies based on chronic water quality criteria, rather than stormwater drainages. The aquatic receptors used to derive surface water quality criteria are not present in stormwater drainage swales that only have water present during precipitation events. The exposure pathway for aquatic receptors to total and dissolved lead in stormwater runoff is considered incomplete. Although terrestrial ecological receptors may be directly exposed to constituents in stormwater runoff during precipitation events, these exposures are acute in nature and do not represent a potential risk to terrestrial receptors. Just as with human exposures, ecological receptors are likely to be exposed to constituents in surface water at Wallace Creek that receives stormwater runoff from the skeet range. Lead was reported at concentrations below detectable levels for both total and dissolved analyses in the surface water sample collected from Wallace Creek. Current concentrations of lead in stormwater runoff at the range, therefore, are not likely to pose a risk to human health and the environment. Continued monitoring is appropriate to ensure that future impacts from lead in stormwater runoff to water quality in Wallace Creek are minimized.

Sediment samples were collected from the stormwater drainage swale; however, the material in the bottom of the drainages is only considered sediment only during rainfall events when stormwater is present. During dry periods, exposure to constituents in material at the bottom of the stormwater drainage swales would be consistent with exposure to constituents in soil. Although recreational criteria for chemicals in soil have not been established for lead and/or PAHs, industrial criteria are available. Industrial criteria are more conservative than recreational criteria since it is based on 8-hour exposures over a 250-day exposure duration compared to 2 to 4-hour exposure over 12 to 40 days per year for recreational criteria. All detected concentrations in soil and sediment are over an order of magnitude below industrial RSLs, indicating minimal risk for potential recreational exposure to skeet users.

The exposure of ecological receptors to lead and PAHs in sediment is similar to the human health-based assessment in that aquatic receptors are not present in stormwater drainage swales; therefore, the exposure pathway for aquatic receptors is incomplete. Only lead had a reportable concentration above its respective sediment benchmark concentration. The upper 95 percent confidence limit (95% UCL) on the mean concentration of lead in surface soil and sediment samples from the range was 28.7 mg/kg, which is below the sediment benchmark concentration for lead of 30.2 mg/kg. These results indicate that lead in surface soil from the range and stormwater drainages do not pose a potential threat to sediment quality in Wallace Creek. The USEPA ecological soil screening level (eco-SSL) for lead in soil is 11 mg/kg, which is below the background concentration for lead in soil at MCIEAST-MCB CAMLEJ of 27.5 mg/kg (CH2M Hill, 2011). The limited number soil samples with exceedances of the eco-SSL for lead and relatively low overall concentration of lead in soil at the site indicate that terrestrial ecological receptors are not at risk due to potential exposure to lead in soil at the site.

Table 2-6
Surface Water Sample Results
September 2014
Range Environmental Vulnerability Assessment
MCIEAST-MCB Camp Lejeune, NC

CONSTITUENT SCREENING						K-2 IMPACT AREA				G-10 IMPACT AREA				GSRA	STONES BAY		WALLACE CREEK		NEW RIVER	
Surface Water ID	**DoD Screening Values[a]**		**NC Protection Standards[b]**			**K2_SW-02**	**K2_SW-04**	**K2_SW-05**		**G10_SW-08**	**G10_SW-09**		**G10_SW-10**	**GSRA_SW-01**	**SB_SW-01**		**WC_SW-01**		**NR_REF-SW-05**	
North Carolina Surface Water Classification						SA; HQW	SC; HQW; NSW	SC; HQW; NSW		SA; HQW	SC; NSW		SC; NSW	C; Sw	SA; HQW		SB; NSW		SC; HQW; NSW	
Sample Date	**Ecological**	**Ecological**	**Freshwater**	**Saltwater**	**Human**	Sep-14	Sep-14	Sep-14		Sep-14	Sep-14		Sep-14	Sep-14	Sep-14		Sep-14		Sep-14	
Sample Interval	**Freshwater[c]**	**Marine[d]**	**Aquatic Life**	**Aquatic Life**	**Health[e]**				Duplicate		Upper[g]	Lower[g]			Upper[g]	Lower[g]	Upper[g]	Lower[g]	Upper[g]	Lower[g]
Metals (µg/L)																				
Lead, Total	---	---	25	25	---	**3.3**	NA	**2.1**	**1.9**	NA	NA	NA	NA	**7.7**	**0.44 J**	**0.40 J**	0.50 U	0.50 U	**0.86 J**	**0.36 J**
Lead, Dissolved	Varies[f]	8.1	---	---	---	**2.5**	NA	**0.79 J**	**0.77 J**	NA	NA	NA	NA	0.50 U	0.50 U	**2.5**	0.50 U	0.50 U	0.50 U	0.50 U
Adjusted DoD Hardness Criteria (chronic)	Varies[f]													0.09						
Explosives (µg/L)																				
2-Amino-4,6-dinitrotoluene	1,480	1,480	---	---	150	NA	0.11 U	0.10 U	0.10 U	0.10 U	0.11 U	0.10 U	0.10 U	NA	NA	NA	NA	NA	0.10 U	0.10 U
4-Amino-2,6-dinitrotoluene	---	---	---	---	150	NA	0.11 U	0.10 U	0.10 U	0.10 U	0.11 U	0.10 U	0.10 U	NA	NA	NA	NA	NA	0.10 U	0.10 U
1,3-Dinitrobenzene	---	180	---	---	140	NA	0.11 U	0.10 U	0.10 U	0.10 U	0.11 U	0.10 U	0.10 U	NA	NA	NA	NA	NA	0.10 U	0.10 U
2,4-Dinitrotoluene	44	480	---	---	3.4	NA	0.11 U	0.10 U	0.10 U	0.10 U	0.11 U	0.10 U	0.10 U	NA	NA	NA	NA	NA	0.10 U	0.10 U
2,6-Dinitrotoluene	81	1,000	---	---	0.71	NA	0.11 U	0.10 U	0.10 U	0.10 U	0.11 U	0.10 U	0.10 U	NA	NA	NA	NA	NA	0.10 U	0.10 U
HMX	150	330	1,400	1,700	63,000	NA	0.11 U	0.10 U	0.10 U	0.10 U	0.11 U	0.10 U	0.10 U	NA	NA	NA	NA	NA	0.10 U	0.10 U
Nitrobenzene	270	66.8	---	---	30	NA	0.11 U	0.10 U	0.10 U	0.10 U	0.11 U	0.10 U	0.10 U	NA	NA	NA	NA	NA	0.10 U	0.10 U
2-Nitrotoluene	---	---	---	---	1.5	NA	0.11 U	0.10 U	0.10 U	0.10 U	0.11 U	0.10 U	0.10 U	NA	NA	NA	NA	NA	0.10 U	0.10 U
3-Nitrotoluene	750	---	---	---	5,300	NA	0.11 U	0.10 U	0.10 U	0.10 U	0.11 U	0.10 U	0.10 U	NA	NA	NA	NA	NA	0.10 U	0.10 U
4-Nitrotoluene	1,900	---	---	---	18	NA	0.11 U	0.10 U	0.10 U	0.10 U	0.11 U	0.10 U	0.10 U	NA	NA	NA	NA	NA	0.10 U	0.10 U
RDX	360	5,000	---	---	11	NA	0.11 U	0.10 U	0.10 U	0.10 U	0.11 U	0.10 U	0.10 U	NA	NA	NA	NA	NA	0.10 U	0.10 U
Tetryl	---	---	---	---	4,300	NA	0.11 U	0.10 U	0.10 U	0.10 U	0.11 U	0.10 U	0.10 U	NA	NA	NA	NA	NA	0.10 U	0.10 UJ
1,3,5-Trinitrobenzene	---	25	---	---	75,000	NA	0.11 U	0.10 U	0.10 U	0.10 U	0.11 U	0.10 U	0.10 U	NA	NA	NA	NA	NA	0.10 U	0.10 U
2,4,6-Trinitrotoluene	---	---	---	---	39	NA	0.11 U	0.10 U	0.10 U	0.10 U	0.11 U	0.10 U	0.10 U	NA	NA	NA	NA	NA	0.10 U	0.10 U
Nitroglycerin	138	138	---	---	67	NA	0.21 U	0.21 U	0.21 U	0.21 U	0.22 U	0.20 U	0.20 U	NA	NA	NA	NA	NA	0.20 U	0.20 U
PETN	85,000	85,000	---	---	---	NA	0.53 U	0.52 U	0.52 U	0.52 U	0.54 U	0.51 U	0.51 U	NA	NA	NA	NA	NA	0.51 U	0.51 U
Other																				
Perchlorate (µg/L)	9,300	9,300	---	---	2.8	NA	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	NA	NA	NA	NA	NA	0.10 U	0.10 U
Hardness, as $CaCO_3$ (mg/L)	---	---	---	---	---	2400	NA	2200	NA	NA	NA	NA	NA	5.2	2200	3200	2200	2200	1900	1700

Notes

Yellow = Detected concentration

Red = Detection exceeds screening criteria

Gray = Total Hardness

(hatched) = Does not apply

(light green) = Hardness-adjusted freshwater ecological screening criteria for dissolved lead

"---" = Not listed in standards

µg/L = micrograms per Liter

J = estimated value

mg/L = milligrams per liter

NA = not analyzed

U = analyte was not detected; reporting limit shown

UJ = analyte was not detected above the detection limit, but the reporting limit should be considered estimated.

a.) Operational Range Assessment Screening Values (DoD, Version 6.2, September 2013)

b.) NC protection standards obtained from North Carolina Administrative Code for surface water (15A NCAC 02B, May 15, 2013).
For Class C, SC, and HQW, use most stringent of criteria between freshwater (or saltwater, as applicable) and human health.

c.) DoD operational range assessment screening values for protection of freshwater surface water. Obtained from Table 2 of "Operational Range Assessment Screening Values" (DoD, Version 6.2, September 2013).

d.) DoD operational range assessment screening values for protection of marine surface water. Obtained from Table 3 of "Operational Range Assessment Screening Values" (DoD, Version 6.2, September 2013).

e.) Based on consumption of fish only

f.) Screening criteria adjusted per USEPA National Recommended Water Quality Criteria parameters for calculating dissolved metals that are hardness-dependent. North Carolina does not have protection standards for dissolved metals.

g.) Upper and lower refer to the water column interval sampled. Upper indicates the sample was collected from within 0-1 foot below the water surface. Lower indicates the sample was collected from within 2-3 feet above the streambed.

Sample-Specific North Carolina Surface Water Classifications

K2_SW-02	SA; HQW
K2_SW-04	SC; HQW; NSW
K2_SW-05	SC; HQW; NSW
G10_SW-08	SA; HQW
G10_SW-09	SC; NSW
G10_SW-10	SC; NSW
GSRA_SW-01	C; Sw
SB_SW-01	SA; HQW
WC_SW-01	SB; NSW
NR_REF-SW-05	SC; HQW; NSW

SA	Tidal salt water suitable for commercial shellfishing and all other tidal saltwater uses.
SB	Tidal salt water protected for primary recreation which includes swimming on a frequent or organized basis and all Class SC uses.
SC	Tidal salt water protected for secondary recreation , fishing, aquatic life including propogation and survival, and wildlife. All saltwaters shall be classified to protect these uses at a minimum.
C	Freshwaters protected for secondary recreation, fishing, aquatic life including propogation and survival, and wildlife. All freshwaters shall be classified to protect these uses at a minimum.
Sw	Swamp Waters. Waters which have low velocities and other natural characeteristics which are different from adjacent streams.
HQW	High Quality Waters. Waters which are rated as excellent based on biological and physical/chemical characteristics through Division of Water Quality monitoring or special studies, native and special species trout waters (and their tributaries) designated by the Marine Fisheries Commission, primary nursery areas (PNA) designated by Marine Fisheries Commission, all water supply watersheds which are classified either WS-I or WS-II or those for which a formal petition for reclassification as WS-I or WS-II has been received from the appropriate local government and accepted by the Division of Water Quality and all Class SA waters.
NSW	Nutrient Sensitive Waters. Waters subject to growths of microscopic or macroscopic vegetation requiring limitations on nutrient inputs.

Table 2-7
Groundwater Sample Results
September 2014
Range Environmental Vulnerability Assessment
MCIEAST-MCB Camp Lejeune, NC

CONSTITUENT SCREENING			MONITORING WELL					POTABLE SUPPLY WELL			NON-POTABLE SUPPLY WELL			
Monitoring Well ID	**DoD Screening Value (Drinking Water)[a]**	**NC Groundwater Standard[b]**	**MW-03**		**MW-04**	**MW-2**	**MW-01**	**PSW-1**	**PSW-2**	**PSW-3**	**NPSW-2**	**NPSW-3**		**NPSW-1**
Sample Date			Sep-14	Duplicate	Sep-14	Sep-14	Sep-14	Sep-14	Sep-14	Sep-14	Sep-14	Sep-14	Duplicate	Sep-14
Metals (µg/L)														
Lead, Total	15	15	**0.96 J**	**0.29 J**	**1.7**	NA	NA	NA	NA	**1.5**	NA	NA	NA	NA
Lead, Dissolved	15	15	0.50 U	**1.5**	**0.26 J**	NA	NA	NA	NA	**0.69 J**	NA	NA	NA	NA
Other														
Perchlorate (µg/L)	15	1.4	0.10 U	0.10 U	NA	0.10 U	0.10 U	0.10 U	0.10 U	NA	0.10 U	0.10 U	0.10 U	0.10 U
Hardness, as $CaCO_3$ (mg/L)	---	----	230	NA	19	NA	NA	NA	NA	320	NA	NA	NA	NA

Notes
Yellow = Detected concentration
Red = Detection exceeds screening criteria
Gray = Total Hardness
"---" = not listed in standards
$CaCO_3$ = calcium carbonate
J = estimated value
mg/L = milligrams per Liter
µg/L = micrograms per Liter
NA = not analyzed
U = analyte was not detected, reporting limit shown
a.) DoD operational range assessment screening values for protection of human drinking water. Table 1 of "Operational Range Assessment Screening Values" (Version 6.2, September 2013).
b.) The most conservative of North Carolina Groundwater Quality Standards (NCGWQS), Regional Screening Levels (RSLs), and Maximum Contaminant Levels (MCLs) were used for screening criteria. NCGWQS, 15A NCAC 02L.0200, effective April 1, 2013. RSLs, USEPA, November 2014. MCLs, USEPA, November 2014

Table 2-8
R-100 Skeet Range Surface Water Sampling Results
September 2014
Range Environmental Vulnerability Assssment
MCIEAST-MCB Camp Lejeune, NC

CONSTITUENT SCREENING			SKEET RANGE		
Sample ID	**DoD Screening Ecological Freshwater[a]**	**NC Protection Standard Freshwater Aquatic Life[b]**	**R100_SW-01**		**R100_SW-04**
Sample Date			Sep-14	Duplicate	Sep-14
Metals (µg/L)					
Lead, Total	---	25	26 J	31 J	3.3 J
Lead, Dissolved	Varies[c]	---	22	23	2.2
Adjusted DoD Hardness Criteria (chronic)	Varies[c]		**0.21**	**0.21**	**0.11**
Adjusted DoD Hardness Criteria (acute)	Varies[c]		**5.47**	**5.47**	**2.89**
PAHs (µg/L)					
Phenanthrene	---	0.7	0.51 U	0.52 U	0.52 U
Benzo(a)pyrene	---	---	0.51 U	0.52 U	0.52 U
Acenaphthene	---	60	0.51 U	0.52 U	0.52 U
Acenaphthylene	---	---	0.51 U	0.52 U	0.52 U
Benz(a)anthracene	---	---	0.51 U	0.52 U	0.52 U
Fluorene	---	30	0.51 U	0.52 U	0.52 U
Chrysene	---	---	0.51 U	0.52 U	0.52 U
Fluoranthene	---	0.11	0.51 U	0.52 U	0.52 U
Benzo(b)fluoranthene	---	---	0.51 U	0.52 U	0.52 U
Benzo(k)fluoranthene	---	---	0.51 U	0.52 U	0.52 U
Naphthalene	---	12	0.51 U	0.52 U	0.52 U
2-Methylnaphthalene	---	---	0.51 U	0.52 U	0.52 U
Anthracene	---	0.05	0.51 U	0.52 U	0.52 U
Dibenz(a,h)anthracene	---	---	0.51 U	0.52 U	0.52 U
Indeno(1,2,3-cd)pyrene	---	---	0.51 U	0.52 U	0.52 U
Benzo(g,h,i)perylene	---	---	0.51 U	0.52 U	0.52 U
Pyrene	---	---	0.51 U	0.52 U	0.52 U
General Parameters					
Hardness, as $CaCO_3$ (mg/L)	---	---	11	11	6.3

Notes:

Yellow = Detected concentration

Red = Detection exceeds screening criteria

Gray = Total Hardness

= Does not apply

= Hardness-adjusted freshwater ecological screening criteria for dissolved lead

"---" = not listed in standards

µg/L = micrograms per liter

mg/L = milligrams per Liter

J = estimated value

U = not detected; reporting limit reported.

a.) DoD operational range assessment screening values for protection of freshwater surface water. Obtained from Table 2 of "Operational Range Assessment Screening Values" (DoD, Version 6.2, September 2013).

b.) NC protection standards obtained from North Carolina Administrative Code for surface water (15A NCAC 02B). North Carolina does not have standards for dissolved metals.

c.) Screening criteria adjusted per USEPA National Recommended Water Quality Criteria parameters for calculating dissolved metals that are hardness-dependent.

Table 2-9
R-100 Skeet Range Sediment Sample Results
September 2014
Range Environmental Vulnerability Assessment
MCIEAST-MCB Camp Lejeune, NC

CONSTITUENT SCREENING			SKEET RANGE				
Sample ID	Screening Value		R100-SED-01	R100-SED-02	R100-SED-03	R100-SED-04	
Depth			0-6	0-6	0-6	0-6	0-6
Sample Date	DoD Freshwater Sediment[a]	EPA Region 4 Screening[b]	Sep-14	Sep-14	Sep-14	Sep-14	Duplicate
Metals (mg/kg)							
Lead	47	30.2	**73 J**	**24 J**	**7.1 J**	**12 J**	**17 J**
PAHs (µg/kg)							
2-Methylnaphthalene	---	---	22 U	20 U	22 U	25 U	24 U
Acenaphthene	---	330	22 U	20 U	22 U	25 U	24 U
Acenaphthylene	---	330	22 U	20 U	22 U	25 U	24 U
Anthracene	---	330	22 U	20 U	22 U	25 U	24 U
Benzo(a)anthracene	---	330	22 U	20 U	22 U	25 U	24 U
Benzo(a)pyrene	---	330	22 U	**13 J**	22 U	25 U	24 U
Benzo(b)fluoranthene	---	---	22 U	**21 J**	22 U	25 U	24 U
Benzo(g,h,i)perylene	---	---	22 U	20 U	22 U	25 U	24 U
Benzo(k)fluoranthene	---	---	44 U	40 U	43 U	50 U	49 U
Chrysene	---	330	22 U	**13 J**	22 U	25 U	24 U
Dibenzo (a,h) anthracene	---	330	44 U	40 U	43 U	50 U	49 U
Fluoranthene	---	330	22 U	20 U	22 U	25 U	24 U
Fluorene	---	330	22 U	20 U	22 U	25 U	24 U
Indeno(1,2,3-cd)pyrene	---	---	44 U	**13 J**	43 U	50 U	49 U
Naphthalene	---	330	22 U	20 U	22 U	25 U	24 U
Phenanthrene	---	330	22 U	20 U	22 U	25 U	24 U
Pyrene	---	330	22 U	20 U	22 U	25 U	24 U
Other Parameters (mg/kg)							
Total Phosphorus	---	---	4.6 JH	NA	NA	NA	NA
Sulfate	---	---	37	NA	NA	NA	NA
Total Organic Carbon	---	---	11,000	NA	NA	NA	NA
Total Inorganic Carbon	---	---	93	NA	NA	NA	NA
General Parameters							
pH	---	---	3.42 H	4.09 H	3.32 H	3.52 H	NA
Cation Exchange Capacity (mequv/100g)	---	---	8.7	NA	NA	NA	NA
Percent Moisture	---	---	27	17	25	35	34
Shot Density (shot/kg soil)	---	---	NA	NA	NA	NA	NA

Notes:
Yellow = Detected concentration
Red = Dectection exceeds screening criteria
Gray = Sediment characterization parameter
"---" = not listed in standards
µg/kg = micrograms per kilogram
H = holding time for preparation or analysis was exceeded
J = estimated value
mg/kg = milligrams per kilogram
NA = not analyzed
U = not detected; reporting limit reported
a.) DoD operational range assessment screening values for protection of freshwater sediment. Table 2 of "Operational Range Assessment Screening Values" (Version 6.2, Sep
b.) USEPA Region 4 Waste Management Division Sediment Screening Values. http://www.epa.gov/region4/superfund/programs/riskassess/ecolbul.html#tbl3
North Carolina does not monitor sediment because there are no sediment standards.

Table 2-10
R-100 Skeet Range Soil Sample Results
September 2014
Range Environmental Vulnerability Assessment
MCIEAST-MCB Camp Lejeune, NC

CONSTITUENT SCREENING				SKEET RANGE												
Sample ID	**USEPA Residential RSL[a]**	**USEPA Industrial RSL[a]**	**North Carolina Soil Screening Levels[b]**	**R100-SB-01**			**R100-SB-02**		**R100-SB-03**		**R100-SB-04**		**R100-SB-05**		**R100-SB-06**	
Depth (inches bgs)				**0-6**	**0-6**	**18-24**	**0-6**	**18-24**	**0-6**	**18-24**	**0-6**	**18-24**	**0-6**	**18-24**	**0-6**	**18-24**
Sample Date				Sep-14	Duplicate	Sep-14	Sep-14	Sep-14	Sep-14	Sep-14	Sep-14	Sep-14	Sep-14	Sep-14	Sep-14	Sep-14
Metals (mg/kg)																
Lead	400	800	270	**5.9 J**	**37 J**	**18**	**6.3**	**48**	**29**	**8.1**	**15**	**9.7**	**25**	**8.8**	**18**	**9.3**
PAHs (µg/kg)																
2-Methylnaphthalene	23,000	300,000	1,600	19 U	19 U	19 U	21 U	21 U	22 U	23 U	19 U	19 U	24 U	20 U	26 U	21 U
Acenaphthene	350,000	4,500,000	8,400	19 U	19 U	19 U	21 U	21 U	22 U	23 U	19 U	19 U	24 U	20 U	26 U	21 U
Acenaphthylene	--	--	20,900	19 U	19 U	19 U	21 U	21 U	22 U	23 U	19 U	19 U	24 U	20 U	26 U	21 U
Anthracene	1,700,000	23,000,000	660,000	19 U	19 U	19 U	21 U	21 U	22 U	23 U	19 U	19 U	24 U	20 U	26 U	21 U
Benzo(a)anthracene	150	2900	180	19 U	19 U	19 U	**23 J**	21 U	22 U	23 U	19 U	19 U	24 U	20 U	26 U	21 U
Benzo(a)pyrene	15	290	59	19 U	19 U	19 U	**29 J**	21 U	22 U	23 U	19 U	19 U	24 U	20 U	26 U	21 U
Benzo(b)fluoranthene	150	2900	600	19 U	19 U	19 U	**39 J**	21 U	22 U	23 U	19 U	19 U	24 U	20 U	26 U	21 U
Benzo(g,h,i)perylene	--	--	7,800,000	19 U	19 U	19 U	**18 J**	21 U	22 U	23 U	19 U	19 U	24 U	20 U	26 U	21 U
Benzo(k)fluoranthene	1,500.0	29,000	5,900	38 U	38 U	38 U	**23 J**	42 U	43 U	45 U	38 U	38 U	48 U	40 U	51 U	43 U
Chrysene	15,000	290,000	18,000	19 U	19 U	19 U	**23 J**	21 U	22 U	23 U	19 U	19 U	24 U	20 U	26 U	21 U
Dibenzo (a,h) anthracene	15	290	190	38 U	38 U	38 U	42 U	42 U	43 U	45 U	38 U	38 U	48 U	40 U	51 U	43 U
Fluoranthene	230,000	3,000,000	330,000	19 U	19 U	19 U	**30 J**	21 U	22 U	23 U	19 U	19 U	24 U	20 U	26 U	21 U
Fluorene	230,000	3,000,000	56,000	19 U	19 U	19 U	21 U	21 U	22 U	23 U	19 U	19 U	24 U	20 U	26 U	21 U
Indeno(1,2,3-cd)pyrene	150	2900	3,470	38 U	38 U	38 U	**23 J**	42 U	43 U	45 U	38 U	38 U	48 U	40 U	51 U	43 U
Naphthalene	3,800.0	17,000	210	19 U	19 U	19 U	21 U	21 U	22 U	23 U	19 U	19 U	24 U	20 U	26 U	21 U
Phenanthrene	--	--	67,600	19 U	19 U	19 U	21 U	21 U	22 U	**16 J**	19 U	19 U	24 U	20 U	26 U	21 U
Pyrene	170,000	2,300,000	220,000	19 U	19 U	19 U	**23 J**	21 U	22 U	23 U	19 U	**14 J**	24 U	20 U	26 U	21 U
Other Parameters (mg/kg)																
Total Phosphorus	---	---	---	NA	NA	NA	16	16	5.9 J	11	NA	NA	NA	NA	NA	NA
Sulfate	---	---	---	NA	NA	NA	8.5	8.3	45	23	NA	NA	NA	NA	NA	NA
Total Organic Carbon	---	---	---	NA	NA	NA	3,000 J	11,000	2,300	16,000	NA	NA	NA	NA	NA	NA
Total Inorganic Carbon	---	---	---	NA	NA	NA	120	130	20 J	920	NA	NA	NA	NA	NA	NA
General Parameters																
pH	---	---	---	3.86 H	NA	7.06 H	3.99 H	4.45 H	3.98 H	3.33 H	4.64 H	4.46 H	2.88 H	3.22 H	3.23 H	3.32 H
Cation Exchange Capacity (mequv/100g)	---	---	---	NA	NA	NA	2.4	6.4	2.4	10.2	NA	NA	NA	NA	NA	NA
Percent Moisture	---	---	---	12	14	13	21	23	24	27	11	13	32	16	36	23

Notes:

Yellow = Detected concentration
Red = Dectection exceeds screening criteria
Gray = Soil characterization parameter
"---" = not listed in standards
µg/kg = micrograms per kilogram
bgs = below ground surface
H = holding time for preparation or analysis was exceeded
J = estimated value
mequv/100g = milli-equivalents per 100 grams
mg/kg = milligrams per kilogram
NA = not analyzed
U - not detected; reporting limit reported
a) USEPA Regional Screening Levels, updated January 2015.
b.) North Carolina Federal Remediation Branch soil to groundwater soil screening levels (July 2013)

Only benzo(a)pyrene exceeded the residential soil RSL in one soil sample, but the detected concentration was one order of magnitude below industrial RSL. Given the recreational use at the site, industrial screening criteria is a conservative screening, as described above. No threats to human health or the environment are indicated for soil.

Soil and Sediment Characterization

Soil and sediment characteristics that can have a significant influence on mobility and availability of MC in the environment include pH, phosphorus, sulfate, cation exchange capacity, and organic matter. Lead and many of the organic MC are more mobile under acidic conditions where the soil pH is less than 6, as was observed at the skeet range. Lead will form highly insoluble minerals (less mobile and less available for uptake) in the presence of high levels of phosphate or sulfide; however samples analyses indicate low phosphorus and sulfur concentrations at the skeet range. In addition to potential for forming insoluble minerals, lead can bind strongly to certain soil types, typically clays under near neutral pH conditions, as measured by the cation exchange capacity. The cation exchange capacity measured at the skeet range is low, characteristic of very sandy soils that will not bind lead, and organic matter concentrations measured at the skeet range are not expected to strongly bind organic MC or lead in the soil or sediment. Based on analyses for the soil and sediment samples, the soil characteristics are conducive to increasing mobility and availability of MC.

2.5.4 Installation Data

MCIEAST-MCB CAMLEJ collects field data as part of installation routine monitoring and environmental investigations. Potable supply wells are routinely sampled, and these data were reviewed to determine if they indicate releases from any of the ranges. Additionally, the installation performed an environmental study in Bear Creek in beginning in 2009 because historical use areas were discovered outside the installation boundary.

Potable supply wells are sampled semiannually at the installation, and sampling data were provided for years 2011 to 2013 for review and consideration. HMX was the only explosive detected during this time period, with a July 2013 estimated concentration of 0.12 µg/L in one well (PSW-3,) located near the north-central installation boundary. This is below the DoD screening value of 780 µg/L. Perchlorate was sporadically detected with a maximum detected concentration of 0.21 µg/L (estimated), which is below the DoD screening value of 15 µg/L and the North Carolina protection standard of 2 µg/L. Lead was detected during 2012 and 2013 with two detected concentrations at or exceeding the DoD screening value for human drinking water and North Carolina groundwater protection standard of 15 µg/L in October 2012. Lead was detected at a concentration of 18 µg/L in LCH-1 and 15 µg/L in PSW-5. Well LCH-1 is located at the north-central installation boundary near PSW-4, while PSW-5 is located adjacent to the F-Ranges MC loading area on the northern installation boundary. These wells were resampled in March 2013; LCH-1 contained an estimated lead concentration of 0.19 µg/L, and lead was not detected in PSW-5. .

Several SDZs associated with historical ranges located in the southeastern portion of the installation around Bear Creek extended beyond the installation boundary and onto what is now private and state-owned property. As a result, MCIEAST-MCB CAMLEJ conducted investigations from October 2009 to

May 2010 that included an aerial geophysical survey, terrestrial digital geophysical mapping, an intrusive investigation of Bear Island, and environmental sampling. Soil, surface water, groundwater, sediment, and pore water samples collected were analyzed for explosives residues, perchlorate, and metals to evaluate whether contamination related to the former range activities was present in the area. Explosives residues were not detected in any samples; perchlorate was detected in groundwater samples at levels below the regulatory screening level; information on metals data was not found. Based on the results of the environmental sampling, it was determined that there was no unacceptable risk to humans or the environment from exposure to soil, surface water, groundwater, pore water, or sediment. Therefore, no further environmental sampling was deemed necessary. Results of REVA monitoring in September 2014 further support that there is not a release of MC in Bear Creek from current or historical activities.

3. Findings and Conclusions

Table 3-1: Summary of Results and Conclusions of the Hydrologic Subwatershed Areas where MC Loading Areas are Located

Shelter Swamp Creek Subwatershed	
Analysis	**Findings/Results**
MC loading areas (% area in the subwatershed)	**SR-6, SR-7** (66%)**, SR-10** (28%)
Identified REVA receptors	Surface Water/Sediment: ecological (special status species include red-cockaded woodpecker, rough-leaved loosestrife) Groundwater: human (county water supply wells), discharge to surface water
Surface water screening-level modeling	Estimated MC concentrations in surface water runoff at the edge of the loading areas were predicted to be below detectable concentrations. No additional surface water screening assessment is recommended at this time.
Sediment screening-level modeling	Annual average edge-of-loading-area MC concentrations in sediment were predicted to be below detectable concentrations. No additional sediment screening assessment is recommended at this time.
Groundwater screening-level modeling	Estimated MC concentrations in infiltrating water were predicted to be below detectable concentrations before reaching the water table. No additional groundwater screening assessment is recommended at this time.
SAR	**SR-8**
Qualitative evaluation	Surface water / sediment ranking = MODERATE Groundwater ranking = MODERATE Total annual lead use within this subwatershed is approximately 54,604 lb. Surface water sampling for lead was conducted in the Shelter Swamp Creek subwatershed due to high lead loading.
Sampling	**One surface water sample location** (GSRA-SW-01)
Sample results	One sample was collected on the western boundary of the installation in the northern tributary of Shelter Swamp Creek and analyzed for total and dissolved lead. *Total lead = 7.7 µg/L (North Carolina screening criterion is 25 µg/L)* *Dissolved lead = not detected (ND).*
Conclusion	The screening-level assessment results do not indicate a current release of

	perchlorate or HE to surface water, sediment, or groundwater at detectable concentrations from the MC loading areas identified within the Shelter Swamp Creek subwatershed. Sampling results in Shelter Swamp Creek indicate that lead is not migrating off range in surface water at concentrations that threaten human health or the environment. Monitoring should be continued as the total lead concentration indicated there may be some movement of lead downstream; however, the sampling location is a significant down gradient distance from SR-8 and may have other contributing sources. Ranges SR-6 and SR-7 also contribute high quantities of lead to this subwatershed.
Juniper Swamp Subwatershed	
Analysis	**Findings/Results**
MC loading area	**SR-10** (72%)
Identified REVA receptors	Surface water / sediment: ecological (special status species include rough-leaved loosestrife) Groundwater: human (county water supply wells), discharge to surface water
Surface water screening-level modeling	Estimated MC concentrations in surface water runoff at the edge of the SR-10 MC loading area were predicted to be below detectable concentrations. No additional surface water screening assessment is recommended at this time.
Sediment screening-level modeling	Annual average edge-of-loading-area MC concentrations in sediment were predicted to be below detectable concentrations. No additional sediment screening assessment is recommended at this time.
Groundwater screening-level modeling	Estimated MC concentrations in infiltrating water from the SR-10 MC loading area were predicted to be below detectable concentrations. No additional groundwater screening assessment is recommended at this time.
SAR	**SR-11**
Qualitative evaluation	Surface water / sediment ranking = MINIMAL (screening evaluation) Groundwater ranking = MINIMAL (screening evaluation) Total annual lead use within this subwatershed is approximately 4,468 lb.
Sampling	**No samples**
Conclusion	The screening-level assessment results do not indicate a current release of perchlorate, HE, or lead to surface water, sediment, or groundwater at detectable concentrations from the MC loading area or SAR identified within the Juniper Swamp subwatershed.

Southwest Creek Subwatershed	
Analysis	**Findings/Results**
MC loading areas	**SR-7** (34%), **Devil Dog**
Identified REVA receptors	Surface water / sediment: ecological (special status species include red-cockaded woodpecker, American alligator) Groundwater: human (installation water supply wells), discharge to surface water
Surface water screening-level modeling	Estimated MC concentrations from surface water runoff and groundwater base flow entering Southwest Creek were predicted to be below detectable concentrations. No additional surface water screening assessment is recommended at this time.
Sediment screening-level modeling	Annual average edge-of-loading-area MC concentrations in sediment were predicted to be below detectable concentrations. No additional sediment screening assessment is recommended at this time.
Groundwater screening-level modeling	Estimated MC concentrations in infiltrating water were predicted to be below detectable concentrations before reaching the Castle Hayne aquifer. No additional groundwater screening assessment is recommended at this time.
SAR	**B-12**
Qualitative evaluation	Surface water / sediment ranking = MINIMAL (screening evaluation) Groundwater ranking = MINIMAL (screening evaluation) Total annual lead use within this subwatershed is approximately 4,825 lb.
Sampling	**No samples**
Conclusion	The screening-level assessment results do not indicate a current release of perchlorate or HE to surface water, sediment, or groundwater at detectable concentrations from the MC loading areas identified within the Southwest Creek subwatershed.
Stones Creek Subwatershed	
Analysis	**Findings/Results**
MC loading area	**L-5**
Identified REVA receptors	Surface water / sediment: ecological (special status species include red-cockaded woodpecker) Groundwater: human (county water supply wells), discharge to surface water
Surface water	Estimated MC concentrations from surface water runoff and groundwater base

screening-level modeling	flow were predicted to be below detectable concentrations at the confluence of Stones Creek with Stones Bay. No additional surface water assessment is recommended at this time.
Sediment screening-level modeling	Annual average edge-of-loading-area MC concentrations in sediment were predicted to be below detectable concentrations at the confluence of Stones Creek with Stones Bay. No additional sediment screening assessment is recommended at this time.
Groundwater screening-level modeling	The estimated perchlorate concentration in groundwater was predicted to reach the Castle Hayne aquifer and travel to a groundwater receptor location (county well located off-installation). All other estimated MC concentrations were predicted below detectable concentrations in infiltrating water. Groundwater sampling was recommended.
SARs	**Dodge City, Multi-Purpose, Mechanical Pistol, Walk Down Pistol**
Qualitative evaluation	Dodge City Surface water / sediment ranking = MODERATE Groundwater ranking = MINIMAL Multi-Purpose, Mechanical Pistol, and Walk Down Pistol Surface water / sediment ranking = MINIMAL (screening evaluation) Groundwater ranking = MINIMAL (screening evaluation) Total annual lead use within this subwatershed is approximately 41,891 lb. Approximately 70% of the lead is contributed by L-5 and Alpha range. Another 27% is used by ranges with bullet traps. Although Alpha range lies just within the boundary of the Stones Creek subwatershed, it was evaluated with Bravo and Charlie ranges in the New River at Stones Bay subwatershed since they have similar use and range design, and are immediately adjacent to one another. A surface water sample was collected in Stones Bay near the confluence of Stones Creek and Stones Bay in part because of high lead loading within this subwatershed. Results are presented with the New River at Stones Bay subwatershed.
Sampling	**One groundwater sample** (MW-1)
Sample results	One groundwater sample was collected in the monitoring well south of the L-5 MC loading area and up gradient of the off-installation county supply wells (MW-1) and analyzed for perchlorate. *Perchlorate = ND*
Conclusion	The screening-level and qualitative assessment results do not indicate a current release of perchlorate, HE, or lead to surface water, sediment, or groundwater at

	detectable concentrations from the MC loading areas or SARs identified within the Stones Creek subwatershed. This was further confirmed by sampling results.
New River at Stones Bay Subwatershed	
Analysis	**Findings/Results**
MC loading areas	**Stones Bay Area, K-407, K-408, K-500A, K-500** (45%)
Identified REVA receptors	Surface water / sediment: ecological (special status species include red-cockaded woodpecker) Groundwater: discharge to surface water
Surface water screening-level modeling	Estimated MC concentrations from surface water runoff and base flow were predicted to be below detectable concentrations in surface water entering the New River at Stones Bay. No additional surface water screening assessment is recommended at this time.
Sediment screening-level modeling	Annual average edge-of-loading-area MC concentrations in sediment were predicted to be below detectable concentrations. No additional sediment screening assessment is recommended at this time.
Groundwater screening-level modeling	Estimated MC concentrations were predicted to be below detectable concentrations before reaching groundwater receptor locations. No additional groundwater screening assessment is recommended at this time.
SARs	**Alpha, Bravo, Charlie, Hathcock, Square Bay, K-402, K-402A, K-406A, K-406B**
Qualitative evaluation	K-406A/K-406B Surface water / sediment ranking = HIGH Alpha, Bravo, and Charlie; Hathcock; and K-402/K-402A Surface water / sediment ranking = MODERATE Alpha, Bravo, Charlie Ranges; K-406A/K-406B; and Hathcock Groundwater ranking = MODERATE K-402/K-402A Groundwater ranking = MINIMAL Square Bay Surface water / sediment ranking = MINIMAL (screening evaluation) Groundwater ranking = MINIMAL (screening evaluation)

	Total annual lead use within this subwatershed is approximately 45,951 lb. One surface water sample was collected on the western side of the K-2 Impact Area down gradient of K-406A and K-406B due to a high ranking and high lead loading within the subwatershed. One sample was collected in Stones Bay due to high lead loading within the subwatershed.
Sampling	**Two surface water sample locations** (SB-SW-01, K2-SW-02)
Sample results	Upper and lower depth interval surface water samples were collected from a location in Stones Bay outside the SDZ (SB-SW-01). *Upper sample total lead = 0.44 ug/L (North Carolina screening criterion is 25 µg/L)* *Upper sample dissolved lead = ND* *Lower sample total lead = 0.4 µg/L* *Lower sample dissolved lead = 2.5 µg/L (DoD screening criterion is 8.1 µg/L).* *Total and dissolved lead results in the lower sample indicate error based on a dissolved lead concentration greater than the total lead concentration.* One sample (K2-SW-02) was collected in a creek on the western side of the K-2 Impact Area near its discharge into Stones Bay. *Total lead = 3.3 µg/L* *Dissolved lead = 2.5 µg/L.*
Conclusion	The screening-level and qualitative assessment results do not indicate a current release of perchlorate, HE, or lead to surface water, sediment, or groundwater at detectable concentrations from the MC loading areas or SARs identified within the New River at Stones Bay subwatershed. This is further confirmed by the sampling results.
New River between Stick Creek and Whitehurst Creek Subwatershed	
Analysis	**Findings/Results**
MC loading areas	**K-510, EOD-2, ETA-5/5A** (22%)
Identified REVA receptors	Surface water / sediment: ecological (special status species include red-cockaded woodpecker) Groundwater: human (installation water supply wells), discharge to surface water
Surface water screening-level modeling	Estimated MC concentrations from surface water runoff and base flow were predicted to be below detectable concentrations in surface water entering the New River between Stick Creek and Whitehurst Creek. No additional surface water screening assessment is recommended at this time.
Sediment screening-level modeling	Annual average edge-of-loading-area MC concentrations in sediment were predicted to be below detectable concentrations. No additional sediment screening assessment is recommended at this time.

Groundwater screening-level modeling	The estimated perchlorate concentration in groundwater was predicted to reach the Castle Hayne aquifer and travel to a groundwater receptor location (non-potable supply well). All other estimated MC concentrations were predicted below detectable concentrations before reaching the groundwater receptor location. Groundwater sampling was recommended.
SARs	**A-1, D-29A, D-29B, D-30**
Qualitative evaluation	<u>D-30</u> Surface water / sediment ranking = MODERATE <u>A-1, D-29A, and D-29B (screening evaluation)</u> Surface water / sediment ranking = MINIMAL <u>A-1, D-29A, D-29B, and D-30 (screening evaluation)</u> Groundwater ranking = MINIMAL Total annual lead use within this subwatershed is approximately 13,889 lb.
Sampling	**One groundwater sample** (NPSW-1)
Sample results	A groundwater sample was collected from the non-potable supply well located outside the northeast boundary of the K-2 Impact Area. *Perchlorate = ND*
Conclusion	The screening-level and qualitative assessment results do not indicate a current release of perchlorate, HE, or lead to surface water, sediment, or groundwater at detectable concentrations from the MC loading areas or SARs identified within the New River between Stick Creek and Whitehurst Creek subwatershed. This is further confirmed by the sampling results.
New River between Town Creek and Stones Bay Subwatershed	
Analysis	**Findings/Results**
MC loading areas	**K-500** (55%)**, K-2 Impact Area, K-504A/B, K-505, K-323, ETA-5/5A** (78%)**, ETA-7/7C, ETA-9, ETA-10, EOD-3, Combat Town, ETA-4** (52%)**, G-19 Ranges, G-10 Impact Area** (80%)**, G-10A, F-6**
Identified REVA receptors	Surface water / sediment: ecological (special status species include red-cockaded woodpecker, rough-leaved loosestrife, American alligator) Groundwater: human (installation water supply wells), discharge to surface water
Surface water screening-level modeling	Estimated RDX and TNT concentrations in surface water runoff and base flow were predicted to reach the New River between Town Creek and Stones Bay above detectable concentrations. All other estimated MC concentrations were below detectable concentrations.

	Surface water sampling was recommended.
Sediment screening-level modeling	Estimated MC concentrations in sediment were predicted to be below detectable concentrations at the New River between Town Creek and Stones Bay. No additional sediment screening assessment is recommended at this time.
Groundwater screening-level modeling	The estimated perchlorate concentration in groundwater was predicted to reach the Castle Hayne aquifer and migrate to non-potable and potable supply wells. All other estimated MC concentrations were predicted below detectable concentrations before reaching the Castle Hayne aquifer. Groundwater sampling was recommended.
SARs	**K-501, K-501A, K-503, K-503A, K-506, K-507, K-508, K-509, K-325**
Qualitative evaluation	<u>K-325, K-503/K-503A, K-508</u> Surface water / sediment ranking = HIGH <u>K-501/K-501A, K-506, K-507, K-509</u> Surface water / sediment ranking = MODERATE <u>K-325, K-501/K-501A, K-503/K-503A, K-508</u> Groundwater ranking = MODERATE <u>K-506, K-507, K-509</u> Groundwater ranking = MINIMAL The range footprints of K-501A and K-503A and a small part of K-501 and K-503 are located in the subwatershed of the New River between Stick Creek and Whitehurst Creek, and they fire toward the K-2 Impact Area. These ranges are reported in this subwatershed since most of the expended rounds will land in it. Total annual lead use within this subwatershed is approximately 59,857 lb. Surface water sampling was conducted on the eastern side of the K-2 Impact Area down gradient of K-325, K-503/K-503A, and K-508 as a result of the high rankings and high lead loading within the subwatershed.
Sampling	**Four surface water sample locations** (K2-SW-04, K2-SW-05, G10-SW-09, G10-SW-10), **Six groundwater samples** (PSW-2, PSW-1, NPSW-2, MW-2, MW-3 and MW-4)
Sample results	Five surface water samples were collected from four locations. Two locations were in the New River on the western side of the K-2 Impact Area (K2-SW-04, K2-SW-05), and two locations were in streams draining the G-10 Impact Area near the discharge to the New River (G10-SW-09 upper and lower depth intervals, G10-SW-10). All samples were analyzed for explosives and perchlorate, and K2-

	SW-05 was also analyzed for total and dissolved lead. *Explosives and perchlorate = ND in all surface water samples* <u>K2-SW-05</u> *Total lead = 2.1 µg/L (North Carolina screening criterion is 25 µg/L)* *Dissolved lead = 0.79 µg/L (DoD screening criterion is 8.1 µg/L).* Two monitoring wells located on the northern boundary of the K-2 Impact Area (MW-3 and MW-4) were sampled for total and dissolved lead. *Total lead = 0.96 µg/L and 1.7 µg/L (DoD and North Carolina screening criteria is 15 µg/L).* *Dissolved lead = 1.5 (duplicate sample) and 0.26 µg/L (DoD screening criterion is 15 µg/L).* Two supply wells (PSW-2, PSW-1), one non-potable supply well (NPSW-2), and one monitoring well (MW-2) were sampled around the perimeter of the G-10 Impact Area and analyzed for perchlorate. *Perchlorate = ND in all groundwater samples*
Conclusion	The screening-level and qualitative assessment results do not indicate a current release of perchlorate, HE, or lead to surface water, sediment, or groundwater from the MC loading areas or SARs identified within the New River between Town Creek and Stones Bay subwatershed. This is further confirmed by the sampling results.
Wallace Creek Subwatershed	
Analysis	**Findings/Results**
MC loading areas	**ETA-3, F Ranges**
Identified REVA receptors	Surface water / sediment: ecological (special status species include red-cockaded woodpecker, American alligator) Groundwater: human (installation water supply wells), discharge to surface water
Surface water screening-level modeling	Estimated MC concentrations from surface water runoff and base flow were predicted to be below detectable concentrations entering Wallace Creek. No additional surface water screening assessment is recommended at this time.
Sediment screening-level modeling	Annual average edge-of-loading-area MC concentrations in sediment were predicted to be below detectable concentrations. No additional sediment screening assessment is recommended at this time.
Groundwater screening-level	The estimated perchlorate concentration in groundwater was predicted to reach the Castle Hayne aquifer and migrate to a potable supply well. All other estimated

modeling	MC concentrations were predicted below detectable concentrations before reaching the groundwater receptor location. Groundwater sampling was recommended.
SARs	**F-4, F-11A, F-11B, F-18, R-100**
Qualitative evaluation	<u>F-18, R-100</u> Surface water / sediment ranking = HIGH Groundwater ranking = MODERATE <u>R-100</u> Groundwater ranking = MINIMAL <u>F-4, F-11A, and F-11B (screening evaluation)</u> Surface water / sediment ranking = MINIMAL Groundwater ranking = MINIMAL R-100 scored a minimal ranking; however, it was modified to a high ranking due to surface water and sediment sample results. Total annual lead use within this subwatershed is approximately 12,677 lb. Surface water sampling was conducted in Wallace Creek based on the high ranking of F-18. Surface water, sediment, and soil sampling were conducted at R-100 as part of a baseline evaluation for this range.
Sampling	**One surface water sample location** (WC-SW-01), **One groundwater sample** (PSW-3), **Two skeet range surface water samples** (R100_SW-01 and R100_SW-04), **Four skeet range sediment samples** (R100_SD-01, R100_SD-02, R100_SD-03, R100_SD-04), **Six skeet range surface soil samples and six skeet range subsurface soil samples** (R100_SB-01, R100_SB-02, R100_SB-03, R100_SB-04, R100_SB-05, R100_SB-06)
Sample results	Upper and lower depth intervals were collected in Wallace Creek and analyzed for total and dissolved lead. *Total and dissolved lead = ND* One public supply well (PSW-3) was sampled for total and dissolved lead. *Total lead = 1.5 µg/L (DoD screening criteria is 15 µg/L)* *Dissolved lead = 0.69 µg/L (DoD and North Carolina screening criteria is 15 µg/L).* Two surface water samples (R100_SW-01, R100_SW-04) were collected at the skeet range and analyzed for total and dissolved lead and PAHs. *Total lead = 26 µg/L and 3.3 µg/L (North Carolina protection standard for freshwater aquatic life 25 µg/L).*

	Dissolved lead = 22 µg/L and 2.2 µg/L (DoD hardness-adjusted screening values for ecological freshwater are 0.21 µg/L and 0.11 µg/L for chronic exposure, and 5.47 µg/L and 2.89 for acute exposure). *PAHs = ND* Four sediment samples (R100_Sed-01 through R100_SW-04) were collected at the skeet range and analyzed for total and dissolved lead and PAHs. *Lead = 73 mg/kg, 24 mg/kg, 7.1 mg/kg, 17 mg/kg (duplicate sample) (DoD and USEPA Region 4 freshwater sediment screening benchmarks are 47 and 30.2 mg/kg).* *PAHs < USEPA Region 4 screening benchmarks (detected in one sample)* Six soil samples (R100_SB-01 through R100_SW-06) were collected and analyzed for lead and PAHs. *Lead = 5.9 to 48 mg/kg (most conservative screening criteria = 270 mg/kg)* *Benzo(a)pyrene = 29 µg/kg in one sample > residential RSL of 15 µg/kg* *PAHs in three samples < screening criteria*
Conclusion	The screening-level and qualitative assessment results do not indicate a current release of perchlorate, HE, or lead to surface water, sediment, or groundwater at detectable concentrations from the MC loading areas or SARs identified within the Wallace Creek subwatershed. This is further confirmed by the sampling results. Total lead exceeded screening criteria in one surface water sample and dissolved lead exceeded in two surface water samples at the skeet range. Lead exceeded screening benchmarks in one sediment sample. The highest concentrations of lead were detected near the end of a drainage swale where range debris and wads accumulated. Low soil/sediment pHs and other soil chemistry parameters that were measured are potentially conducive to mobilizing lead on the skeet range. Most lead detected in surface water was in the dissolved form. Soil amendments and removal of range debris could be helpful in reducing lead in surface water runoff.
Intracoastal Waterway between Alligator Bay and Freeman Creek Subwatershed	
Analysis	**Findings/Results**
MC loading area	**ETA-2** (56%)
Identified REVA receptors	Surface water / sediment: ecological (special status species include red-cockaded woodpecker, rough-leaved loosestrife, green sea turtle, loggerhead sea turtle, leatherback sea turtle, seabeach amaranth, piping plover) Groundwater: human (installation water supply wells), discharge to surface water
Surface water screening-level	Estimated MC concentrations from surface water runoff and base flow were predicted to be below detectable concentrations entering the Intracoastal

modeling	Waterway between Alligator Bay and Freeman Creek. No additional surface water screening assessment is recommended at this time.
Sediment screening-level modeling	Annual average edge-of-loading-area MC concentrations in sediment were predicted to be below detectable concentrations. No additional sediment screening assessment is recommended at this time.
Groundwater screening-level modeling	Estimated MC concentrations in infiltrating water were predicted to be below detectable concentrations before reaching the water table. No additional groundwater screening assessment is recommended at this time.
SARs	**No SARs**
Sampling	**No samples**
Conclusion	The screening-level assessment results do not indicate a current release of perchlorate or HE to surface water, sediment, or groundwater at detectable concentrations from the MC loading area identified within the Intracoastal Waterway between Alligator Bay and Freeman Creek subwatershed. Total annual lead use within this subwatershed is approximately 0 lb.
New River between Stones Bay and Intracoastal Waterway Subwatershed	
Analysis	**Findings/Results**
MC loading areas	**ETA-1, ETA-2** (44%)
Identified REVA receptors	Surface water / sediment: ecological (special status species include red-cockaded woodpecker, rough-leaved loosestrife, bald eagle) Groundwater: human (installation water supply wells), discharge to surface water
Surface water screening-level modeling	Estimated MC concentrations from surface water runoff and base flow were predicted to be below detectable concentrations entering the New River between Stones Bay and the Intracoastal Waterway. No additional surface water screening assessment is recommended at this time.
Sediment screening-level modeling	Annual average edge-of-loading-area MC concentrations in sediment were predicted to be below detectable concentrations. No additional sediment screening assessment is recommended at this time.
Groundwater screening-level modeling	Estimated MC concentrations in infiltrating water were predicted to be below detectable concentrations before reaching the Castle Hayne aquifer. No additional groundwater screening assessment is recommended at this time.
SAR	**I-1**
Qualitative	Surface water / sediment ranking = MINIMAL (screening evaluation)

evaluation	Groundwater ranking = MINIMAL (screening evaluation) Total annual lead use within this subwatershed is approximately 1,296 lb.
Sampling	**No samples**
Conclusion	The screening-level and qualitative assessment results do not indicate a current release of perchlorate, HE, or lead to surface water, sediment, or groundwater at detectable concentrations from the MC loading areas or SAR identified within the New River between Stones Bay and Intracoastal Waterway subwatershed.
Bear Creek Subwatershed	
Analysis	**Findings/Results**
MC loading areas	**Mobile MOUT Complex, MAC-3, G-10 Impact Area** (20%)**, G-6** (82%)**, EOD-1** (8%)**, G-7** (1%)
Identified REVA receptors	Surface water / sediment: ecological (special status species include red-cockaded woodpecker, rough-leaved loosestrife) Groundwater: human (county and installation water supply wells, non-potable supply wells), discharge to surface water
Surface water screening-level modeling	Estimated RDX and TNT concentrations in surface water runoff and base flow were predicted to reach Bear Creek at detectable concentrations. All other estimated MC concentrations were predicted below detectable concentrations. Surface water sampling was recommended.
Sediment screening-level modeling	Estimated MC concentrations in sediment entering Bear Creek were predicted to be below detectable concentrations. No additional sediment screening assessment is recommended at this time.
Groundwater screening-level modeling	The estimated perchlorate concentration in groundwater was predicted to reach the Castle Hayne aquifer and travel to a groundwater receptor location (installation non-potable supply well). All other estimated MC concentrations were predicted below detectable concentrations in infiltrating water. Groundwater sampling was recommended.
SARs	**MAC-1, MAC-2, MAC-4, MAC-5, MAC-6**
Qualitative evaluation	MAC-1, MAC-2, MAC-4, MAC-5, and MAC-6 Surface water / sediment ranking = MODERATE Groundwater ranking = MINIMAL Total annual lead use within this subwatershed is approximately 5,218 lb.
Sampling	**One surface water sample location** (G10-SW-08)**, One groundwater sample**

	(NPSW-3)
Sample results	One surface water sample was collected in Bear Creek prior to discharge into the Intracoastal Waterway (G10-SW-08) and analyzed for explosives and perchlorate. *Explosives and perchlorate = ND* One non-potable supply well located within the Mobile MOUT Complex (NPSW-3) was sampled and analyzed for perchlorate. *Perchlorate = ND*
Conclusion	The screening-level and qualitative assessment results do not indicate a current release of perchlorate, HE, or lead to surface water, sediment, or groundwater at detectable concentrations from the MC loading areas or SARs identified within the Bear Creek subwatershed. This is further confirmed by the sampling results.
Intracoastal Waterway between Browns Inlet and Queen Creek Subwatershed	
Analysis	**Findings/Results**
MC loading areas	**G-6** (18%)**, EOD-1** (92%)**, G-7** (99%), **N1/BT-3 Impact Area** (30%) (N1/BT-3 Impact Area MC loading area not modeled)
Identified REVA receptors	Surface water / sediment: ecological (special status species include red-cockaded woodpecker, rough-leaved loosestrife, green sea turtle, loggerhead sea turtle, leatherback sea turtle, seabeach amaranth, piping plover) Groundwater: discharge to surface water
Surface water screening-level modeling	Estimated MC concentrations from surface water runoff and base flow were predicted below detectable concentrations entering the Intracoastal Waterway between Browns Inlet and Queens Creek. No additional surface water screening assessment is recommended at this time.
Sediment screening-level modeling	Annual average edge-of-loading-area MC concentrations in sediment were predicted to be below detectable concentrations. No additional sediment screening assessment is recommended at this time.
Groundwater screening-level modeling	Estimated MC concentrations in infiltrating water were predicted to be below detectable concentrations before reaching the water table. No additional groundwater screening assessment is recommended at this time.
SARs	**No SARs**
Sampling	**No samples**
Conclusion	The screening-level assessment results do not indicate a current release of perchlorate or HE to surface water, sediment, or groundwater at detectable concentrations from the MC loading areas identified within the Intracoastal Waterway between Browns Inlet and Queens Creek subwatershed.

	Total annual lead use within this subwatershed is approximately 936 lb.
Freeman Creek Subwatershed	
Analysis	**Findings/Results**
MC loading area	**ETA-4** (48%)
Identified REVA receptors	Surface water / sediment: ecological (special status species include red-cockaded woodpecker, rough-leaved loosestrife) Groundwater: human (installation water supply wells), discharge to surface water
Surface water screening-level modeling	Estimated MC concentrations in surface water runoff and base flow were predicted to be below detectable concentrations at the confluence of Freeman Creek and the Intracoastal Waterway. No additional surface water screening assessment is recommended at this time.
Sediment screening-level modeling	Annual average edge-of-loading-area MC concentrations in sediment were predicted to be below detectable concentrations. No additional sediment screening assessment is recommended at this time.
Groundwater screening-level modeling	Estimated MC concentrations were predicted to be below detectable concentrations before reaching the water table. No additional groundwater screening assessment is recommended at this time.
SAR	**G-21**
Qualitative evaluation	Surface water / sediment ranking = MODERATE Groundwater ranking = MODERATE Total annual lead use within this subwatershed is approximately 0 lb.
Sampling	**No samples**
Conclusion	The screening-level and qualitative assessment results do not indicate a current release of perchlorate, HE, or lead to surface water, sediment, or groundwater at detectable concentrations from the MC loading area or SAR identified within the Freeman Creek subwatershed.

Note: ND = Not Detected

4. References

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Appendix A

Operational Range
Summary Table

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Training Area	Fixed Range	Start Date	End Date	Size (acres)	Status	Small Arms Range	MOUT Facility	Description	Primary Use
AA	N/A		present	228	Operational			Maneuver training area	Tactical maneuver training
AC	N/A		present	144	Operational			Maneuver training area	Tactical maneuver training
BC	N/A		present	692	Operational			Maneuver training area	Tactical maneuver training
EA	N/A		present	841	Operational			Maneuver training area	Amphibious operations training area
EB	N/A		present	431	Operational			Maneuver training area	Amphibious operations training area
	GP-20		present	2	Operational			Gun position	
EC	N/A		present	202	Operational			Maneuver training area (amphibious operations training)	Amphibious operations training area
FA	N/A	1941	present	1081	Operational			Maneuver training area	Tactical maneuver training
	F-2	1950	present	1152	Operational			Machinegun field firing and multipurpose BZO range	Squad automatic rifle, transition range
	F-5	1972	present	1086	Operational			Squad/fire team live fire maneuver course	Squad/fire team live fire maneuver course
	F-25T		present	1826	Operational			Squad/fire team live fire maneuver course	
	GP-1 (no name)		present	22	Operational			Gun position	
FB	N/A		present	922	Operational			Maneuver training area	
	F-4		present	922	Operational	X		Fire team/squad attack range	Rifle familiarization range
FC	N/A	1941	present	1982	Operational			Maneuver training area	Tactical maneuver training
	MAC-1	1990	present	752	Operational	X	X	Urban quick kill range for fire team/squad size units	Urban quick kill range, basic room/building entry and clearing range
	MAC-2	1990	present	753	Operational	X	X	Search and kill range	Search and kill range, basic room entry and clearing range
	MAC-3	1990	present	744	Operational	X	X	Live fire grenade house	Close quarters battle, live fire grenade house
	MAC-4	1990	present	705	Operational	X	X	Cover and clear	Fire team MOUT
	MAC-5	1990	present	811	Operational	X	X	Dodge city (basic squad MOUT range)	Basic squad MOUT range
	MAC-6	2005	present	766	Operational	X	X	Enhanced marksmanship range	Enhanced marksmanship range, NBC field firing range, quick kill range, non-lethal range
	MAC-7		present	25	Operational		X	MOUT grenadier gunnery range	MOUT grenadier gunnery range
	MOUT Lejeune -UTF 2 ST -UTF 3 ST -BIV -Enhanced		present	31	Operational		X	MOUT complex, shoothouse, 2 story urban training facility with moveable walls/doors, elevator shaft, internal/external ladder walls	MOUT

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Training Area	Fixed Range	Start Date	End Date	Size (acres)	Status	Small Arms Range	MOUT Facility	Description	Primary Use
	Mobile MOUT Complex		present	20	Operational		X	Mobile MOUT Facility with 71 total Buildings/containers, 66 non-live fire and 10 live fire containers with roads, 11 tracked vehicle pads, courtyard walls, and tunnels and many more training enhancements	MOUT
	MOUT Sniper Tower		present	<1	Operational		X	MOUT Facility	
FD	N/A	1941	present	911	Operational			Maneuver training area	Tactical maneuver training
	F-6	1972	present	31	Operational			Hand grenade range	Hand grenade range
FE	N/A	1941	present	922	Operational			Maneuver training area	Tactical maneuver training
	GP-2 (Swan)		present	18	Operational			Gun position	
FF	N/A	1941	present	962	Operational			Maneuver training area	Tactical maneuver training
FG	N/A	1941	present	1810	Operational			Maneuver training area	Tactical maneuver training
	ETA-3	1994	2013	67	Historical Use			Engineering training area	Engineer demolition training
	F-11A	1950	present	733	Operational	X		Baffled rifle BZO/pistol range	Basic 30 meter firing range (ZERO)
	F-11B	1950	present	250	Operational	X		Baffled pistol range	Pistol qualification/requalification
	F-18	1970	present	4160	Operational	X		Machinegun field firing range	Machinegun field firing range
G-10 Impact Area	N/A	1953	present	4995	Operational			Dudded impact area	
	G-10A EOD			<1	Operational				
	G-19A	2010	present	737	Operational			Light anti-armor/anti-tank weapons range, shoulder-launched multipurpose assault weapon range	Light anti-armor/anti-tank weapons range, shoulder-launched multipurpose assault weapon range
	G-19B	2010	present	73	Operational			Grenade Launcher Range	Grenade launcher range
	G-10 Urban Close Air Support Facility (UCAS)		present	11	Operational			G-10 urban CAS training facility (UCAS)	Urban close air support, FAC/JTAC training
GA	N/A	1941	present	450	Operational			Maneuver training area	Tactical maneuver training
	G-3		present	9236	Operational			Infantry Weapons Range	Infantry weapons range
	G-10 Live Fire Convoy Range -Site 3 -Site 4	2004	present	3654	Operational			G-10 Convoy Operations Course (live fire/non-live fire convoy range)	Live fire/non-live fire convoy range
	MP-7		present		Operational			Mortar position	
GB	N/A	1941	present	535	Operational			Maneuver training area	Tactical maneuver training
	G-29		present	4370	Operational				
	MP-1		present		Operational			Mortar position	
	MP-2		present		Operational			Mortar position	
	MP-3		present		Operational			Mortar position	
GC	N/A	1941	present	623	Operational			Maneuver training area	Tactical maneuver training
	MP-4		present		Operational			Mortar position	
	MP-5		present		Operational			Mortar position	
	MP-6		present		Operational			Mortar position	

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	G-27	Fall 2014	present	1632	Future Use			Infantry squad battle course	Infantry squad battle course (fire and manuever/movement range)
GD	N/A	1941	present	1102	Operational			Maneuver training area	Tactical maneuver training
	EOD-1	1994	2012	45	Historical Use			Explosive ordnance disposal range (G-10 Impact Area)	EOD range
	G-6/CBC	estimated 1951	present	3204	Operational			Infantry company battle course	Infantry company battle course, (company live fire and maneuver)
	MP-8				Historical Use			Mortar position	
GE	N/A	1941	present	527	Operational			Maneuver training area	Tactical maneuver training
	GP-7 (Crane)		present	23	Operational			Gun position	
GF	N/A	1941	present	927	Operational			Maneuver training area	Tactical maneuver training
	ETA-4	1994	present	87	Operational			Engineering training area	Engineer demolition training
	G-21	2012	present	4992	Operational	X		Machinegun range	Infantry and mounted machinegun training
GG	N/A	1941	present	1412	Operational			Maneuver training area	Tactical maneuver training
	GP-10 (Goose)		present	22	Operational			Gun position	
	GP-13 (Falcon)		present	32	Operational			Gun position	
GH	N/A	1941	present	855	Operational			Maneuver training area	Tactical maneuver training
	G-5		present	4109	Operational			Vehicle convoy range, infantry weapons range, AAV/LAV gunnery range	Vehicle convoy range, infantry weapons range, AAV/LAV gunnery range
	GP-12		present	17	Operational			Gun position	
GI	N/A	1941	present	560	Operational			Maneuver training area	Tactical maneuver training
	G-7	~1947	present	1946	Operational			Infantry weapons range, field artillery direct fire range	Infantry weapons range/artillery direct fire range, direct fire range
	GP-9 (Gull)		present	21	Operational			Gun position	
HA	N/A	1941	present	1369	Operational			Maneuver training area	Tactical maneuver training
	ETA-7 - 7A - 7B - 7C - 7D	2009	present	66	Operational			Engineering training area	Engineer demolition training
	ETA-8	2013	present	6	Operational			Engineering training area	Engineer demolition training
	GP-29 (Plover)		present	33	Operational			Gun position	
HB	N/A	1941	present	1542	Operational			Maneuver training area	Tactical maneuver training
	GP-16 (Dodo)		present	19	Operational			Gun position	
	GP-25 (Dove)		present	10	Operational			Gun position	
HC	N/A	1941	present	421	Operational			Maneuver training area	Tactical maneuver training
HD	N/A	1941	present	1161	Operational			Maneuver training area	Tactical maneuver training

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HE	N/A	1941	present	633	Operational			Maneuver training area	Tactical maneuver training
HF	N/A	1941	present	1067	Operational			Maneuver training area	Tactical maneuver training
	MOUT - Combat Town	1976	present	192	Operational		X	62 buildings with compound walls/gates	Combat in built-up areas, MOUT
	Hawk FOB			3	Operational			Forward operating base	
HG	N/A	1941	present	589	Operational			Maneuver training area	Tactical maneuver training
	GP-35 (Finch)		present	18	Operational			Gun position	
HH	N/A	1941	present	530	Operational			Maneuver training area	Tactical maneuver training
	GP-23 (Jaybird)		present	49	Operational			Gun position	
	EOD-3	2013	present	16	Operational			Demolition range	Demolition training
	ETA-9	2013	present	8	Operational			Engineering training area	Engineer demolition training
	ETA-10	2013	present	7	Operational			Engineering training area	Engineer demolition training
IA	N/A	1941	present	1067	Operational			Maneuver training area	Tactical maneuver training
	GP-17 (Osprey)		present	21	Operational			Gun position	
	GP-21 (Heron)		present	18	Operational			Gun position	
IB	N/A	1941	present	861	Operational			Maneuver training area	Tactical maneuver training
	GP-15 (Quail)		present	27	Operational			Gun position	
IC	N/A	1941	present	906	Operational			Maneuver training area	Tactical maneuver training
ID	N/A	1941	present	293	Operational			Maneuver training area	Tactical maneuver training
	GP-22 (Bluebird)		present	72	Operational			Gun position	
IE	N/A	1941	present	1433	Operational			Maneuver training area	Tactical maneuver training
	GP-26		present	17	Operational			Gun position	
	GP-30 (Egret)		present	22	Operational			Gun position	
IF	N/A	1941	present	1802	Operational			Maneuver training area	Tactical maneuver training
	ETA-1 -ETA-1 OBST -ETA-1 BRID -ETA-1 FIEL	1994	See notes	154	Operational			Engineering training area	Engineer demolition training
	ETA-2	1994	present	1150	Operational			Engineering training area	Engineer demolition training
	I-1	1960	present	1203	Operational	X		Baffled small arms range	Small arms aualification/requalification range, non-lethal weapons (NLW) range
	GP-27 (Canary)		present	21	Operational			Gun position	
IG	N/A	1941	present	530	Operational			Maneuver training area	Tactical maneuver training
	GP-18 (Albatross)		present	17	Operational			Gun position	

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JA	N/A		present	397	Operational			Maneuver training area	Tactical maneuver training
	GP-31 (Sandpiper)		present	15	Operational			Gun position	
	GP-33 (Oriole)		present	16	Operational			Gun position	
JB	N/A		present	194	Operational			Maneuver training area	Tactical maneuver training
JC	N/A		present	212	Operational			Maneuver training area	Tactical maneuver training
	GP-32 (Kite)		present	17	Operational			Gun position	
JD	N/A		present	108	Operational			Maneuver training area	Tactical maneuver training
JE	N/A		present	128	Operational			Maneuver training area	
K-2 Impact Area	N/A	1950	present	3237	Operational			Dudded impact area	
	K-325		present	972	Operational	X		Combat marksmanship program range	CMP range
	K-402		present	990	Operational	X		Fire and maneuver range	Individual tactical training range
	K-402A		present	18	Operational	X		House/room clearing range	MOUT
	K-406A		present	948	Operational	X		CMP range	CMP range
	K-406B		present	1177	Operational	X		Friend/foe reaction range	Close combat range/CMP range (behind the structure)
	K-407		present	1177	Operational			Live fire ambush range (day/night)	Live fire ambush range
	K-408		present	1173	Operational		X	Urban obstacle course	MOUT
	K-500	2011	present	579	Operational			Mortar range	Mortar firing position
	K-500A	2011	present	808	Operational			Grenade launcher range (vehicle or ground mounted firing)	Vehicle or ground mounted firing of grenade launcher
	K-501	2010	present	770	Operational	X		Rifle/machinegun range (static live fire)	Rifle/machinegun static live fire range
	K-501A	2010	present	719	Operational	X		Rifle/machinegun BZO/zero range (static live fire)	Rifle/machinegun static live fire range
	K-502	2011	present	269	Operational			Rocket range	Engaging moving targets with rockets
	K-503	2009	present	770	Operational	X		Rifle (static live fire)	Static live fire range
	K-503A	2009	present	719	Operational	X		Rifle BZO/zero range (static live fire)	Static live fire range
	K-504A	2011	present	69	Operational			Grenade launcher range	Grenade launcher range
	K-504B	2011	present	15	Operational			Grenade launcher range	Grenade launcher range
	K-505	2013	present	853	Operational			Rocket range	Live fire rocket range
	K-506	2013	present	913	Operational	X		Day/night and combat field firing range	Infantry familiarization firing
	K-507	2013	present	891	Operational	X		Close combat/CMP range	Close combat/CMP range
	K-508	2013	present	902	Operational	X		BZO/live-fire maneuver range	Rifle BZO/live-fire maneuver training
	K-509	2013	present	1081	Operational	X		Live-fire and maneuver range	Live-fire and maneuver training
KA	N/A	1941	present	617	Operational			Maneuver training area	Tactical maneuver training
KB	N/A	1941	present	1092	Operational			Maneuver training area	Tactical maneuver training
	K-510	2008	present	52	Operational		X	Live hand grenade range	Live hand grenade range

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KC	N/A	1941	present	1009	Operational			Maneuver training area	Tactical maneuver training
KD	N/A	1941	present	428	Operational			Maneuver training area	Tactical maneuver training
	EOD-2	1970	present	68	Operational			Explosive ordnance disposal range (Verona Loop area)	EOD range
	ETA-5	1994	present	16	Operational			Engineering training area	Engineer demolition training
	ETA-5A	1994	present	189	Operational			Urban breaching house (breaching operations)	Breaching operations
LA	N/A	1941	present	1449	Operational			Maneuver training area	Tactical maneuver training
	L-5	1957	present	2329	Operational			Infantry live fire maneuver range	Infantry live fire maneuver range
LB	N/A	1941	present	723	Operational			Maneuver training area	Tactical maneuver training
LC	N/A	1941	present	854	Operational			Maneuver training area	Tactical maneuver training
LD	N/A	1941	present	264	Operational			Maneuver training area	Tactical maneuver training
LE	N/A	1941	present	818	Operational			Maneuver training area	Tactical maneuver training
LF	N/A	1941	present	1461	Operational			Maneuver training area	Tactical maneuver training
HI	N/A	1941	present	707	Operational			Maneuver training area	Tactical maneuver training
	Alpha	mid-1980s	present	1101	Operational	X		Known distance ranges (25 yards - 600 yards)	Rifle marksmanship training
	Bravo	mid-1980s	present	1081	Operational	X		Known distance ranges (25 yards - 600 yards)	Rifle marksmanship training
	Charlie	mid-1980s	present	1029	Operational	X		Known distance ranges (25 yards - 600 yards)	Rifle marksmanship training
	Claymore			1	Operational				
	Dodge City	mid-1980s	present	1591	Operational	X		200 meter multiple supported and elevated shooting positions (urban sniper training)	Urban sniper training
	Hathcock Range	mid-1980s	present	1683	Operational	X		50 thru 1000 yard rifle/sniper range	Sniper live fire range
	Mechanical Pistol	mid-1980s	present	232	Operational	X		50 meter, 50 firing point pistol range	Pistol marksmanship range
	Multi-Purpose	mid-1980s	present	1109	Operational	X		100 meter small arms range	Rifle marksmanship range, CMP/CQB range, pistol/rifle/shotgun range
	Walk Down Pistol		present	379	Operational	X		50 meters, 50 firing point range	Pistol marksmanship range
	Breacher Pit UTF		present	5	Operational			Breacher pit	Explosive and thermal breaching
	Breacher Training Facility (RR-215)		present	5	Operational			Breacher training buildings with crib wall	Breaching: Explosive/ballistic thermal and mechanical
	Non-Lethal Weapons (NLW) Range 1		present	5	Operational			NLW range (SOTG only)	NLW small caliber live fire range
	Non-Lethal Weapons (NLW) Range 2		present	5	Operational			NLW range (SOTG only) large caliber weapons/devices	NLW large caliber live fire range
	Square Bay (RR-227)			252	Operational	X		Live fire pistol/rifle range	Live fire combat drills with pistols/rifles

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MA	N/A	1941	present	934	Operational			Maneuver training area	Tactical maneuver training
	MOUT Devil Dog		present	18	Operational		X	MOUT	
MB	N/A	1941	present	1115	Operational			Maneuver training area	Tactical maneuver training
MC	N/A	1941	present	1297	Operational			Maneuver training area	Tactical maneuver training
MD	N/A	1941	present	1335	Operational			Maneuver training area	Tactical maneuver training
ME	N/A	1941	present	1726	Operational			Maneuver training area	Tactical maneuver training
MF	N/A	1941	present	1412	Operational			Maneuver training area	Tactical maneuver training
QA	N/A	1941	present	1166	Operational			Maneuver training area	Tactical maneuver training
	GP-3 (Woodpecker)		present	18	Operational			Gun position	
QB	N/A	1941	present	512	Operational			Maneuver training area	Tactical maneuver training
RA	N/A	1941	present	494	Operational			Maneuver training area	Tactical maneuver training
	R-100	2013	present	99	Operational	X		Skeet/trap range	Skeet/trap shooting range
RB	N/A	1941	present	771	Operational			Maneuver training area	Tactical maneuver training
SA	N/A	1992	present	1248	Operational			Maneuver training area	Tactical maneuver training
SB	N/A	1992	present	653	Operational			Maneuver training area	Tactical maneuver training
SC	N/A	1992	present	1202	Operational			Maneuver training area	Tactical maneuver training
SD	N/A	1992	present	1456	Operational			Maneuver training area	Tactical maneuver training
	SR-7	1997	present	11568	Operational			Multipurpose training range (MPTR)	LAR crew qualification firing range
SE	N/A	1992	present	1686	Operational			Maneuver training area	Tactical maneuver training
SF	N/A	1992	present	4655	Operational			Maneuver training area	Tactical maneuver training
SG	N/A	1992	present	1743	Operational			Maneuver training area	Tactical maneuver training
	SR-9	Fall 2014	present	7971	Future Use			Infantry platoon battle course	Infantry platoon battle course (Fire and manuever/movement range)
SH	N/A	1992	present	1076	Operational			Maneuver training area	Tactical maneuver training
SI	N/A	1992	present	3497	Operational			Maneuver training area	
	SR-8/SR-8A	2009	present	6042	Operational	X		Multipurpose machinegun range (MPMG)	Machinegun qualification firing range

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SJ	N/A	1992	present	3497	Operational			Maneuver training area	Tactical maneuver training
	SR-6	1995	present	6323	Operational			Infantry platoon battle course	Infantry platoon battle course (Fire and manuever/movement range)
SK	N/A	1992	present	2563	Operational			Maneuver training area	Tactical maneuver training
SL	N/A	1992	present	5109	Operational			Maneuver training area	Tactical maneuver training
SM	N/A	1992	present	1065	Operational			Maneuver training area	Tactical maneuver training
SN	N/A	1992	present	1584	Operational			Maneuver training area	Tactical maneuver training
SO	N/A	1992	present	1658	Operational			Maneuver training area	Tactical maneuver training
	SR-10	1997	present	9902	Operational			Multi-purpose range complex	Tank crew qualification firing range
	SR-11	2001	present	254	Operational	X		Baffled pistol range	Pistol qualification/requalification
SP	N/A	1992	present	982	Operational			Maneuver training area	Tactical maneuver training
SQ	N/A	1992	present	560	Operational			Maneuver training area	Tactical maneuver training
SR	N/A	1992	present	990	Operational			Maneuver training area	Tactical maneuver training
ST	N/A	1992	present	2421	Operational			Maneuver training area	Tactical maneuver training
	SR-12 - Counter IED Home Station Lane Training Complex	2010	present		Operational			JIEDDO site; driving course on IED's	
SU	N/A	1992	present	1447	Operational			Maneuver training area	Tactical maneuver training
SV	N/A	1992	present	2459	Operational			Maneuver training area	Tactical aviation and ground maneuver training
	Camp Davis, Airfield Seizure Facilities		present	85	Operational			Mock airfield structures for joint/combined training/exercises	Tactical airfield assault and seizure
	Davis TOW		present	138	Operational			Practice missile range	
SW	N/A	1992	present	658	Operational			Maneuver training area	Tactical maneuver training
N1/BT-3 Impact Area	Brown's Island	1945	1976	1038	Operational				
	E-1		present	9502	Operational			Air defense firing range	Anti-aircraft range
	H Range		present	7095	Operational/ Water Range			Waterborne live fire range	Riverine assault range, waterborne gunnery range, oceanside gunnery range
	Naval Gunfire		present	33478	Operational/ Water Range				
	D-29A	1958	present	278	Operational	X		Baffled pistol range	Pistol qualification/requalification
	D-29B	1958	present	278	Operational	X		Baffled pistol range	Pistol qualification/requalification
	D-30	1958	present	278	Operational	X		Baffled pistol range	Pistol qualification/requalification
MCOLF Oak Grove		1950	1970	1	Operational				
New River	MOUT Geiger FOB		present	18	Operational		X	MOUT	
	A-1	1958	present	278	Operational	X		Baffled pistol range	Pistol qualification/requalification
	B-12	1960	present	278	Operational	X		Baffled pistol range	Pistol qualification/requalification

Note:

Data not available

N/A: data not applicable

New Range

Closed/Inactive since 5-Yr Review

Size of range includes range footprint and SDZ

Some GPs do not have a designated call sign

Appendix B

MC Loading Rates and Lead Deposition Estimates

Table B-1. Estimated MC Loading and Lead Deposition

MC Loading Area	Years of Use Assessed [a]		Assumed Loading Area (m^2)	Estimated Annual Loading Rate ($kg/m^2/yr$)				Lead Deposition
	Begin	End		HMX	RDX	TNT	Perchlorate	Total lb/yr
N1/BT-3 Impact Area	2011	2014	9.42E+05	3.55E-13	1.59E-10	7.44E-13	7.21E-10	9,920
F Ranges	2011	2014	5.03E+05	0.00E+00	2.02E-11	2.49E-11	2.89E-08	4,724
G-10 Impact Area	2011	2014	3.95E+06	1.64E-07	1.12E-05	8.84E-05	1.69E-08	10,418
G-19 Ranges	2011	2014	5.13E+04	6.09E-07	1.59E-05	1.34E-06	1.13E-07	72
G-6 (CBC)	2011	2014	2.26E+05	1.37E-11	8.16E-09	2.90E-09	3.60E-09	2,203
G-7	2011	2014	3.79E+05	0.00E+00	1.37E-06	1.77E-06	9.07E-09	545
K-2 Impact Area	2011	2014	2.15E+06	7.42E-12	6.53E-08	4.06E-07	8.29E-13	1.13E-03
K-323	2011	2011	3.96E+04	0.00E+00	0.00E+00	2.39E-10	0.00E+00	1.4
K-407	2011	2014	1.13E+04	0.00E+00	1.65E-07	3.37E-09	3.18E-09	19.7
K-500	2011	2014	5.19E+05	5.29E-10	5.81E-06	2.82E-06	4.20E-09	1,834
K-500A	2011	2014	3.31E+04	9.87E-10	8.01E-05	6.59E-09	9.88E-11	18.3
K-504A/B	2011	2014	4.30E+04	0.00E+00	2.19E-05	2.59E-09	4.98E-10	43
K-505	2013	2014	3.40E+04	2.78E-07	1.02E-05	3.85E-06	7.66E-09	103
L-5	2011	2014	3.41E+05	3.27E-13	2.08E-08	1.10E-10	1.37E-07	15,458
SR-6	2011	2014	6.80E+05	3.71E-12	1.47E-10	4.93E-11	6.13E-09	11,922
SR-7	2011	2014	2.73E+06	2.85E-09	1.03E-07	2.43E-12	4.95E-09	13,354
SR-10	2011	2014	3.37E+06	4.62E-09	3.12E-08	2.26E-11	3.28E-09	5,912
EOD-1	2011	2013	8.44E+04	1.93E-11	1.10E-06	1.16E-06	2.06E-11	2.83E-02
EOD-2	2011	2013	2.72E+04	1.44E-07	6.36E-06	4.60E-06	4.24E-09	2.04E-01
EOD-3	2013	2014	6.29E+04	6.90E-10	3.36E-06	3.96E-06	5.73E-11	2.72E-01
ETA-1	2011	2014	1.23E+05	2.47E-09	2.59E-06	5.31E-06	2.75E-08	20.5
ETA-2	2011	2014	2.47E+05	0.00E+00	7.84E-07	3.52E-07	8.68E-09	2.82E-02
ETA-3	2011	2013	7.75E+03	1.18E-08	3.60E-04	3.01E-04	1.55E-07	2.3
ETA-4	2011	2014	5.90E+04	4.31E-10	1.82E-05	1.27E-05	7.14E-10	5.83E-01
ETA-5/5A	2011	2014	4.11E+04	3.41E-09	4.55E-09	9.25E-06	2.20E-08	7.63E-01
ETA-7/7C	2011	2014	1.02E+05	1.18E-09	2.85E-05	2.00E-05	9.57E-11	7.07E-01
ETA-9	2013	2014	3.21E+04	1.64E-09	1.70E-05	1.85E-05	1.78E-10	6.74E-01
ETA-10	2013	2014	2.94E+04	0.00E+00	3.60E-08	1.57E-07	0.00E+00	1.4
F-6	2011	2014	3.72E+04	0.00E+00	8.52E-06	5.46E-06	1.38E-08	3.64E-02

MC Loading Area	Years of Use Assessed [a]		Assumed Loading Area (m^2)	Estimated Annual Loading Rate ($kg/m^2/yr$)				Lead Deposition
	Begin	End		HMX	RDX	TNT	Perchlorate	Total lb/yr
G-10A	2011	2014	1.69E+03	3.46E-07	1.01E-04	1.81E-04	4.35E-07	10.6
K-408	2011	2014	1.65E+04	0.00E+00	0.00E+00	0.00E+00	9.41E-09	19.4
K-510	2011	2014	8.77E+04	0.00E+00	2.77E-05	1.78E-05	4.49E-08	4.15E-01
MAC-3	2011	2014	3.95E+03	0.00E+00	8.80E-08	5.66E-08	1.44E-10	6.31E-02
Combat Town	2011	2014	2.63E+04	1.08E-13	3.55E-08	2.01E-12	9.53E-08	7.14E-02
Devil Dog	2011	2014	8.76E+03	0.00E+00	8.21E-10	1.22E-11	5.44E-08	3.60E-04
Mobile MOUT Complex	2011	2014	1.21E+05	4.00E-10	8.57E-08	4.07E-10	1.22E-07	1.6
Stone Bay Area	2011	2014	5.19E+03	7.68E-05	2.61E-06	3.58E-07	3.58E-07	7.6

Note:
$kg/m^2/yr$ = kilograms per square meter per year
m^2 = square meters
lb/yr = pounds per year
[a] FY

Table B-2. Estimated Annual Lead Deposition on SARs

SAR	Lead Deposition	
	kg/yr	lb/yr
A-1	1.38E+03	3,050
B-12	1.29E+02	285
D-29A/B	2.07E+03	4,570
D-30	1.37E+03	3,015
F-4	1.35E+02	298
F-11A/B	1.35E+03	2,980
F-18	2.12E+03	4,672
G-21	2.47E+03	5,440
I-1	5.79E+02	1,276
K-309 (Inactive; part of K-505 constructed over K-309 footprint)	4.84E+02	1,067
K-315 (Inactive; part of K-506 constructed over K-315 footprint)	1.70E+03	3,754
K-319 (Inactive; part of K-508 constructed over K-319 footprint)	1.60E+03	3,528
K-321/321A (Inactive; part of K-509 constructed on top of K-321/321A footprint)	3.49E+03	7,686
K-325	2.14E+03	4,723
K-402	1.03E+03	2,274
K-406A/B	3.74E+03	8,254
K-501/501A	3.69E+03	8,133
K-503/503A	4.17E+03	9,202
K-506	5.56E+02	1,226
K-508	3.37E+03	7,437
K-509	6.06E+02	1,336
MAC Small Arms	5.99E+02	1,321
R-100	0.00E+00	0
SR-8	1.46E+04	32,213
SR-11	9.57E+01	211
Stone Bay Walk Down	6.30E+02	1,389
Stone Bay Dodge City	6.70E+02	1,477
Stone Bay Hathcock	1.07E+03	2,355

SAR	Lead Deposition	
	kg/yr	lb/yr
Stone Bay Mechanical Pistol	2.03E+03	4,475
Stone Bay Multi-Purpose	2.46E+03	5,415
Stone Bay Alpha	6.20E+03	13,677
Stone Bay Bravo	7.09+03	15,627
Stone Bay Charlie	7.51E+03	16,551

Note:
kg/yr = kilograms per year
Gray shading indicates that the range is no longer active, and another range was constructed in the range footprint.

Table B-3. Lead Loading in Subwatersheds

Subwatershed	MC Loading Areas	SARs	Total Lead (lb/yr)
Shelter Swamp Creek	SR-6, SR-7, SR-10	SR-8	54,604
Juniper Swamp	SR-10	SR-11	4,468
Southwest Creek	SR-7, Devil Dog	B-12	4,825
Stones Creek	L-5	Mechanical Pistol, Multi-Purpose, Walk Down, Dodge City, Alpha	41,891
New River at Stones Bay	Stones Bay Area, K-407, K-408, K-500A, K-500	Bravo, Charlie, Hathcock, K-402, K-406A/B	45,951
New River between Stick Creek and Whitehurst Creek	K-510, EOD-2, ETA-5/5A	A-1, D-29A/B, D-30, K-501/501A (40%)	13,889
New River between Town Creek and Stones Bay	K-500, K-2 Impact, K-504A/B, K-505, K-323, ETA-5/5A, ETA-7/7C, ETA-9, ETA-10, EOD-3, Combat Town, ETA-4, G-19 Ranges, G-10 Impact Area, G-10A, F-6	K-501/501A (60%), K-503/503A, K-309, K-315, K-319, K-321/321A, K-325, K-506, K-508,K-509, G-21	59,857
Wallace Creek	ETA-3, F-Ranges	R-100, F-18, F-4, F-11A/B	12,677
Intracoastal Waterway between Alligator Creek and Freeman Creek	ETA-2	None	~0
New River between Stones Bay and Intracoastal Waterway	ETA-1, ETA-2	I-1	1,296
Bear Creek	Mobile MOUT Complex, MAC-3, G-10 Impact, G-6, EOD-1, G-7	MAC Ranges	5,218
Intracoastal Waterway between Browns Inlet and Queen Creek	G-6, EOD-1, G-7	None	936
Freeman Creek	ETA-4	None	~0

ARCADIS

Appendix C

Screening-Level Assessments and Modeling Parameters

Technical Memorandum

Surface Water Screening-Level Assessment

ARCADIS
Infrastructure · Water · Environment · Buildings

Technical Memorandum

Date:	August 25, 2014
To:	Jennifer Wilber, Marine Corps Installations Command
Copy:	Dave Lynch, Charity Delaney (Marine Corps Installations Command East – Marine Corps Base Camp Lejeune) Catherine Zoeckler, Julie Dobschuetz, Ben Latham, Susan Herbert, Edidia Nefso (ARCADIS)
From:	Desiree Halsor (ARCADIS)
Re:	Assessment of Munitions Constituent (MC) Concentrations in Surface Water and Sediment from MC Loading Areas at Marine Corps Installations Command East – Marine Corps Base Camp Lejeune.
Project No.:	06285043.0000

INTRODUCTION

This memorandum documents the results and recommended path forward based on a screening-level assessment of potential munitions constituent (MC) concentrations in surface water and sediment at Marine Corps Installations Command East – Marine Corps Base Camp Lejeune (MCIEAST-MCB CAMLEJ). The Range Environmental Vulnerability Assessment (REVA) screening-level assessment methods evaluated the potential for MC to migrate from operational range areas via surface water and sediment to potential human and ecological receptor locations. Recommendations are presented for identified receptor locations that require investigation based on the screening-level assessment. The procedures used to conduct this screening-level assessment are presented in the REVA 5-Year Review Manual (HQMC, 2010). MC loading areas were selected for screening-level modeling based on range use and proximity to potential receptor locations. A separate technical memorandum has been prepared in parallel which addresses MC transport in groundwater from the MC loading areas (ARCADIS, 2014).
Thirty six MC loading areas were assessed (**Figure 1**):

- G-10 Impact Area
- G-6 (CBC)
- G-10A
- G-7
- G-19 Ranges
- K-2 Impact Area
- K-500
- K-500A
- K-504A/B
- K-505
- K-323
- K-407

- K-408
- K-510
- F-Ranges
- F-6
- L-5
- Combat Town
- EOD-1
- EOD-2
- EOD-3
- ETA-1
- ETA-2
- ETA-3
- ETA-4
- ETA-5/5A
- ETA-7/7C
- ETA-9
- ETA-10
- Stone Bay Area
- MOUT Complex
- SR-6
- SR-7
- SR-10
- Devil Dog
- MAC-3

Note:
CBC – Company Battle Course
EOD – Explosives Ordnance Disposal
ETA – Engineer Training Area
MAC – MOUT Assault Course
MOUT – Military Operations in Urban Terrain

METHODS

Screening-level analyses were used to estimate average annual concentrations of REVA MC in surface water and sediment at the edge of each MC loading area. MC loading areas were then grouped by receptor exposure locations (i.e. subwatersheds), and the percentage of each loading area draining to the given receptor exposure location was approximated. These estimates were used to provide an area-weighted sum of the MC concentrations from the individual loading areas draining to the receptor exposure location. Baseflow entering surface water receptor exposure points from shallow groundwater was approximated in the groundwater screening-level analysis and also factored into the downstream mixing.

The receptor locations for these MC loading areas include the different segments of the New River and the Intracoastal Waterway, tributary streams of the New River and the Intracoastal Waterway, and two swamps located west of the New River. The primary receptors identified for surface water and sediment at MCI-EAST MCB CAMLEJ are ecological receptors. Surface water at MCI-EAST MCB CAMLEJ is used for recreational purposes including fishing, swimming, and boating; however, surface water does not represent a human exposure pathway because it is not used as a drinking water source. The receptor locations, associated MC loading areas, and approximate percent of loading areas draining to the receptor location are presented in **Table** 1, and subwatersheds, receptor locations, and MC loading areas are shown on **Figure 2**.

Table 1: Proportion of MC Loading Areas Draining to Receptor Locations

Receptor Location (corresponding number on Figure 2)	MC Loading Area Draining to Receptor Location	Approximate Percent of Loading Area Draining to Receptor Location
Shelter Swamp Creek (1)	SR-6	100%
	SR-7	66%
	SR-10	28%
Juniper Swamp (2)	SR-10	72%
Southwest Creek (3)	SR-7	34%
	Devil Dog	100%
Stones Creek (4)	L-5	100%
New River at Stones Bay (5)	Stone Bay Area	100%
	K-407	100%
	K-408	100%
	K-500A	100%
	K-500	45%
New River between Stick Creek and Whitehurst Creek (6)	K-510	100%
	EOD-2	100%
	ETA-5/5A	22%
New River between Town Creek and Stones Bay (7)	K-500	55%
	K-2 Impact	100%
	K-504A/B	100%
	K-505	100%
	K-323	100%
	ETA-5/5A	78%
	ETA-7/7C	100%
	ETA-9	100%
	ETA-10	100%
	EOD-3	100%
	Combat Town	100%
	ETA-4	52%
	G-19 Ranges	100%
	G-10 Impact	80%
	G-10A	100%
	F-6	100%
Wallace Creek (8)	ETA-3	100%
	F-Ranges	100%
Intracoastal Waterway between Alligator Creek and Freeman Creek (9)	ETA-2	56%
New River between Stones Bay and Intracoastal Waterway	ETA-1	100%

Receptor Location (corresponding number on Figure 2)	MC Loading Area Draining to Receptor Location	Approximate Percent of Loading Area Draining to Receptor Location
(10)	ETA-2	44%
Bear Creek (11)	Mobile MOUT Complex	100%
	MAC-3	100%
	G-10 Impact	20%
	G-6	82%
	EOD-1	8%
	G-7	1%
Intracoastal Waterway between Browns Inlet and Queen Creek (12)	G-6	18%
	EOD-1	92%
	G-7	99%
Freeman Creek (13)	ETA-4	48%

The primary input data for the screening-level calculations are the annual MC loading rates estimated for each MC loading area. The MC loading rates were estimated using an MC loading calculator developed specifically for REVA, which was parameterized with data collected from range personnel and operational records at MCIEAST-MCB CAMLEJ. The screening-level surface water and sediment assessment was conducted for the period 2011–2014; however, the following ranges were not active during this entire time period and were assessed for the period MC loading was known to have occurred:

- K-323 (became inactive in 2011, conducted only for 2011)
- K-505, EOD-3, ETA-9, and ETA-10 (activated 2013, conducted for the period 2013–2014)
- EOD-1 (became inactive 2012, conducted for period 2011-2012)
- ETA-3 (usage limited from 2011 to 2013; conducted for the period 2011–2013)

Surface Water Screening-Level Approach

MC were assumed to be transported through dissolution into surface water runoff and as particulates adsorbed in eroded soil to estimate the average annual MC concentrations in surface water runoff leaving each MC loading area. The CalTOX partitioning model was used to estimate the total MC mass partitioned from surface soil deposition to surface water runoff. This total MC mass was divided by an estimate of the surface water runoff volume generated over the MC loading areas to estimate MC concentration migrating from the MC loading areas (edge-of-loading-area concentrations in surface water runoff).

MC concentrations in surface water runoff entering the downstream receptor locations were estimated by dividing the total MC mass contributed to the receptor location by the estimated surface water runoff volume over the entire drainage area upstream of the receptor location.

In addition to direct surface water runoff sources, shallow groundwater is a known source of base flow and potential MC loads to surface water at the MC loading areas. The Technical Memorandum: Screening-Level Assessment of Munitions Constituents (MC) Concentrations in Groundwater from MC Loading Areas at MCIEAST-MCB CAMLEJ, dated August 2014, estimates detectable cyclomethylene trinitramine (RDX) concentrations discharging to two MC loading areas (ETA-5/5A and EOD-2) and detectable perchlorate concentrations discharging to 12 MC loading areas (G-10A, G-19 Ranges, F-Ranges, K-510, L-5, ETA-1, ETA-3, ETA-5/5A, Combat Town, Mobile MOUT Complex, Devil Dog, and Stone Bay Area). The RDX and perchlorate concentrations predicted to discharge into the nearest stream were included for a mixing calculation with runoff sources. In this case, the MC mass loading contributed from surface water runoff and groundwater inflow was divided by the sum of the surface water runoff and base flow volumes over the entire drainage area upstream of the receptor location to estimate the MC concentration in surface water.

The estimates of MC concentrations in surface water runoff entering the downstream receptor location were compared to median method detection limits (MDLs) for each MC. Median MDLs are an established set of values for cyclotetramethylene tetranitramine (HMX), RDX, 2,4,6-trinitrotoluene (TNT), and perchlorate to serve as a benchmark to compare to the model results and determine whether additional actions are warranted. MDLs are used as a benchmark because they are an indicator of whether the assessment predicts the constituent is present at a detectable concentration.

Sediment Screening-Level Approach

The CalTOX partitioning model was used to estimate the MC mass partitioned to soil/sediment and available for transport in runoff from the MC loading areas. Annual soil erosion rates were estimated using the Revised Universal Soil Loss Equation (RUSLE), which incorporates the major factors affecting erosion to predict the rate of soil loss in mass per area per year. The MC concentrations in eroded soil/sediment leaving the MC loading areas were estimated by dividing the MC mass in eroded soil (obtained from CalTOX) by the estimated total soil erosion (obtained from RUSLE).

If an MC concentration in sediment at the edge of the MC loading area was predicted to exceed its median MDL, additional screening-level analysis was conducted to estimate MC concentration in sediment at the downstream receptor location. This involved estimating the total MC mass transported in sediment to the receptor location and the mass of sediment transported to the downstream receptor location from the entire upstream area. It is conservatively assumed that 100 percent of the sediment leaving the MC loading area is deposited into downstream surface waters.

RESULTS
Surface Water

Table 2 presents the estimated annual average edge-of-loading-area concentrations in surface water runoff from individual MC loading areas. Bolded values are predicted concentrations that were carried into the next step of the evaluation.

Table 2: Screening-Level Estimates of Annual Average Edge-of-Loading-Area MC Concentrations in Surface Water Runoff

	HMX	RDX	TNT	Perchlorate
Median MDL (μg/L)	*0.077*	*0.097*	*0.108*	*0.06*
MC Loading Area	**Predicted Surface Water Runoff Concentration at Edge-of-Loading Area (μg/L)**			
G-10 Impact Area	**0.0872**	**4.65**	**21.8**	**0.00918**
G-6 (CBC)	~0	**0.00668**	**0.00199**	**0.00435**
G-10A	**0.186**	**42.1**	**66.7**	**0.339**
G-7	NA	**0.802**	**0.778**	**0.00695**
G-19 Ranges	**0.414**	**8.13**	**0.328**	**0.0922**
K-2 Impact Area	~0	**0.0560**	**0.213**	~0
K-407	NA	**0.115**	**0.00161**	**0.00311**
K-408	NA	NA	NA	**0.0103**
K-500	~0	**2.47**	**0.822**	**0.00234**
K-500A	~0	**33.2**	**0.00184**	~0
K-504A/B	NA	**8.62**	~0	~0
K-505	**0.145**	**4.12**	**1.01**	**0.00410**
K-323	NA	NA	~0	NA
K-510	NA	**11.8**	**6.87**	**0.0456**
F-Ranges	NA	~0	~0	**0.0283**
F-6	NA	**3.69**	**2.07**	**0.00778**
L-5	~0	**0.00922**	~0	**0.138**
Combat Town	~0	**0.0156**	~0	**0.0959**
EOD-1	~0	**0.485**	**0.447**	~0
EOD-2	**0.0778**	**2.23**	**1.79**	**0.00234**
EOD-3	~0	**1.43**	**1.23**	~0
ETA-1	**0.00157**	**1.29**	**2.40**	**0.0316**
ETA-2	NA	**0.362**	**0.118**	**0.00524**
ETA-3	**0.00621**	**143**	**57.2**	**0.143**
ETA-4	~0	**7.83**	**4.75**	~0

	HMX	RDX	TNT	Perchlorate
Median MDL (µg/L)	*0.077*	*0.097*	*0.108*	*0.06*
MC Loading Area	**Predicted Surface Water Runoff Concentration at Edge-of-Loading Area (µg/L)**			
ETA-5/5A	**0.00193**	**20.0**	**3.15**	**0.0230**
ETA-7/7C	~0	**11.2**	**3.36**	~0
ETA-9	~0	**7.53**	**6.02**	~0
ETA-10	NA	**0.0178**	**0.0556**	NA
Stone Bay Area	**0.0280**	**31.2**	**0.832**	**0.355**
Mobile MOUT Complex	~0	**0.0367**	~0	**0.113**
SR-6	~0	~0	~0	**0.00334**
SR-7	**0.00157**	**0.0434**	~0	**0.00280**
SR-10	**0.00244**	**0.0125**	~0	**0.00178**
Devil Dog	NA	~0	~0	**0.0553**
MAC-3	NA	**0.0685**	**0.0299**	~0

Notes:
µg/L = micrograms per liter
N/A = not modeled, as the MC loading area was estimated to be negligible
Bolded values indicate non-negligible predicted concentrations which were carried through to the next step of modeling

As mentioned above, shallow groundwater flow at MCIEAST-MCB CAMLEJ discharges into surface water features, including the New River and its tributaries (including Wallace Creek, Bear Creek, Stones Creek, and Southwest Creek). As part of the groundwater assessment, RDX and perchlorate in groundwater was predicted to potentially reach the nearest surface water receptor location at detectable concentrations from 13 of the 36 MC loading areas modeled (**Table 3**). These concentrations were incorporated into the downstream mixing in the next step of the evaluation.

Table 3: Predicted MC Concentrations in Groundwater Reaching the Nearest Surface Water Receptor Locations

	HMX	RDX	TNT	Perchlorate	
Median MDL (µg/L)	*0.077*	*0.097*	*0.108*	*0.06*	
MC Loading Area	**Predicted Surface Water Runoff Concentration at Edge-of-Loading-Area (µg/L)**				**Subwatershed**
G-10A	NA	NA	NA	**0.771**	New River between Town Creek and Stones Bay
G-19 Ranges	NA	NA	NA	**0.139**	New River between Town Creek and Stones Bay
F-Ranges	NA	NA	NA	**0.08**	Wallace Creek
K-510	NA	NA	NA	**0.136**	New River between Stick and Whitehurst Creek

	HMX	RDX	TNT	Perchlorate	
Median MDL (µg/L)	*0.077*	*0.097*	*0.108*	*0.06*	
MC Loading Area	**Predicted Surface Water Runoff Concentration at Edge-of-Loading-Area (µg/L)**				**Subwatershed**
L-5	NA	NA	NA	**0.381**	Stones Creek
ETA-1	NA	NA	NA	**0.083**	New River between Stones Bay and Intracoastal Waterway
ETA-3	NA	NA	NA	**0.398**	Wallace Creek
ETA-5/5A	NA	0.071	NA	**0.066**	New River between Town Creek and Stones Bay
ETA-5/5A	NA	~0	NA	**0.066**	New River between Stick and Whitehurst Creek
Combat Town	NA	NA	NA	**0.265**	New River between Town Creek and Stones Bay
EOD-2	NA	**0.197**	NA	NA	New River between Stick and Whitehurst Creek
Mobile MOUT Complex	NA	NA	NA	**0.304**	Bear Creek
Devil Dog	NA	NA	NA	**0.151**	Southwest Creek
Stone Bay Area	NA	~0	NA	**1.08**	New River at Stones Bay

Note:

NA = not modeled because MC was eliminated for further assessment based on the first step of the groundwater screening assessment
~0 denotes that the MC degrade before reaching the water table.
Bold indicates the predicted concentration is above the median MDL and is incorporated into the next step of the evaluation.

Table 4 presents the annual average MC concentrations in surface water (including surface water runoff and baseflow contributions) estimated to enter the identified surface water receptor locations. Receptor locations with a predicted detectable concentration are highlighted on **Figure 3**. Results are summarized as follows:

- HMX and perchlorate were not predicted to be above the median MDLs at any of the surface water downstream receptor locations.
- RDX and TNT were predicted to be above the REVA median MDLs in the New River between Town Creek and Stones Bay as well as Bear Creek (**Figure 3**).
- RDX and TNT were predicted to be below the REVA median MDL in surface water at all other downstream receptor locations (**Table 4**).

Table 4: Screening-Level Estimates of Annual Average MC Concentrations in Surface Water Runoff and Baseflow Entering Downstream Receptor Locations

	HMX	RDX	TNT	Perchlorate
Median MDL (µg/L)	*0.077*	*0.097*	*0.108*	*0.06*
Surface Water Exposure Point	**Predicted Surface Water Concentration at Nearest Surface Water Receptor Location (µg/L)**			
Shelter Swamp Creek	~0	~0	~0	~0
Juniper Swamp	~0	~0	~0	~0
Southwest Creek	~0	~0	~0	~0
Stones Creek	~0	~0	~0	1.53E-03
New River at Stones Bay	~0	0.0371	0.00399	~0
New River between Stick Creek and Whitehurst Creek	~0	0.0216	0.0115	~0
New River between Town Creek and Stones Bay	0.00354	**0.221**	**0.828**	~0
Wallace Creek	~0	0.0212	0.00851	~0
Intracoastal Waterway between Alligator Creek and Freeman Creek	~0	0.00627	0.00977	~0
New River between Stones Bay and Intracoastal Waterway	NA	0.00106	~0	~0
Bear Creek	0.00246	**0.132**	**0.615**	~0
Intracoastal Waterway between Browns Inlet and Queen Creek	~0	0.0135	0.0130	~0
Freeman Creek	~0	0.0195	0.0118	~0

Notes:
N/A = not modeled, as the MC loading area was estimated to be negligible
Shading and bold indicates the preidcted concentration is above the median MDL

Sediment

The estimated annual average edge-of-loading-area concentrations in sediment from individual MC loading areas are presented in **Table 5**. Bolded concentrations were carried into the next step of the evaluation. The average annual concentrations of TNT in sediment at the edge of G-10 Impact Area, G-10A, and EOD-3 MC loading areas were predicted to be above the REVA median MDL. Concentrations of all other MC in sediment at the edges of all modeled MC loading areas were predicted to be below REVA median MDLs.

Table 5: Predicted MC Concentrations in Sediment Reaching the Edge of Loading Area

	HMX	RDX	TNT	Perchlorate
Median MDL (µg/Kg)	*77.9*	*78*	*63.1*	*0.213*
MC Loading Area	**Predicted Sediment Runoff Concentration at Edge-of-Loading Area (µg/kg)**			
G-10 Impact Area	**0.00349**	**0.416**	**131**	~0
G-6 (CBC)	~0	~0	**0.00303**	~0
G-10A	**0.00266**	**1.35**	**144**	~0
G-7	NA	**0.0311**	**2.03**	~0
G-19 Ranges	**0.0214**	**0.940**	**2.55**	~0
K-2 Impact Area	~0	**0.00252**	**0.638**	~0
K-407	~0	**0.156**	**3.49**	~0
K-408	~0	**2.53**	**0.00940**	~0
K-500	NA	**0.835**	**0.00408**	~0
K-500A	**0.00534**	**0.339**	**5.55**	~0
K-504A/B	NA	NA	~0	NA
K-505	NA	**0.382**	**15.0**	~0
K-323	NA	~0	~0	~0
K-510	NA	**0.115**	**4.34**	~0
F-Ranges	~0	~0	~0	~0
F-6	~0	~0	~0	~0
L-5	~0	**0.0148**	**0.922**	~0
Combat Town	**0.00109**	**0.0846**	**3.77**	~0
EOD-1	~0	**0.0358**	**4.49**	~0
EOD-2	NA	**0.0211**	**0.462**	~0
EOD-3	~0	**18.9**	**510**	~0
ETA-1	~0	**0.246**	**10.1**	~0
ETA-2	~0	**0.942**	**10.0**	~0
ETA-3	~0	**2.02**	**40.4**	~0
ETA-4	~0	**1.58**	**2.82**	~0
ETA-5/5A	~0	**0.00178**	~0	~0
ETA-7/7C	~0	~0	~0	~0
ETA-9	~0	**0.00699**	~0	~0
ETA-10	~0	**0.00243**	~0	~0
Stone Bay Area	NA	~0	~0	~0
Mobile MOUT Complex	~0	**0.0916**	**5.22**	~0
SR-6	~0	**0.461**	**24.4**	~0

	HMX	RDX	TNT	Perchlorate
Median MDL (µg/Kg)	*77.9*	*78*	*63.1*	*0.213*
MC Loading Area	**Predicted Sediment Runoff Concentration at Edge-of-Loading Area (µg/kg)**			
SR-7	NA	~0	**0.201**	NA
SR-10	NA	**0.00516**	**0.00482**	~0
Devil Dog	NA	NA	NA	~0
MAC-3	NA	**0.00308**	**0.0899**	~0

Note:
µg/kg = micrograms per kilogram
N/A = not modeled, as the MC loading area was estimated to be negligible
Bolded values indicate non-negligible predicted concentrations which were carried through to the next step of modeling

Table 6 presents the average annual MC concentrations in sediment entering all identified downstream receptor locations. All estimated concentrations were predicted to be below REVA median MDLs (i.e., not detectable).

Table 6: Screening-Level Estimates of Annual Average MC Concentrations in Sediment Entering Downstream Surface Water Receptor Locations

	HMX	RDX	TNT	Perchlorate
Median MDL (µg/Kg)	*77.9*	*78*	*63.1*	*0.213*
Surface Water Exposure Point	**Predicted Sediment Concentration at Nearest Surface Water Receptor Location (µg/kg)**			
Shelter Swamp Creek	~0	~0	~0	~0
Juniper Swamp	~0	~0	~0	~0
Southwest Creek	~0	~0	~0	~0
Stones Creek	~0	~0	~0	~0
New River at Stones Bay	~0	0.00160	0.00845	~0
New River between Stick Creek and Whitehurst Creek	~0	~0	0.0339	~0
New River between Town Creek and Stones Bay	~0	0.0129	2.69	~0
Wallace Creek	~0	0.00129	0.0349	~0
Intracoastal Wway between Alligator Creek and Freeman Creek	~0	~0	0.0240	~0
New River between Stones Bay and Intracoastal Wway	NA	~0	0.00136	~0
Bear Creek	~0	0.00766	2.41	~0
Intracoastal Wway between Browns Inlet and Queen Creek	~0	0.00101	0.0660	~0
Freeman Creek	~0	~0	0.0251	~0

Note:
N/A = not modeled, as the MC loading area was estimated to be negligible

CONCLUSIONS

Based on the surface water and sediment screening analyses results, the model predicted detectable MC concentrations (RDX and perchlorate) in surface water runoff and baseflow potentially entering two identified surface water receptor exposure locations (New River between Town Creek and Stones Bay, and Bear Creek). Sampling is recommended based on the results of the surface water modeling, for explosives and perchlorate to confirm trace values/ non-detect of perchlorate.

MC concentrations in sediment potentially entering any identified surface water receptor exposure locations were predicted to be below REVA median MDLs; therefore, no additional sampling for sediment is recommended at this time. The MC loading areas will be evaluated in the next periodic review to evaluate continued loading through time.

Surface water sampling is also recommended at annual monitoring locations within MCIEAST-MCB CAMLEJ based on past monitoring results, and downstream of some small arms ranges based on a qualitative evaluation. Preliminary results of this evaluation indicated a higher potential for impacts to surface water from five ranges or groups of ranges. These included:

- K-406A/K-406B
- K-325
- F-18
- SR-8
- Alpha, Bravo, Charlie Ranges

Table **7** presents the process used to identify sampling locations, and these locations are shown on **Figure 4**.

Table 7: Proposed Surface Water Sampling Locations at MCIEAST-MCB CAMLEJ

Proposed Surface Water Sample	Associated Range or Receptor Location	Identification Method	Constituents for Analysis
K2-SW-04	New River Between Town Creek and Stones Bay	Modeling	Explosives, Perchlorate
K2-SW-05	New River Between Town Creek and Stones Bay, K-325	Modeling, Small Arms Range Evaluation	Explosives, Perchlorate, Total and Dissolved Lead, Hardness
New Location	New River Between Town Creek and Stones Bay	Modeling	Explosives, Perchlorate
New Location	New River Between Town Creek and Stones Bay	Modeling	Explosives, Perchlorate
New Location	Bear Creek	Modeling	Explosives, Perchlorate

K2-SW-02	K-406A/K-406B	Annual Monitoring, Small Arms Range Evaluation	Total and Dissolved Lead, Hardness
Wallace Creek	F-18	Small Arms Range Evaluation	Total and Dissolved Lead, Hardness
New Location	SR-8	Small Arms Range Evaluation	Total and Dissolved Lead, Hardness
New Location	Alpha, Bravo, Charlie Ranges	Small Arms Range Evaluation	Total and Dissolved Lead, Hardness
New Background Location	NA	Reference	Explosives, Perchlorate, Total and Dissolved Lead, Hardness

Note: NA = not applicable

REFERENCES

ARCADIS. 2014. Technical Memorandum: *Screening-Level Assessment of Munitions Constituent (MC) Concentrations in Groundwater from MC Loading Areas at Marine Corps Installations Command East – Marine Corps Base Camp Lejeune.*

Headquarters Marine Corps (HQMC). 2010. REVA Five-Year Review Manual.

FIGURES

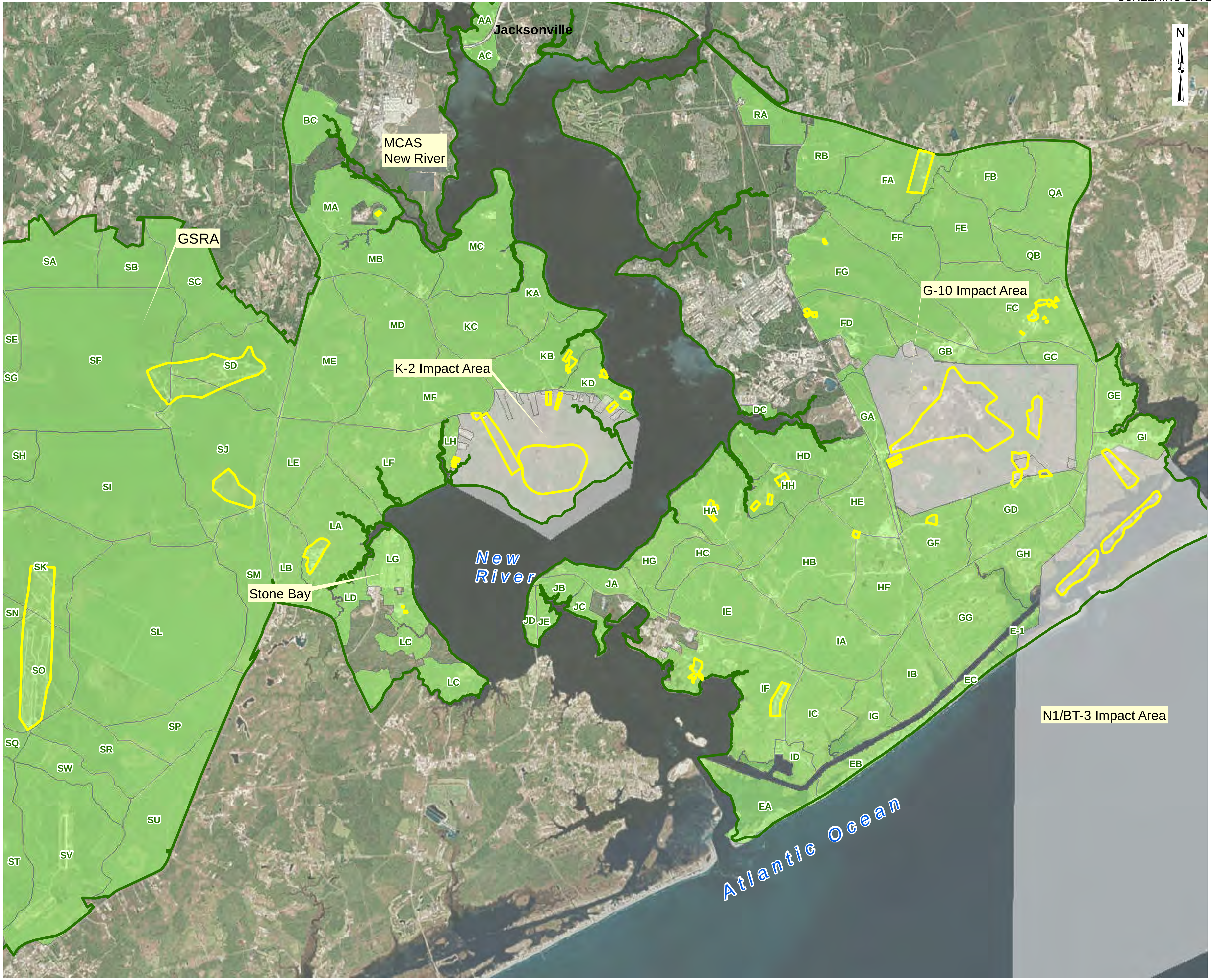
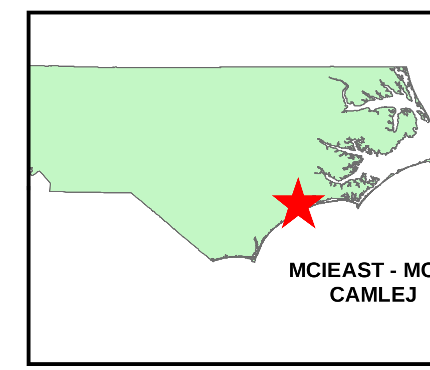


FIGURE 1
MCIEAST-MCB CAMLEJ
MC LOADING AREAS

REVA
MCIEAST - MCB CAMLEJ

Legend
- Installation Boundary
- Training Area
- Impact Area
- MC Loading Area

Note:
GSRA - Greater Sandy Run Area
- MC loading areas are shown in yellow text.



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Units: Meters

Date: June 2015

Source: Aerial - ESRI
MCB/NREA GIS Office 2014

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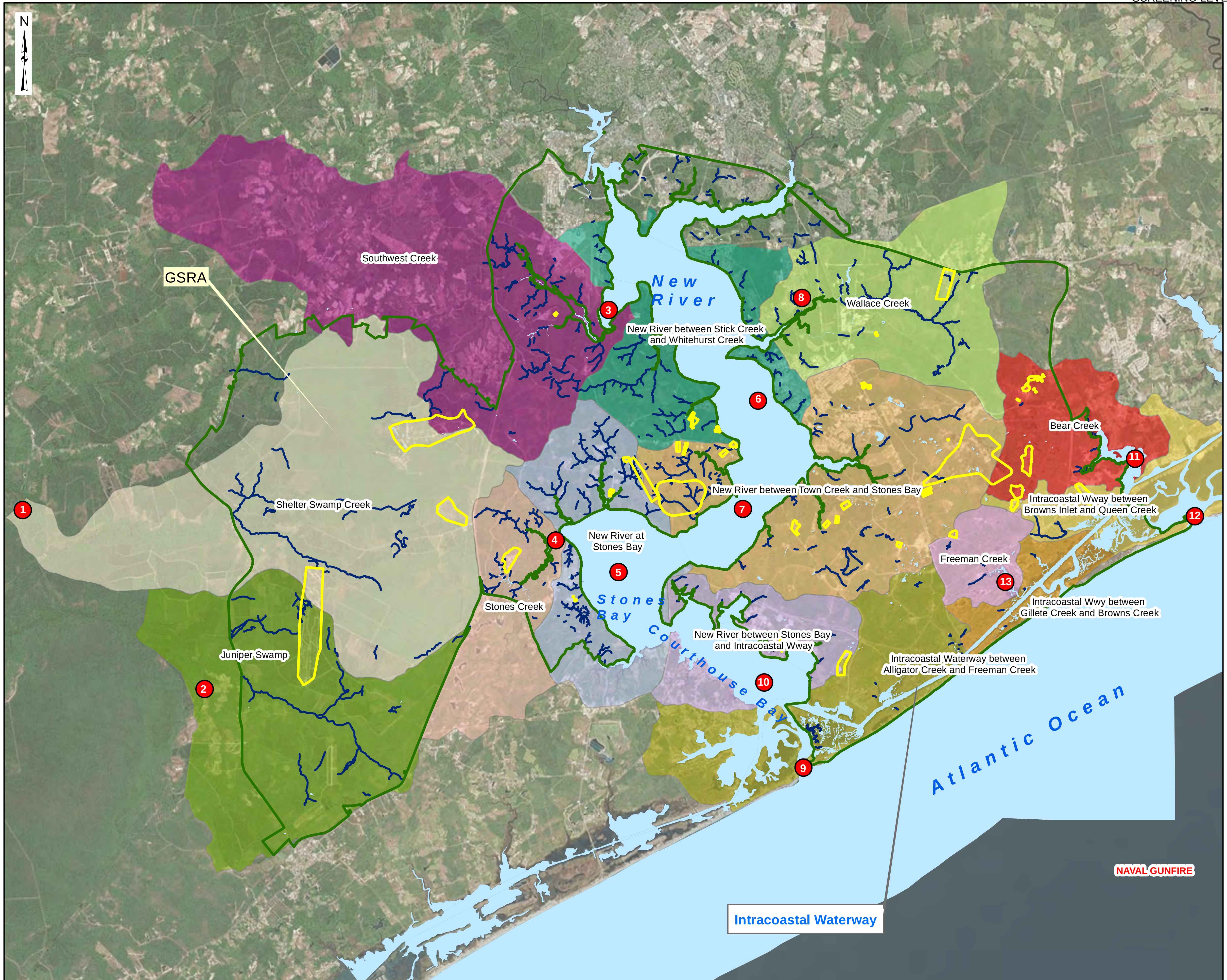
FIGURE 2
MCIEAST-MCB CAMLEJ SURFACE WATER FEATURES AND MC LOADING AREAS

REVA
MCIEAST - MCB CAMLEJ



Legend

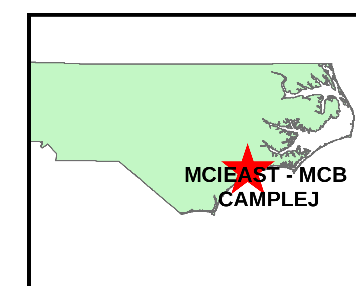
- MC Loading
- SW Receptor Locations
- Installation Boundary

Stream

- Dry
- Intermittent
- Permanent
- Surface Water

Subwatershed Area

- Bear Creek
- Freeman Creek
- Intracoastal Waterway between Browns Inlet and Queen Creek
- Intracoastal Waterway between Alligator Creek and Freeman Creek
- Intracoastal Waterway between Gillete Creek and Browns Creek
- Juniper Swamp
- New River at Stones Bay
- New River between Stick Creek and Whitehurst Creek
- New River between Town Creek and Stones Bay
- New River between Stones Bay and Intracoastal Waterway
- Shelter Swamp Creek
- Southwest Creek
- Stones Creek
- Wallace Creek



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Units: Meters

Date: August 2014

Source: Aerial - ESRI
MCB/NREA GIS Office 2014

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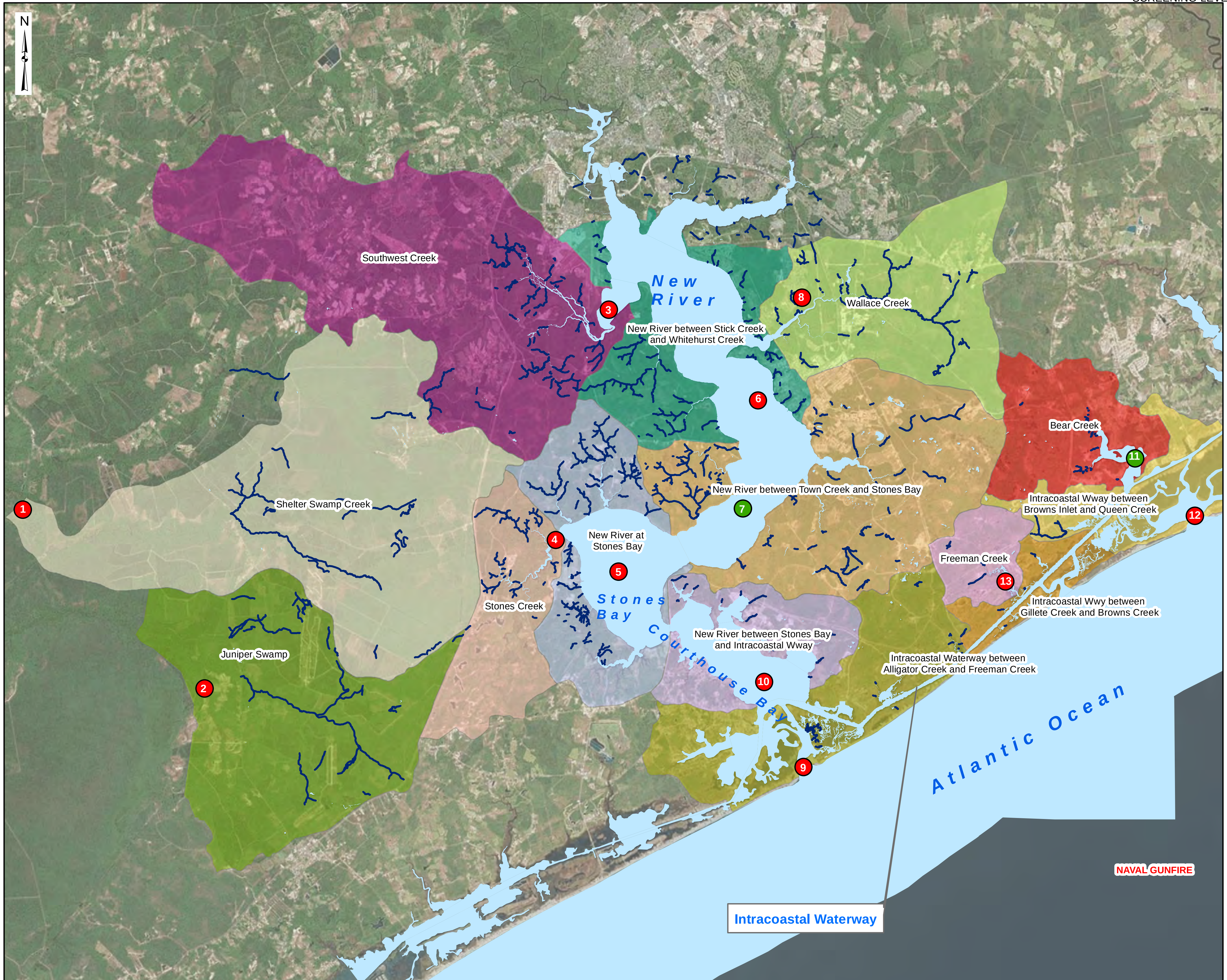
FIGURE 3
MCIEAST-MCB CAMLEJ MODEL PREDICTIONS AT SURFACE WATER RECEPTOR LOCATIONS

REVA
MCIEAST - MCB CAMLEJ



Legend

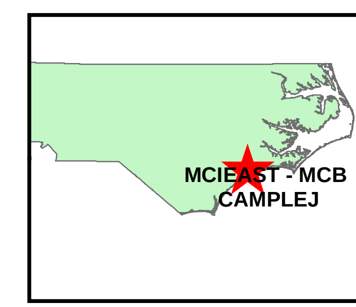
- SW Receptor Locations with no Predicted Detections
- SW Receptor Locations with Predicted Detections

Stream

- Dry
- Intermittent
- Permanent
- Surface Water

Subwatershed Area

- Bear Creek
- Freeman Creek
- Intracoastal Waterway between Browns Inlet and Queen Creek
- Intracoastal Waterway between Alligator Creek and Freeman Creek
- Intracoastal Waterway between Gillete Creek and Browns Creek
- Juniper Swamp
- New River at Stones Bay
- New River between Stick Creek and Whitehurst Creek
- New River between Town Creek and Stones Bay
- New River between Stones Bay and Intracoastal Waterway
- Shelter Swamp Creek
- Southwest Creek
- Stones Creek
- Wallace Creek



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Coordinate System: UTM
Zone: 18N
Datum: NAD83
Units: Meters

Date: August 2014

Source: Aerial - ESRI
MCB/NREA GIS Office 2014

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Additional Tables

Surface Water Screening-Level Assessment

Table C-1: Percent MC Mass Contributed by MC Loading Areas
Tables C-2 through C-8: Modeling Parameters

Table C-1 presents the estimated percentage of total MC mass contributed by the individual MC loading areas draining to the nine downstream off-range receptor locations at the installation boundary that receive drainage from multiple MC loading areas.

Table C-1: Screening-Level Estimates of Percent MC Mass Contributed by Individual MC Loading Areas into Off-Range Receptor Locations Receiving Drainage from Multiple MC Loading Areas

Receptor Location (corresponding number on Figure 2-3)	MC Loading Area	Percent MC Mass Contributed			
		HMX	RDX	TNT	Perchlorate
Shelter Swamp Creek (1)	SR-6	~0	~0	60	26
	SR-7	54	86	7	55
	SR-10	46	14	33	19
Southwest Creek (3)	SR-7	100	~100	94	91
	Devil Dog	0	~0	6	9
New River at Stones Bay (5)	Stones Bay Area	64	9	2	61
	K-407	0	~0	~0	1
	K-408	0	0	0	6
	K-500A	8	60	~0	~0
	K-500	28	31	98	32
New River between Stick Creek and Whitehurst Creek (6)	K-510	0	81	89	93
	EOD-2	99	6	7	2
	ETA-5/5A	1	13	4	5
New River between Town Creek and Stones Bay (7)	K-500	~0	4	~0	2
	K-2 Impact	~0	~0	~0	~0
	K-504A/B	0	2	~0	~0
	K-505	2	1	~0	~0
	K-323	0	0	~0	0
	ETA-5/5A	~0	3	~0	1
	ETA-7/7C	~0	6	1	~0
	ETA-9	~0	1	~0	~0
	ETA-10	0	~0	~0	0
	EOD-3	~0	1	~0	~0
	Combat Town	~0	~0	~0	4
	ETA-4	~0	1	~0	~0
	G-19 Ranges	6	2	~0	9
	G-10 Impact	92	78	98	82
	G-10A	~0	~0	~0	1
	F-6	0	1	~0	1

Receptor Location (corresponding number on Figure 2-3)	MC Loading Area	Percent MC Mass Contributed			
		HMX	RDX	TNT	Perchlorate
Wallace Creek (8)	ETA-3	100	~100	~100	7
	F-Ranges	0	~0	~0	93
New River between Stones Bay and Intracoastal Waterway (10)	ETA-1	100	80	96	79
	ETA-2	0	20	4	21
Bear Creek (11)	Mobile MOUT Complex	~0	~0	~0	52
	MAC-3	~0	~0	~0	~0
	G-10 Impact	~100	~100	~100	46
	G-6	~0	~0	~0	2
	EOD-1	~0	~0	~0	~0
	G-7	~0	~0	~0	~0
Intracoastal Waterway between Browns Inlet and Queen Creek (12)	G-6	23	~0	~0	3
	EOD-1	77	14	13	~0
	G-7	0	86	87	97

Table C-2: Climate Data Used in the Surface Water Screening Assessment

Data Type	Value	Reference(s)
Annual Average Precipitation (in/yr)	72.5	Weather Station in Jacksonville, NC (Malcolm Pirnie, 2008)
Annual Average Wind Speed (mph)	8.1	Weather Station in Jacksonville, NC (Malcolm Pirnie, 2008)
Annual Average Ambient Environmental Temperature (^{0}F)	5	Weather Station in Jacksonville, NC (Malcolm Pirnie, 2008)
Groundwater base flow (in/yr)	12	mind-range value from Baker Environmental, 1998

Note:
in/yr = inches per year
mph = miles per hour
^{0}F = degrees Fahrenheit

Table C-3: Soil Types and Hydrologic Properties at Identified MC Loading Areas

MC Loading Area	Land Cover[a]	Slope (%)[a]	Predominant Soil Map Symbol[b]	Soil Description[b]	Soil Bulk Density (kg/m^3)b	Runoff Coefficient[c]	Runoff ($m^3/m^2/d$)[d]	Annul Recharge (% ppt)[e]
G-10 Impact Area	~5% forest cover	4.5	Ln	fine sand	1600	0.72	1.33	19.5
G-6	~70% forest cover	3.7	KuB, Ln	fine sand	1700	0.27	0.50	18
G-10 A	unvegetated	2.4	KuB	fine sand	1700	0.71	1.31	19.5
G-7	~ 30% forest cover	4.3	BaB, WaB	fine sand	1577	0.52	0.96	18
G-19 Ranges	~30% forest cover	3	Ln, KuB	fine sand	1500	0.57	1.06	18
K-2 Impact Area	~80% forest cover	6	MaC, BaB	loamy fine sand, fine sand	1650	0.23	0.43	18
K-500	~3% forested cover	3.9	On, BaB	loamy fine sand, fine sand	1650	0.70	1.29	19.5
K-500A	~1% forest cover	5	NoB, BaB-FoA-St	loamy fine sand, fine sand	1483	0.72	1.33	18
K-504A/B	unvegetated	11	BaB-FoA-St	fine sand	1467	0.76	1.40	18
K-505	unvegetated	4	Mac, BaB-FoA-St	loamy fine sand, fine sand	1533	0.73	1.34	19.5
K-323	~ 10% forest cover	3	BaB	fine sand	1600	0.65	1.19	19.5
K-510	unvegetated	6.3	WaB	fine sand	1450	0.72	1.33	18
F-Ranges	~5% forest cover	3.5	BaB, St	fine sand, loamy fine sand	1600	0.70	1.29	19.5
F-6	~3% forest cover	3	KuB, BaB	fine sand	1700	0.69	1.27	19.5
L-5	~ 5% forest cover	4.5	KuB	fine sand	1650	0.68	1.25	19.5
Combat Town	~ 5% forest cover	3	KuB	fine sand	1700	0.68	1.25	19.5
EOD-1	~ 5% forest cover	4	KuB	fine sand	1700	0.68	1.25	19.5
EOD-2	<1% forest cover	1.5	WaB	fine sand	1450	0.69	1.28	21
ETA-1	~15% forest cover	6	WaB	fine sand	1450	0.62	1.13	18
ETA-2	~10% forest cover	3.5	AnB, Ln	fine sand	1450	0.65	1.19	19.5
ETA-3	unvegetated	2	On	loamy fine sand	1680	0.71	1.31	21
ETA-4	~2% forested cover	3	KuB	fine sand	1700	0.70	1.28	19.5
ETA-5/5A	~3 % forested cover	5	BaB	fine sand	1600	0.69	1.27	18
ETA-7/7C	unvegetated	3	Ly	fine sandy loam	1500	0.73	1.34	19.5
Stone Bay Area	unvegetated	9.6	BaB-FoA-St	fine sand	1600	0.74	1.36	18
Mobile MOUT Complex	~ 5% forest cover	7.8	BaB-FoA-St, MaC	fine sand, loamy fine sand	1600	0.71	1.31	18
SR-6	~2% forested cover	3.5	St, Ln	loamy fine sand, fine sand	1500	0.72	1.32	19.5
SR-7	~10% forest cover	3.1	Wo, Ln	loamy fine sand, fine sand	1500	0.69	1.27	19.5
SR-10	~5% forest cover	3.5	Wo	loamy fine sand	1500	0.72	1.33	19.5
Devil Dog	~10% forest cover	2.32	BaB-FoA-St	fine sand	1467	0.67	1.23	19.5
EOD-3	~ 5% forest cover	9.6	NoB	loamy fine sand	1450	0.71	1.31	18
ETA-10	~ 20% forest cover	4.9	NoB, MaC	loamy fine sand	1525	0.60	1.10	19.5
ETA-9	~10% forest cover	11	NoB	loamy fine sand	1450	0.68	1.25	18
K-407	~ 50% forest cover	8.4	MaC, NoB	loamy fine sand	1525	0.44	0.81	11.5
K-408	~60 % forest cover	13	NoB and MaC	loamy fine sand	1525	0.38	0.70	11.5
MAC-3	~60% forest cover	4.3	NoB, Pt	loamy fine sand, poorly drained excavated pit	1450	0.35	0.65	11.5

Note:

Soiil moisture content was estimated to be0.24 for all MC loading areas based on the field capacity value forsand (Fetter, 1994)

Soil air content was estimated to be 0.19 for all MC loading areas based on soil porosity (Mc Whorter and Sundada, 1977) less soil moisture content

AnB = Alpine fine sand
BaB = Baymeade fine sand
FoA = Foreston loamy fine
Kub = Kureb fine sand
Ln = Leon fine sand
MaC = Marvyn loamy fine sand
NoB = Norfolk loamy fine sand
On = Onslow loamy fine sand
St = Stallings loamy fine sand
WaB = Wando fine sand

kg/m^3 = kilograms per cubic meter
$m^3/m^2/d$ = cubic meter per square meter per day
% ppt = percent precipitation
[a] Spatial data (MCIEAST MCB CAMLEJ, 2014)
[b] Soil survey report (USDA SCS, 1992)

[c] picked from tabulated data (McCuen, 1998)
[d] Estimated from runoff coefficient and precipitation
[e] Estimated from a range of known recharge rates for the area (Heath, 1989), land cover and slope

Table C-4: Parameter Values used to Estimate Soil Erosion

MC Loading Area	Area (m^2)	K[a]	LS[b]	C[c]	P[d]	A ($kg/m^2/d$)
G-10 Impact Area	3.95E+06	0.1	1.21	0.20	0.8	3.24E-03
G-6	2.26E+05	0.1	1.04	0.19	1	3.33E-03
G-10 A	1.69E+03	0.1	0.61	0.20	1	2.05E-03
G-7	3.79E+05	0.1	1.16	0.19	1	3.79E-03
G-19 Ranges	5.13E+04	0.1	0.80	0.18	1	2.49E-03
K-2 Impact Area	2.15E+06	0.17	1.59	0.18	0.8	6.57E-03
K-500	5.19E+05	0.17	1.08	0.20	0.8	4.94E-03
K-500A	3.31E+04	0.18	1.34	0.20	0.8	6.49E-03
K-504A/B	4.30E+04	0.12	2.64	0.20	1	1.07E-02
K-505	3.40E+04	0.16	1.08	0.20	1	5.84E-03
K-323	3.96E+04	0.1	0.80	0.20	0.8	2.12E-03
K-510	8.77E+04	0.1	2.02	0.20	0.8	5.46E-03
F-Ranges	5.03E+05	0.17	0.96	0.20	1	5.43E-03
F-6	3.72E+04	0.1	0.80	0.20	0.8	2.16E-03
L-5	3.41E+05	0.1	1.33	0.20	1	4.43E-03
Combat Town	2.63E+04	0.1	0.80	0.20	1	2.68E-03
EOD-1	8.44E+04	0.1	1.14	0.20	1	3.81E-03
EOD-2	2.72E+04	0.1	0.35	0.20	1	1.18E-03
ETA-1	1.23E+05	0.1	1.90	0.19	1	6.10E-03
ETA-2	2.47E+05	0.1	0.97	0.20	1	3.21E-03
ETA-3	7.75E+03	0.1	0.48	0.20	1	1.62E-03
ETA-4	5.90E+04	0.1	0.80	0.20	1	2.69E-03
ETA-5/5A	4.11E+04	0.1	1.51	0.20	1	5.05E-03
ETA-7/7C	1.02E+05	0.2	0.80	0.20	1	5.40E-03
Stone Bay Area	5.19E+03	0.1	3.30	0.20	0.8	8.93E-03
Mobile MOUT Complex	1.21E+05	0.15	2.09	0.20	0.8	8.30E-03
SR-6	6.80E+05	0.1	0.97	0.20	1	3.24E-03
SR-7	2.73E+06	0.1	0.83	0.20	1	2.76E-03
SR-10	3.37E+06	0.1	0.97	0.20	0.8	2.60E-03
Devil Dog	8.76E+03	0.12	0.66	0.20	1	2.55E-03
EOD-3	6.29E+04	0.2	2.42	0.20	1	1.62E-02
ETA-10	2.94E+04	0.19	1.34	0.19	1	8.26E-03
ETA-9	3.21E+04	0.2	2.64	0.20	1	1.75E-02
K-407	1.13E+04	0.18	2.17	0.19	1	1.25E-02
K-408	1.65E+04	0.19	2.92	0.19	1	1.71E-02
MAC-3	3.95E+03	0.2	1.16	0.19	1	7.37E-03

Note:

R factor value of 275 was picked for all loading areas (Brady, 1984)

A = predicted soil loss
C = cover and management fact
K = soil erodibility factor
$kg/m^2/d$ = kilogram per square n
LS = topographic factor (influen

P = erosion control practice factor
R = rainfall and runoff factor
[a] Soil survey report (USDA SCS, 1992)
[b] Slope length and gradient were used to select LS (USDA ARS, 1997).
[c] Estimated based on vegetation cover (USDA ARS, 1997)

[d] Factor selected based on storm water best management practices on range (MCIEAST-MCB CAMLEJ, 2010)

Table C-5: Chemical Properties of TNT

Installation name:	MCIEAST-MCB CAMLEJ
Date:	December, 2014
Munitions Constituent:	TNT

Row	Data Type	Description	Source Type	Rationale	Reference(s)	Value/Result	Units	Necessary Actions / Data Gaps
1	Molecular weight	Molecular weight of TNT	☑ Literature ☐ Site Data ☐ Assumption		Walsh et al., 1995	227.1	g/mol	
2	Solubility	Water solubility of TNT	☑ Literature ☐ Site Data ☐ Assumption		Walsh et al., 1995	Minimum: Average: 5.72E-01 Maximum:	mol/m^3	
3	Vapor pressure	Vapor pressure of TNT	☑ Literature ☐ Site Data ☐ Assumption		Walsh et al., 1995	Minimum: Average: 1.47E-04 Maximum:	Pa	
4	Henry's law constant	Henry's law constant of TNT	☑ Literature ☐ Site Data ☐ Assumption		HQMC, 2009	Minimum: Average: 1.10E-08 Maximum:	atm-m^3/mol	
5	Kow	Octanol-water partition coefficient for TNT	☑ Literature ☐ Site Data ☐ Assumption		HQMC, 2009	Minimum: Average: 72.4 Maximum:	unitless	
6	Koc	Organic carbon partition coefficient for TNT	☐ Literature ☐ Site Data ☑ Assumption		HQMC, 2009	Minimum: Average: 525 Maximum:	mL/g	
7	K_D	Equilibrium distribution coefficient	☐ Literature ☑ Site Data ☐ Assumption	Evaluated from the product of organic carbon partition coefficient and soil organic carbon fraction (**Table B-8**)		Minimum: Average: Maximum:		
8	Diffusion coefficient in air	Diffusion coefficient of TNT in air	☑ Literature ☐ Site Data ☐ Assumption		HQMC, 2009	Minimum: Average: 6.40E-02 Maximum:	cm^2/sec	
9	Diffusion coefficient in water	Diffusion coefficient of TNT in water	☑ Literature ☐ Site Data ☐ Assumption		HQMC, 2009	Minimum: Average: 6.71E-06 Maximum:	cm^2/sec	
10	Half-life in soil	Reaction half-life of TNT in soil	☑ Literature ☐ Site Data ☐ Assumption	A representative value selected by subjuect matter expert based on a compilation of academic, industrial and government references	HQMC, 2009	Minimum: Most likey: 23.1 Maximum:	days	

Table C-5: Chemical Properties of HMX

Installation name:	MCIEAST-MCB CAMLEJ
Date:	December, 2014
Munitions Constituent:	TNT

Row	Data Type	Description	Source Type	Rationale	Reference(s)	Value/Result		Units	Necessary Actions / Data Gaps
1	Molecular weight	Molecular weight of HMX	☑ Literature ☐ Site Data ☐ Assumption		Walsh et al., 1995		296.2	g/mol	
2	Solubility	Water solubility of HMX	☑ Literature ☐ Site Data ☐ Assumption		Walsh et al., 1995	Minimum: Average: Maximum:	 1.69E-02 	mol/m^3	
3	Vapor pressure	Vapor pressure of HMX	☑ Literature ☐ Site Data ☐ Assumption		Walsh et al., 1995	Minimum: Average: Maximum:	 4.40E-12 	Pa	
4	Henry's law constant	Henry's law constant of HMX	☑ Literature ☐ Site Data ☐ Assumption		HQMC, 2009	Minimum: Average: Maximum:	 2.63E-15 	atm-m^3/mol	
5	Kow	Octanol-water partition coefficient for TNT	☑ Literature ☐ Site Data ☐ Assumption		HQMC, 2009	Minimum: Average: Maximum:	 1.15 	unitless	
6	Koc	Organic carbon partition coefficient for HMX	☑ Literature ☐ Site Data ☐ Assumption		HQMC, 2009	Minimum: Average: Maximum:	 3.47 	mL/g	
7	K_D	Equilibrium distribution coefficient	☐ Literature ☑ Site Data ☐ Assumption	Evaluated from the product of organic carbon partition coefficient and soil organic carbon fraction (**Table B-8**)		Minimum: Average: Maximum:			
8	Diffusion coefficient in air	Diffusion coefficient of HMX in air	☑ Literature ☐ Site Data ☐ Assumption		HQMC, 2009	Minimum: Average: Maximum:	 6.30E-02 	cm^2/sec	
9	Diffusion coefficient in water	Diffusion coefficient of HMX in water	☑ Literature ☐ Site Data ☐ Assumption		HQMC, 2009	Minimum: Average: Maximum:	 6.02E-06 	cm^2/sec	
10	Half-life in soil	Reaction half-life of HMX in soil	☑ Literature ☐ Site Data ☐ Assumption	A representative value selected by subjuect matter expert based on a compilation of academic, industrial and government references	HQMC, 2009	Minimum: Most likely: Maximum:	 51.3 	days	

Table C-6: Chemical Properties of RDX

Installation name:	MCIEAST-MCB CAMLEJ
Date:	December, 2014
Munitions Constituent:	TNT

Row	Data Type	Description	Source Type	Rationale	Reference(s)	Value/Result		Units	Necessary Actions / Data Gaps
1	Molecular weight	Molecular weight of RDX	☑ Literature ☐ Site Data ☐ Assumption		Walsh et al., 1995		222.1	g/mol	
2	Solubility	Water solubility of RDX	☑ Literature ☐ Site Data ☐ Assumption		Walsh et al., 1995	Minimum: Average: Maximum:	 1.90E-01 	mol/m^3	
3	Vapor pressure	Vapor pressure of RDX	☑ Literature ☐ Site Data ☐ Assumption		Walsh et al., 1995	Minimum: Average: Maximum:	 5.47E-07 	Pa	
4	Henry's law constant	Henry's law constant of RDX	☑ Literature ☐ Site Data ☐ Assumption		HQMC, 2009	Minimum: Average: Maximum:	 1.20E-05 	atm-m^3/mol	
5	Kow	Octanol-water partition coefficient for TNT	☑ Literature ☐ Site Data ☐ Assumption		HQMC, 2009	Minimum: Average: Maximum:	 6.45 	unitless	
6	Koc	Organic carbon partition coefficient for RDX	☑ Literature ☐ Site Data ☐ Assumption		HQMC, 2009	Minimum: Average: Maximum:	 7.76E+00 	mL/g	
7	K_D	Equilibrium distribution coefficient	☐ Literature ☑ Site Data ☐ Assumption	Evaluated from the product of organic carbon partition coefficient and soil organic carbon fraction (**Table B-8**)		Minimum: Average: Maximum:			
8	Diffusion coefficient in air	Diffusion coefficient of RDX in air	☑ Literature ☐ Site Data ☐ Assumption		HQMC, 2009	Minimum: Average: Maximum:	 7.40E-02 	cm^2/sec	
9	Diffusion coefficient in water	Diffusion coefficient of RDX in water	☑ Literature ☐ Site Data ☐ Assumption		HQMC, 2009	Minimum: Average: Maximum:	 7.15E-06 	cm^2/sec	
10	Half-life in soil	Reaction half-life of RDX in soil	☐ Literature ☐ Site Data ☑ Assumption	A representative value selected by subjuect matter expert based on a compilation of academic, industrial and government references	HQMC, 2009	Minimum: Average: Maximum:	 14.2 	days	

Table C-7: Chemical Properties of Perchlorate

Installation name:	MCIEAST-MCB CAMLEJ
Date:	December, 2014
Munitions Constituent:	TNT

Row	Data Type	Description	Source Type	Rationale	Reference(s)	Value/Result		Units	Necessary Actions / Data Gaps
1	Molecular weight	Molecular weight of perchlorate	☑ Literature ☐ Site Data ☐ Assumption		Walsh et al., 1995		99.45	g/mol	
2	Solubility	Water solubility of perchlorate	☑ Literature ☐ Site Data ☐ Assumption		Walsh et al., 1995	Minimum:			
						Average:	2.01E+03		
						Maximum:		mol/m^3	
3	Vapor pressure	Vapor pressure of perchlorate	☑ Literature ☐ Site Data ☐ Assumption		Walsh et al., 1995	Minimum:			
						Average:	3.75E-09	Pa	
						Maximum:			
4	Henry's law constant	Henry's law constant of perchlorate	☐ Literature ☐ Site Data ☑ Assumption	No reported values available; Estmated by CalTOX from vapor pressure and solubility values		Minimum:			
						Most Likely:	1.85E-17	atm-	
						Maximum:		m^3/mol	
5	Kow	Octanol-water partition coefficient for TNT	☑ Literature ☐ Site Data ☐ Assumption		Walsh et al., 1995 Meylan and Howard, 1995	Minimum:			
						Average:	1.40E-06	unitless	
						Maximum:			
6	Koc	Organic carbon partition coefficient for Perchlorate	☐ Literature ☐ Site Data ☑ Assumption	Estimated by the CalTOX model based on the Kow for perchlorate		Minimum:			
						Average:	6.94E-07	mL/g	
						Maximum:			
7	K_D	Equilibrium distribution coefficient	☐ Literature ☐ Site Data ☑ Assumption	Evaluated from the product of organic carbon partition coefficient and soil organic carbon fraction (**Table B-8**)		Minimum:			
						Average:			
						Maximum:			
8	Diffusion coefficient in air	Diffusion coefficient of perchlorate in air	☐ Literature ☐ Site Data ☑ Assumption	No reported values available, input variables used are based on conservative assumptions		Minimum:			
						Average:	7.00E-10	cm^2/sec	
						Maximum:			
9	Diffusion coefficient in water	Reaction half-life of perchlorate in water	☐ Literature ☐ Site Data ☑ Assumption	No reported values available, input variables used are based on conservative assumptions		Minimum:			
						Average:	1.90E-12	cm^2/sec	
						Maximum:			
10	Half-life in soil	Reaction half-life of perchlorate in soil	☐ Literature ☐ Site Data ☑ Assumption	No reported values available, input variables used are based on conservative assumptions		Minimum:			
						Average:	1.00E+07	days	
						Maximum:			

Table C-8: MC Equilibrium Distribution Coefficient Values at MC Loading Areas

MC Loading Area	Soil Organic Carbon Content[a]	MC	Koc (ml/g)	K_D (ml/g)[b]
		HMX	3.47	2.78
		RDX	7.76	6.21
		TNT	525	420
G-10 Impact Area	0.8	Perhlorate	6.94E-07	5.55E-07
		HMX	3.47	1.01
		RDX	7.76	2.25
		TNT	525	152
G-6	0.29	Perhlorate	6.94E-07	2.01E-07
		HMX	3.47	1.01
		RDX	7.76	2.25
		TNT	525	152
G-10A	0.29	Perhlorate	6.94E-07	2.01E-07
		HMX	3.47	1.67
		RDX	7.76	3.72
		TNT	525	252
G-7	0.48	Perhlorate	6.94E-07	3.33E-07
		HMX	3.47	4.51
		RDX	7.76	10.09
		TNT	525	683
G-19 Ranges	1.3	Perhlorate	6.94E-07	9.02E-07
		HMX	3.47	2.01
		RDX	7.76	4.50
		TNT	525	305
K-2 Impact Area	0.58	Perhlorate	6.94E-07	4.03E-07
		HMX	3.47	2.01
		RDX	7.76	4.50
		TNT	525	305
K-500	0.58	Perhlorate	6.94E-07	4.03E-07
		HMX	3.47	2.36
		RDX	7.76	5.28
		TNT	525	357
K-500A	0.68	Perhlorate	6.94E-07	4.72E-07
		HMX	3.47	2.85
		RDX	7.76	6.36
		TNT	525	431
K-504A/B	0.82	Perhlorate	6.94E-07	5.69E-07
		HMX	3.47	2.53
		RDX	7.76	5.66
		TNT	525	383
K-505	0.73	Perhlorate	6.94E-07	5.07E-07
		HMX	3.47	1.53
		RDX	7.76	3.41
		TNT	525	231
K-323	0.44	Perhlorate	6.94E-07	3.05E-07
		HMX	3.47	1.01
		RDX	7.76	2.25
		TNT	525	152
K-510	0.29	Perhlorate	6.94E-07	2.01E-07
		HMX	3.47	3.02
		RDX	7.76	6.75
		TNT	525	457
F-Ranges	0.87	Perhlorate	6.94E-07	6.04E-07
		HMX	3.47	1.01
		RDX	7.76	2.25
		TNT	525	152
F-6	0.29	Perhlorate	6.94E-07	2.01E-07
		HMX	3.47	1.28
		RDX	7.76	2.87
		TNT	525	194
L-5	0.37	Perhlorate	6.94E-07	2.57E-07
		HMX	3.47	1.01
		RDX	7.76	2.25
		TNT	525	152
Combat Town	0.29	Perhlorate	6.94E-07	2.01E-07
		HMX	3.47	1.01
		RDX	7.76	2.25
		TNT	525	152
EOD-1	0.29	Perhlorate	6.94E-07	2.01E-07
		HMX	3.47	1.01
		RDX	7.76	2.25
		TNT	525	152
EOD-2	0.29	Perhlorate	6.94E-07	2.01E-07
		HMX	3.47	1.01
		RDX	7.76	2.25
		TNT	525	152
ETA-1	0.29	Perhlorate	6.94E-07	2.01E-07
		HMX	3.47	2.01
		RDX	7.76	4.50
		TNT	525	305
ETA-2	0.58	Perhlorate	6.94E-07	4.03E-07
		HMX	3.47	4.16
		RDX	7.76	9.31
		TNT	525	630

Table C-8: MC Equilibrium Distribution Coefficient Values at MC Loading Areas

MC Loading Area	Soil Organic Carbon Content[a]	MC	Koc (ml/g)	K_D (ml/g)[b]
ETA-3	1.2	Perhlorate	6.94E-07	8.33E-07
ETA-4	0.29	HMX	3.47	1.01
		RDX	7.76	2.25
		TNT	525	152
		Perhlorate	6.94E-07	2.01E-07
ETA-5/5A	0.44	HMX	3.47	1.53
		RDX	7.76	3.41
		TNT	525	231
		Perhlorate	6.94E-07	3.05E-07
ETA-7/7C	1.6	HMX	3.47	5.55
		RDX	7.76	12.42
		TNT	525	840
		Perhlorate	6.94E-07	1.11E-06
Stone Bay Area	0.44	HMX	3.47	1.53
		RDX	7.76	3.41
		TNT	525	231
		Perhlorate	6.94E-07	3.05E-07
Mobile MOUT Complex	0.44	HMX	3.47	1.53
		RDX	7.76	3.41
		TNT	525	231
		Perhlorate	6.94E-07	3.05E-07
SR-6	1.4	HMX	3.47	4.86
		RDX	7.76	10.86
		TNT	525	735
		Perhlorate	6.94E-07	9.72E-07
SR-7	1.5	HMX	3.47	5.21
		RDX	7.76	11.64
		TNT	525	788
		Perhlorate	6.94E-07	1.04E-06
SR-10	1.74	HMX	3.47	6.04
		RDX	7.76	13.50
		TNT	525	914
		Perhlorate	6.94E-07	1.21E-06
Devil Dog	0.82	HMX	3.47	2.85
		RDX	7.76	6.36
		TNT	525	431
		Perhlorate	6.94E-07	5.69E-07
EOD-3	0.58	HMX	3.47	2.01
		RDX	7.76	4.50
		TNT	525	305
		Perhlorate	6.94E-07	4.03E-07
ETA-10	0.58	HMX	3.47	2.01
		RDX	7.76	4.50
		TNT	525	305
		Perhlorate	6.94E-07	4.03E-07
ETA-9	0.58	HMX	3.47	2.01
		RDX	7.76	4.50
		TNT	525	305
		Perhlorate	6.94E-07	4.03E-07
K-407	0.58	HMX	3.47	2.01
		RDX	7.76	4.50
		TNT	525	305
		Perhlorate	6.94E-07	4.03E-07
K-408	0.58	HMX	3.47	2.01
		RDX	7.76	4.50
		TNT	525	305
		Perhlorate	6.94E-07	4.03E-07
MAC-3	0.58	HMX	3.47	2.01
		RDX	7.76	4.50
		TNT	525	305
		Perhlorate	6.94E-07	4.03E-07

Note:

[a] Estimated from the soil survey organic conent value (USDA SCS, 1992)

[b] Evaluated from the product of organic carbon partition coefficient and soil organic carbon fraction

Technical Memorandum
Groundwater Screening-Level Assessment

Technical Memorandum

Date:	August 25, 2014
To:	Jennifer Wilber, Marine Corps Installations Command
Copy:	Dave Lynch, Charity Delaney (Marine Corps Installations Command East – Marine Corps Base Camp Lejeune) Catherine Zoeckler, Julie Dobschuetz, Britt McMillan, Susan Herbert (ARCADIS)
From:	Edidia Nefso (ARCADIS)
Re:	Assessment of Munitions Constituent (MC) Concentrations in Groundwater from MC Loading Areas at Marine Corps Installations Command East – Marine Corps Base Camp Lejeune.
Project No.:	06285043.0000

INTRODUCTION

This memorandum documents the results and recommended path forward based on screening-level assessment of potential munitions constituent (MC) concentrations in groundwater at Marine Corps Installations Command East – Marine Corps Base Camp Lejeune (MCIEAST-MCB CAMLEJ). The Range Environmental Vulnerability Assessment (REVA) screening-level groundwater assessment was used to assess the potential for MC to migrate from operational range areas vertically through the vadose zone to groundwater within the unconfined surficial aquifer and horizontally within the saturated zone in the surficial aquifer to potential human and ecological receptor locations. The potential for MC to migrate vertically from the surficial aquifer down to the semiconfined Castle Hayne aquifer and horizontally through the Castle Hayne aquifer to potential groundwater receptors (drinking water wells) have also been assessed. Recommendations are presented for identified receptor locations that require further investigation based on the screening-level assessment results.

The procedures used to conduct this screening-level assessment are presented in the REVA 5-Year Review Manual (HQMC, 2010). A separate technical memorandum that addresses MC transport in surface water and sediment has been prepared in parallel (ARCADIS, 2014).

Thirty-six MC loading areas were assessed. These MC loading areas were selected for screening-level modeling based on range use and proximity to potential receptor locations.

- G-10 Impact Area
- G-6 (CBC)
- G-10A
- G-7
- G-19 Ranges
- K-2 Impact Area
- K-500
- K-500A
- K-504A/B
- K-505
- K-323
- K-407
- K-408
- K-510
- F-Ranges
- F-6
- L-5
- Combat Town
- EOD-1
- EOD-2
- EOD-3
- ETA-1
- ETA-2
- ETA-3
- ETA-4
- ETA-5/5A
- ETA-7/7C
- ETA-9
- ETA-10
- Stone Bay Area
- MOUT Complex
- SR-6
- SR-7
- SR-10
- Devil Dog
- MAC-3

Note:
CBC – Company Battle Course
EOD – Explosives Ordnance Disposal
ETA – Engineer Training Area
MAC – MOUT Assault Course
MOUT – Military Operations in Urban Terrain

METHODS

Recharge can occur from the portion of precipitation that falls directly on the MC loading areas and infiltrates the underlying surficial aquifer, largely composed of Pleistocene deposits and recent deposits of sand and silts at MCIEAST-MCB CAMLEJ. Shallow groundwater associated with the surficial aquifer is a known source of base flow to streams, indicating that MC transported in groundwater could discharge to surface waters that are potential human and ecological receptor locations. The shallow groundwater from the surficial aquifer also recharges the underlying semiconfined Castle Hayne aquifer, the drinking water source for the installation and for areas just outside the installation. Over most of the installation, a confining unit reduces the rate of flow to the underlying Castle Hayne aquifer. However, in some locations, the confining unit is very limited to absent. Significant withdrawals by the installation and adjacent county water supply wells have created a strong localized hydraulic gradient toward the water supply wells, and MC load from the upper surficial aquifer potentially can migrate down to the Castle Hayne aquifer where it can be transported to drinking water supply wells.

A four-step process was used to assess the potential for MC from the MC loading areas to migrate vertically from the ground surface through the vadose zone to shallow groundwater in the surficial aquifer, then migrate farther down to the semiconfined Castle Hayne aquifer, and then horizontally through the groundwater to potential receptor locations in surface water (from the surficial aquifer) or groundwater (from the Castle Hayne aquifer). At each step of the process, estimated concentrations were compared to calculated median method detection limits (MDLs). These median MDLs serve as a benchmark to compare with the modeling results and determine whether additional actions are warranted. MDLs are used as a benchmark because they are an indicator of whether the assessment predicts the constituent is present at a detectable concentration.

The screening-level groundwater assessment was conducted for the period 2011–2014; however, the following ranges were not active during this entire time period and were assessed for the period MC loading was known to have occurred:

- K-323 (became inactive in 2011, conducted only for 2011)
- K-505, EOD-3, ETA-9, and ETA-10 (activated 2013, conducted for the period 2013–2014)
- EOD-1 (became inactive 2012, conducted for period 2011-2012)
- ETA-3 (usage limited from 2011 to 2013; conducted for the period 2011–2013)

The following four-step process was used in the screening-level assessment:

Step 1: Initial Groundwater Screening-Level Assessment – MC concentrations are estimated in the portion of the precipitation water that infiltrates to the groundwater (11.5% to 21% based on values for the MCIEAST-MCB CAMLEJ area, estimated slopes and known land cover at the MC loading areas) and are assumed to arrive at the groundwater at that concentration. If a concentration exceeds its median MDL, Step 2 is performed. If all concentrations are lower than the median MDLs, the MC loading area is not evaluated further.

Step 2: Vadose Zone Modeling – The VLEACH vadose zone model with a post-processing step to include decay is used to evaluate the potential for MC to migrate through the vadose zone to the groundwater at concentrations greater than the median MDL. If an MC concentration arriving at the water table is predicted to be greater than its median MDL, steps 3 and 4a are performed; otherwise, the MC loading area is not evaluated further.

Step 3: Transport to Castle Hayne Aquifer – The potential vertical migration of MC through the surficial aquifer into the semiconfined Castle Hayne aquifer is estimated by conservatively assuming that the entire MC load that arrives at the water table or the surficial aquifer is vertically transported to the Castle Hayne aquifer. Dilution factors were used to estimate concentrations in the Castle Hayne aquifer resulting from mixing of the vertical and lateral flows in the surficial and the Castle Hayne aquifers. This assessment conservatively assumes that the confining layer of the Castle Hayne aquifer is absent. If an MC concentration potentially arriving at the Castle Hayne aquifer is estimated to be greater than its median MDL, steps 4a and 4b are performed; otherwise, only step 4a is performed.

Step 4: Saturated Zone Modeling – The screening-level groundwater model, BIOCHLOR, is used to evaluate if MC from the MC loading area have the potential to reach receptors locations (installation and off-installation supply wells and surface waters that are potential ecological and human receptor locations) at levels above the median MDL through saturated groundwater flow. There are two parts to this assessment:

a) MC transport through the surficial aquifer to a surface water receptor location is evaluated using the results from step 2.
b) MC transport through the Castle Hayne aquifer to a drinking water supply well is evaluated using the results from step 3.

If the model predicts a detectable MC concentration at the receptor location from Step 4a, groundwater contributions to surface water transport will be considered within the drainage area assessed in the surface water screening assessment (ARCADIS, 2014). If a detectable MC concentration is predicted from Step 4b, additional assessment and/or sampling is carried out; otherwise, the MC loading area is not evaluated further.

RESULTS

Table 1 presents the estimated MC concentrations in infiltrating water at the MC loading areas assessed. Bolded values in the table indicate that the concentration is predicted to be detectable in the infiltrating water at the MC loading area, and these concentrations are carried forward into Step 2 of the evaluation.

- The concentration of cyclotetramethylene tetranitramine (HMX) in infiltrating water was estimated to be above the median MDL at 6 of the 24 MC loading area assessed for HMX.
- The concentration of cyclomethylene trinitramine (RDX) in infiltrating water was estimated to be above the median MDL at 28 of the 34 MC loading areas assessed for RDX.
- The concentration of 2,4,6-trinitrotoluene (TNT) in infiltrating water was estimated to be above the median MDL at 22 of the 35 MC loading areas assessed for TNT.
- The concentration of perchlorate in infiltrating water was estimated to be above the median MDL at 12 of the 34 MC loading areas assessed for perchlorate.

As a result, these MC were modeled for migration through the vadose zone in Step 2 of the screening-level assessment.

Table 1: Maximum MC Concentrations in Infiltrating Water at MC Loading Areas

		HMX	RDX	TNT	Perchlorate
Median MDL (µg/L)		*0.077*	*0.097*	*0.108*	*0.06*
MC Loading Area	**Recharge Rate (ft/yr)**	**Predicted Maximum Infiltration Concentration (µg/L)**			
G-10 Impact Area	1.18	**0.457**	**31.2**	**246**	0.047
G-6 (CBC)	1.09	~0	0.025	0.009	0.011
G-10A	1.18	**0.963**	**281**	**504**	**1.21**
G-7	1.09	N/A	**4.14**	**5.35**	0.027
G-19 Ranges	1.09	**1.84**	**47.9**	**4.04**	**0.341**
K-2 Impact Area	1.09	~0	**0.197**	**1.23**	~0
K-407	0.69	N/A	**0.779**	0.016	0.015
K-408	0.69	N/A	N/A	N/A	0.044
K-500	1.18	0.001	**16.2**	**7.85**	0.012
K-500A	1.09	0.003	**242**	0.020	~0
K-504A/B	1.09	N/A	**66.0**	0.008	0.002
K-505	1.18	**0.773**	**28.5**	**10.7**	0.021
K-323	1.18	N/A	N/A	0.001	N/A
K-510	1.09	N/A	**83.5**	**53.6**	**0.136**
F-Ranges	1.18	N/A	~0	~0	**0.080**
F-6	1.18	N/A	**23.7**	**15.2**	0.038
L-5	1.18	~0	0.058	~0	**0.381**
Combat Town	1.18	~0	**0.099**	~0	**0.265**
EOD-1	1.18	~0	**3.06**	**3.23**	~0
EOD-2	1.27	**0.372**	**16.5**	**11.9**	0.011
EOD-3	1.09	0.002	**10.2**	**11.9**	~0
ETA-1	1.09	0.007	**7.81**	**16.0**	**0.083**
ETA-2	1.18	N/A	**2.18**	**0.980**	0.024
ETA-3	1.27	0.031	**930**	**779**	**0.400**
ETA-4	1.18	0.001	**50.7**	**35.2**	0.002
ETA-5/5A	1.09	0.010	**137**	**27.9**	**0.066**
ETA-7/7C	1.18	0.003	**79.2**	**55.6**	~0
ETA-9	1.09	0.005	**51.2**	**55.9**	0.001
ETA-10	1.18	N/A	**0.100**	**0.436**	N/A

		HMX	RDX	TNT	Perchlorate
Median MDL (µg/L)		*0.077*	*0.097*	*0.108*	*0.06*
MC Loading Area	**Recharge Rate (ft/yr)**	**Predicted Maximum Infiltration Concentration (µg/L)**			
Stone Bay Area	1.09	**0.160**	**232**	**7.88**	**1.08**
Mobile MOUT Complex	1.09	0.001	**0.259**	0.001	**0.368**
SR-6	1.18	~0	~0	~0	0.017
SR-7	1.18	0.008	**0.287**	~0	0.014
SR-10	1.18	0.013	0.087	~0	0.009
Devil Dog	1.18	N/A	0.002	~0	**0.151**
MAC-3	0.69	N/A	**0.416**	**0.267**	0.001

Note:
ft/yr = feet per year
µg/L = micrograms per liter
N/A = not modeled, as the MC loading was estimated to be negligible
Bold indicates concentration is above the median MDL and continues to the next step of the evaluation.

Results of the vadose zone modeling for the MC loading areas are presented in **Table 2**. Values in bold are above median MDLs and continue to the next step in the evaluation. As mentioned above in the process description, decay rates were applied to the VLEACH output concentrations as a post-processing step based on the elapsed time, and results for both VLEACH (No Decay) and VLEACH (Decay) are shown. The VLEACH (Decay) values are those used to identify estimated concentrations reaching the water table at detectable concentrations. The last column in Table 2 provides an estimate of the time for MC to reach the groundwater at detectable concentrations.

Based on estimated infiltration rates ranging from 8 to 15 inches per year and a depth to groundwater of approximately 1 to 14 feet below ground surface, the minimum travel time is estimated to be less than 1 year for MC to reach the water table at a concentration equal to the respective MC median MDL. The model that includes decay predicts:

- HMX and TNT at all MC loading areas modeled and RDX 25 of the 28 MC loading areas modeled to degrade to concentrations below their respective median MDL before reaching the water table.
- RDX concentrations at 3 of the 28 MC loading areas modeled for RDX and perchlorate concentrations at all 12 MC loading areas modeled for perchlorate to be above their respective median MDLs.
- RDX and perchlorate to be above their median MDLs in groundwater in less than 1 year at EOD-2 (for RDX), ETA-5/5A (for RDX and perchlorate), Stone Bay Area (for RDX and perchlorate), G-10A (for perchlorate) and L-5 (for perchlorate) MC loading areas.

Table 2: Estimated MC Concentrations Reaching the Water Table at the MC Loading Areas

MC Loading Area	MC	Median MDL (µg/L)	VLEACH (No Decay)		VLEACH (Decay)	
			Steady-State Concentration at Water Table (µg/L)	Time to Exceed Median MDL (yr)	Maximum Concentration at Water Table (µg/L)	Time to Exceed Median MDL (yr)
G-10 Impact Area	HMX	*0.077*	**0.457**	~2	~0	--
	RDX	*0.097*	**31.2**	<1	~0	--
	TNT	*0.108*	**246**	~2	~0	--
	Perchlorate	*0.06*	NM	NM	NM	NM
G-10A	HMX	*0.077*	**0.963**	~1	~0	--
	RDX	*0.097*	**281**	<1	~0	--
	TNT	*0.108*	**504**	<1	~0	--
	Perchlorate	*0.06*	**1.21**	<1	**1.21**	<1
G-7	HMX	*0.077*	N/A		N/A	N/A
	RDX	*0.097*	**4.14**	<1	~0	--
	TNT	*0.108*	**5.35**	~5	~0	--
	Perchlorate	*0.06*	NM		NM	NM
G-19 Ranges	HMX	*0.077*	**1.84**	~1	~0	--
	RDX	*0.097*	**47.9**	<1	~0	--
	TNT	*0.108*	**4.04**	~15	~0	--
	Perchlorate	*0.06*	**0.341**	~1	**0.341**	~1
K-2 Impact Area	HMX	*0.077*	NM	NM	NM	NM
	RDX	*0.097*	**0.197**	~1	~0	--
	TNT	*0.108*	**1.23**	~10	~0	--
	Perchlorate	*0.06*	NM	NM	NM	NM
K-500	HMX	*0.077*	NM	NM	NM	NM
	RDX	*0.097*	**16.2**	<1	~0	--
	TNT	*0.108*	**7.85**	~5	~0	--
	Perchlorate	*0.06*	NM	NM	NM	NM
K-500A	HMX	*0.077*	NM	NM	NM	NM
	RDX	*0.097*	**242**	<1	~0	--
	TNT	*0.108*	NM	NM	NM	NM
	Perchlorate	*0.06*	NM	NM	NM	NM
K-504A/B	HMX	*0.077*	N/A	N/A	N/A	N/A
	RDX	*0.097*	**66.0**	<1	~0	--
	TNT	*0.108*	NM	NM	NM	NM

MC Loading Area	MC	Median MDL (µg/L)	VLEACH (No Decay)		VLEACH (Decay)	
			Steady-State Concentration at Water Table (µg/L)	Time to Exceed Median MDL (yr)	Maximum Concentration at Water Table (µg/L)	Time to Exceed Median MDL (yr)
	Perchlorate	*0.06*	NM	NM	NM	NM
K-505	HMX	*0.077*	**0.773**	~5	~0	--
	RDX	*0.097*	**28.5**	<1	~0	--
	TNT	*0.108*	**10.7**	~4	~0	--
	Perchlorate	*0.06*	NM	NM	NM	NM
K-510	HMX	*0.077*	N/A	N/A	N/A	N/A
	RDX	*0.097*	**83.5**	<1	~0	--
	TNT	*0.108*	**53.6**	<1	~0	--
	Perchlorate	*0.06*	**0.136**	~1	**0.136**	~1
K-407	HMX	*0.077*	N/A	N/A	N/A	N/A
	RDX	*0.097*	**0.779**	~5	~0	--
	TNT	*0.108*	NM	NM	NM	NM
	Perchlorate	*0.06*	NM	NM	NM	NM
F-Ranges	HMX	*0.077*	N/A	N/A	N/A	N/A
	RDX	*0.097*	NM	NM	NM	NM
	TNT	*0.108*	NM	NM	NM	NM
	Perchlorate	*0.06*	**0.080**	~3	**0.080**	~3
F-6	HMX	*0.077*	N/A	N/A	N/A	N/A
	RDX	*0.097*	**23.7**	<1	~0	--
	TNT	*0.108*	**15.2**	~5	~0	--
	Perchlorate	*0.06*	NM	NM	NM	NM
L-5	HMX	*0.077*	NM	NM	NM	NM
	RDX	*0.097*	NM	NM	NM	NM
	TNT	*0.108*	NM	NM	NM	NM
	Perchlorate	*0.06*	**0.381**	<1	**0.381**	<1
Combat Town	HMX	*0.077*	NM	NM	NM	NM
	RDX	*0.097*	**0.099**	~2	~0	--
	TNT	*0.108*	NM	NM	NM	NM
	Perchlorate	*0.06*	**0.265**	~1	**0.265**	~1
EOD-1	HMX	*0.077*	NM	NM	NM	NM
	RDX	*0.097*	**3.06**	~1	~0	--
	TNT	*0.108*	**3.23**	~5	~0	--
	Perchlorate	*0.06*	NM	NM	NM	NM
EOD-2	HMX	*0.077*	**0.372**	<1	0.050	--
	RDX	*0.097*	**16.5**	<1	**0.197**	<1

MC Loading Area	MC	Median MDL (µg/L)	VLEACH (No Decay)		VLEACH (Decay)	
			Steady-State Concentration at Water Table (µg/L)	Time to Exceed Median MDL (yr)	Maximum Concentration at Water Table (µg/L)	Time to Exceed Median MDL (yr)
	TNT	*0.108*	**11.9**	<1	0.046	--
	Perchlorate	*0.06*	NM	NM	NM	NM
EOD-3	HMX	*0.077*	NM	NM	NM	NM
	RDX	*0.097*	**10.2**	<1	~0	--
	TNT	*0.108*	**11.9**	~2	~0	--
	Perchlorate	*0.06*	NM	NM	NM	NM
ETA-1	HMX	*0.077*	NM	NM	NM	NM
	RDX	*0.097*	**7.81**	<1	~0	--
	TNT	*0.108*	**16.0**	<1	~0	--
	Perchlorate	*0.06*	**0.083**	<1	**0.083**	<1
ETA-2	HMX	*0.077*	N/A	N/A	N/A	N/A
	RDX	*0.097*	**2.18**	~2	~0	--
	TNT	*0.108*	**0.980**	~20	~0	--
	Perchlorate	*0.06*	NM	NM	NM	NM
ETA-3	HMX	*0.077*	NM	NM	NM	NM
	RDX	*0.097*	**930**	<1	~0	--
	TNT	*0.108*	**779**	~2	~0	--
	Perchlorate	*0.06*	**0.400**	~1	**0.400**	~1
ETA-4	HMX	*0.077*	NM	NM	NM	NM
	RDX	*0.097*	**50.7**	<1	~0	--
	TNT	*0.108*	**35.2**	~3	~0	--
	Perchlorate	*0.06*	NM	NM	NM	NM
ETA-5/5A	HMX	*0.077*	NM	NM	NM	NM
	RDX	*0.097*	**137**	<1	**0.127**	<1
	TNT	*0.108*	**27.9**	<1	0.011	--
	Perchlorate	*0.06*	**0.066**	<1	**0.066**	<1
ETA-7/7C	HMX	*0.077*	NM	NM	NM	NM
	RDX	*0.097*	**79.2**	<1	~0	--
	TNT	*0.108*	**55.6**	~1	~0	--
	Perchlorate	*0.06*	NM	NM	NM	NM
ETA-9	HMX	*0.077*	NM	NM	NM	NM
	RDX	*0.097*	**51.2**	<1	~0	--
	TNT	*0.108*	**55.9**	~1	~0	--
	Perchlorate	*0.06*	NM	NM	NM	NM
ETA-10	HMX	*0.077*	N/A	N/A	N/A	N/A

MC Loading Area	MC	Median MDL (µg/L)	VLEACH (No Decay)		VLEACH (Decay)	
			Steady-State Concentration at Water Table (µg/L)	Time to Exceed Median MDL (yr)	Maximum Concentration at Water Table (µg/L)	Time to Exceed Median MDL (yr)
	RDX	*0.097*	**0.100**	~1	~0	--
	TNT	*0.108*	**0.436**	~5	~0	--
	Perchlorate	*0.06*	N/A	N/A	N/A	N/A
Stone Bay Area	HMX	*0.077*	**0.160**	~1	~0	--
	RDX	*0.097*	**232**	<1	**0.279**	<1
	TNT	*0.108*	**7.88**	<1	~0	--
	Perchlorate	*0.06*	**1.08**	<1	**1.08**	<1
Mobile MOUT Complex	HMX	*0.077*	NM	NM	NM	NM
	RDX	*0.097*	**0.259**	~1	~0	--
	TNT	*0.108*	NM	NM	NM	NM
	Perchlorate	*0.06*	**0.368**	~1	**0.368**	~1
SR-7	HMX	*0.077*	NM	NM	NM	NM
	RDX	*0.097*	**0.287**	~1	~0	--
	TNT	*0.108*	NM	NM	NM	NM
	Perchlorate	*0.06*	NM	NM	NM	NM
Devil Dog	HMX	*0.077*	N/A	N/A	N/A	N/A
	RDX	*0.097*	NM	NM	NM	NM
	TNT	*0.108*	NM	NM	NM	NM
	Perchlorate	*0.06*	**0.151**	~1	**0.1151**	~1
MAC-3	HMX	*0.077*	N/A	N/A	N/A	N/A
	RDX	*0.097*	**0.416**	~1	~0	--
	TNT	*0.108*	**0.267**	~10	~0	--
	Perchlorate	*0.06*	NM	NM	NM	NM

Note:
N/A = not modeled, as the MC loading was estimated to be negligible
NM = not modeled because MC was eliminated for further assessment based on the first step of the groundwater screening assessment
yr = years
-- denotes that the MC degrade before reaching the water table.
Bold indicates concentration exceeds the median MDL and is carried forward in modeling.

Based on the vadose zone results, saturated zone modeling was conducted for RDX at three MC loading areas and for perchlorate at 12 MC loading areas to estimate the MC concentrations potentially discharging to the nearest stream from each MC loading area. Model-predicted RDX and perchlorate concentrations potentially discharging from groundwater to the nearest surface water stream up gradient of identified surface water receptor locations are presented in **Table 3**. Bolded values were incorporated into the surface water assessment.

The assessment predicted that RDX and perchlorate concentrations exceed their median MDLs in shallow groundwater reaching the nearest surface water stream located up gradient of identified surface water receptors from 1 of the 3 MC loading areas modeled for RDX and all 12 MC loading areas modeled for perchlorate. These results (identified in the table in bold) were factored into the surface water screening-level assessment for calculating MC concentrations at receptor locations down gradient of the MC loading areas. These results are presented in Technical Memorandum: Screening-Level Assessment of Munitions Constituent (MC) Concentrations in Surface Water and Sediment from MC Loading Areas at Marine Corps Installations Command East – Marine Corps Base Camp Lejeune, dated August 2014 (ARCADIS, 2014).

Table 3: MC Concentrations Reaching Nearest Perennial Stream Located Up Gradient of Identified Surface Water Receptor Locations

	HMX	RDX	TNT	Perchlorate
Median MDL (µg/L)	*0.077*	*0.097*	*0.108*	*0.06*
MC Loading Area	**Predicted Concentration at Nearest Perennial Stream (µg/L)**			
G-10A	NM	NM	NM	**0.771**
G-19 Ranges	NM	NM	NM	**0.139**
F-Ranges	N/A	NM	NM	**0.080**
K-510	N/A	NM	NM	**0.136**
L-5	NM	NM	NM	**0.381**
ETA-1	NM	NM	NM	**0.083**
ETA-3	NM	NM	NM	**0.398**
ETA-5/5A	NM	0.071 [a], ~0 [b]	NM	**0.066** [a,b]
EOD-2	NM	**0.197**	NM	NM
Combat Town	NM	NM	NM	**0.265**
Mobile MOUT Complex	NM	NM	NM	**0.304**
Devil Dog	N/A	NM	NM	**0.151**
Stone Bay Area	NM	~0	NM	**1.08**

Note:
N/A = not modeled, as the MC loading was estimated to be negligible
NM = not modeled because MC was eliminated for further assessment based on the first step of the groundwater screening assessment
[a] Within the subwatershed of New River between Town Creek and Stones Bay
[b] Within the subwatershed of New River between Stick Creek and Whitehurst Creek
Bold indicates concentration exceeds the median MDL that will be carried forward in the surface water modeling

Transport to the Castle Hayne aquifer was assessed for RDX and perchlorate at the MC loading areas where these MC were predicted to reach the water table above median MDLs (from **Table**

2). Results of the MC concentrations estimated to potentially reach the Castle Hayne aquifer are presented in **Table 4**.

Concentrations of RDX at 1 of the 3 MC loading areas assessed for RDX and perchlorate at 8 of the 12 MC loading areas assessed for perchlorate were estimated to potentially reach the Castle Hayne aquifer above their median MDLs. These values are shown in bold text in **Table 4**. As a result, RDX at the one MC loading area and perchlorate at the eight MC loading areas were modeled for movement through the Castle Hayne aquifer to drinking water supply wells.

Table 4: Estimated MC Concentrations Reaching the Castle Hayne aquifer

	HMX	**RDX**	**TNT**	**Perchlorate**
Median MDL (µg/L)	*0.077*	*0.097*	*0.108*	*0.06*
MC Loading Area	**Predicted Concentration at Nearest Perennial Stream (µg/L)**			
G-10A	NM	NM	NM	**0.313**
G-19 Ranges	NM	NM	NM	**0.141**
F-Ranges	N/A	NM	NM	0.051
K-510	N/A	NM	NM	**0.120**
L-5	NM	NM	NM	**0.378**
ETA-1	NM	NM	NM	0.004
ETA-3	NM	NM	NM	**0.369**
ETA-5/5A	NM	0.038	NM	0.020
EOD-2	NM	**0.155**	NM	NM
Combat Town	NM	NM	NM	**0.242**
Mobile MOUT Complex	NM	NM	NM	**0.344**
Devil Dog	N/A	NM	NM	0.026
Stone Bay Area	NM	0.016	NM	**0.060**

Note:
N/A = not modeled, as MC loading was estimated to be negligible
NM = not modeled because MC was eliminated for further assessment based on the first step of the groundwater screening assessment
Bold indicates concentration exceeds the median MDL and carried forward in modeling

Table 5 presents MC concentrations predicted by the model to potentially reach the nearest drinking water supply wells from the MC loading areas modeled. These results are summarized as follows.

- BIOCHLOR predicted the RDX concentration potentially reaching the closest water supply well from the EOD-2 MC loading area to be below the median MDL.
- Perchlorate was predicted to potentially reach the nearest water supply wells from seven MC loading areas at a concentration above the median MDL (at detectable concentrations), as identified in pink highlighting in **Table 5**.

Table 5: Model-Predicted MC Concentrations Potentially Reaching Groundwater receptors

	HMX	RDX	TNT	Perchlorate	Well ID Where MC Exceeds Median MDL
Median MDL (µg/L)	*0.077*	*0.097*	*0.108*	*0.06*	
MC Loading Area	**Predicted Concentration at Nearest Perennial Stream (µg/L)**				
G-10A	NM	NM	NM	**0.161**	ST27
G-19 Ranges	NM	NM	NM	**0.141**	640
K-510	N/A	NM	NM	**0.100**	VL317
L-5	NM	NM	NM	**0.340**	Unknown[a]
ETA-3	NM	NM	NM	**0.200**	652
EOD-2	NM	~0	NM	NM	None
Combat Town	NM	NM	NM	**0.185**	596
Mobile MOUT Complex	NM	NM	NM	**0.344**	SCR101
Stone Bay Area	NM	NM	NM	0.0321	None

Note:
N/A = not modeled, as MC loading was estimated to be negligible
NM = not modeled because MC was eliminated for further assessment based on the previous step of the groundwater screening assessment
[a] County well located off-installation. The well ID is unknown
Shading and bold indicates concentration exceeds the median MDL

CONCLUSIONS

The unsaturated and saturated zone modeling predicted RDX from 1 MC loading area and perchlorate from 12 MC loading areas to potentially migrate through the surficial aquifer and discharge to perennial streams up gradient of surface water receptor locations at detectable concentrations. Based on these results, the RDX and perchlorate contributions from groundwater were used as one of several input sources for the surface water screening-level assessment, which evaluated MC concentrations in down gradient surface water receptor locations. This evaluation is discussed in the Technical Memorandum: Screening-Level Assessment of MC Concentrations in Surface Water and Sediment from MC Loading Areas at Marine Corps Installations Command East – Marine Corps Base Camp Lejeune (ARCADIS, 2014).

The unsaturated and saturated zone modeling predicted perchlorate from seven MC loading areas to potentially migrate down to the Castle Hayne aquifer and further transport to water supply wells at detectable concentrations and within a very short time window (less than 1 year). Based on these modeling results, additional assessment, such as sampling, is recommended for the supply wells nearest to the G-10A, G-19 Ranges, K-501, ETA-3, Combat Town, and Mobile MOUT Complex MC loading areas. The supply well nearest to the L-5 MC loading area is an off-installation county well. This well will be difficult to access and sample because it is not operated by MCIEAST-MCB CAMLEJ. Instead, a monitoring well that was installed at the installation boundary south of L-5 as part of the REVA Five-Year Review can be sampled. The monitoring well is screened in the Castle Hayne aquifer and is located between L-5 MC loading area and the off-installation county supply wells. Thus, MC transported from the L-5 MC loading area would potentially reach the monitoring well at a higher concentration than the off-installation county wells located farther away from the L-5 MC loading area.

Table 6: Modeled Groundwater Receptor Locations and Proposed Sampling Locations

	Predicted Perchlorate Concentration	**Proposed Sampling Location Well ID**
Median MDL (µg/L)	*0.06*	
MC Loading Area		
G-10A	**0.161**	NPSW-2
G-19 Ranges	**0.141**	PSW-2
K-510	**0.100**	NPSW-1
L-5	**0.340**	MW-01
ETA-3	**0.200**	PSW-6
Combat Town	**0.185**	PSW-1
Mobile MOUT Complex	**0.344**	NPSW-4

Note: PSW = Public Supply Well
NPSW = Non-Potable Supply Well

Table 7 details the identification process of the proposed sampling locations. Small arms ranges were qualitatively evaluated, and preliminary results do not indicate groundwater impacts; therefore, no wells were identified for sampling based on this evaluation.

Table 7: Proposed Groundwater Sampling Locations at MCIEAST-MCB CAMLEJ

Proposed Sample Well ID	Identification Method	Constituents for Analysis
NPSW-2	Modeling	Perchlorate
PSW-2	Modeling	Perchlorate
NPSW-1	Modeling	Perchlorate
MW-01	Modeling	Perchlorate
PSW-6	Modeling, Annual Monitoring	Perchlorate, Total and Dissolved Lead, Hardness
PSW-1	Modeling	Perchlorate
NPSW-4	Modeling	Perchlorate
MW-01	Modeling	Perchlorate
PSW-3	Annual Monitoring	Total and Dissolved Lead, Hardness

MW-03	Annual Monitoring	Total and Dissolved Lead, Perchlorate, Hardness
MW-04	Annual Monitoring	Total and Dissolved Lead, Hardness
MW-05	Annual Monitoring	Explosives
MW-02	Annual Monitoring	Perchlorate

REFERENCES

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Marine Corps Installations East – Marine Corps Base Camp Lejeune. 2014a. Measured Water Level Data at Supply Wells in 2013.

------. 2014b. Environmental and Range Control Offices GIS files.

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Additional Tables

Groundwater Screening-Level Assessment

Tables C-9 through C-12: Modeling Parameters

Table C-9: Groundwater Modeling Parameters - Vadose Zone Properties for MC Loading Areas

VLEACH Parameters	MC Loading Areas																																
1) Polygon Data																																	
Parameter	**G-10 Impact**	**G-10A**	**G-7**	**G-19 Ranges**	**F-Ranges**	**F-6**	**K-2 Impact Area**	**K-500**	**K-500A**	**K-504A/B**	**K-505**	**K-510**	**K-407**	**L-5**	**ETA-1**	**ETA-2**	**ETA-3**	**ETA-4**	**ETA-5/5A**	**ETA-7/7C**	**ETA-9**	**ETA-10**	**Combat Town**	**EOD-1**	**EOD-2**	**EOD-3**	**Mobile MOUT Complex**	**SR-7**	**Devil Dog**	**MAC-3**	**Stone Bay Area**	**Rationale**	**Reference(s)**
Area ($feet^2$)	4.25E+07	1.82E+04	4.08E+06	5.52E+05	5.41E+06	4.01E+05	2.31E+07	5.58E+06	3.56E+05	4.63E+05	3.66E+05	9.43E+05	1.22E+05	3.71E+06	1.33E+06	2.66E+06	8.34E+04	6.35E+05	4.42E+05	1.09E+06	3.45E+05	3.17E+05	2.83E+05	9.08E+05	2.93E+05	6.77E+05	1.30E+06	2.94E+07	9.43E+04	4.25E+04	5.58E+04		
Vertical Cell Dimension (feet)	0.8	0.8	0.2	0.8	0.9	0.9	0.5	0.5	0.5	0.5	0.5	0.4	0.5	0.2	0.2	1.4	1	0.8	0.2	0.4	0.4	0.4	0.8	1	0.1	0.4	1.1	0.9	0.9	1.1	0.2		
Number of Cells (-)	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10		
Height of Polygon (feet)	8	8	2	8	9	9	5	5	5	5	5	4	5	2	2	14	10	8	2	4	4	4	8	10	1	4	11	9	9	11	2	Equivalent to the estimated average depth to water table at loading area based on meassured water levels near the loading areas	Baker Environmental, 1996 & 1997; CH2M Hill, et al., 2001; O'Brien & Gere, 1988; CH2M Hill, 2010; Harden et al., 2004
2) Soil Parameter																																	
Parameter	**G-10 Impact**	**G-10A**	**G-7**	**G-19 Ranges**	**F-Ranges**	**F-6**	**K-2 Impact Area**	**K-500**	**K-500A**	**K-504A/B**	**K-505**	**K-510**	**K-407**	**L-5**	**ETA-1**	**ETA-2**	**ETA-3**	**ETA-4**	**ETA-5/5A**	**ETA-7/7C**	**ETA-9**	**ETA-10**	**Combat Town**	**EOD-1**	**EOD-2**	**EOD-3**	**Mobile MOUT Complex**	**SR-7**	**Devil Dog**	**MAC-3**	**Stone Bay Area**		
Dry Bulk Density (g/cm^2)	1.6	1.7	1.58	1.5	1.6	1.7	1.65	1.65	1.48	1.47	1.53	1.45	1.53	1.65	1.45	1.45	1.68	1.7	1.6	1.5	1.45	1.53	1.7	1.7	1.45	1.45	1.6	1.5	1.47	1.45	1.6	Installation spatial data and soil survey	MCIEAST-MCB CAMLEJ, 2014; USDA SCS, 1992
Effective Porosity (-)	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	Estimated based on the vadose zone material	McWhorter and Sundada, 1977
Volumetric Water Content (-)	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	Estimated field capacity value	Fetter, 1994
Soil Organic Carbon Content (-)	0.00800	0.00290	0.00480	0.01300	0.00870	0.00290	0.00580	0.00580	0.00680	0.00820	0.00730	0.00290	0.00580	0.00370	0.00290	0.00580	0.01200	0.00290	0.00440	0.01600	0.00580	0.00580	0.00290	0.00290	0.00290	0.00580	0.00440	0.01500	0.00820	0.00580	0.00440	Estimated from soil organic content obtained from soil survey	MCIEAST-MCB CAMLEJ, 2014; USDA SCS, 1992
3) Boundary Condition																																	
Parameter	**G-10 Impact**	**G-10A**	**G-7**	**G-19 Ranges**	**F-Ranges**	**F-6**	**K-2 Impact Area**	**K-500**	**K-500A**	**K-504A/B**	**K-505**	**K-510**	**K-407**	**L-5**	**ETA-1**	**ETA-2**	**ETA-3**	**ETA-4**	**ETA-5/5A**	**ETA-7/7C**	**ETA-9**	**ETA-10**	**Combat Town**	**EOD-1**	**EOD-2**	**EOD-3**	**Mobile MOUT Complex**	**SR-7**	**Devil Dog**	**MAC-3**	**Stone Bay Area**		
Recharge Rate (feet/year)	1.18	1.18	1.09	1.09	1.18	1.18	1.09	1.18	1.09	1.09	1.18	1.09	0.69	1.18	1.09	1.18	1.27	1.18	1.09	1.18	1.09	1.18	1.18	1.18	1.27	1.09	1.09	1.18	1.18	0.69	1.09	Estimated based on slop, land cover and soil type from a range of values obtained from a study specific to Coastal Plain areas of North Carolina near MCIEAST-MCB CAMLEJ	MCIEAST-MCB CAMLEJ, 2014; Heath, 1989
Concentration of HMX in Recharge Water (µg/L)	0.457	0.963	N/A	1.836	N/A	N/A	N/A	BMMDL	BMMDL	N/A	0.773	N/A	0.779	BMMDL	BMMDL	N/A	BMMDL	BMMDL	BMMDL	BMMDL	BMMDL	N/A	BMMDL	BMMDL	0.372	BMMDL	BMMDL	BMMDL	0.000	0.000	0.160	Results from the initial groundwater screening analysis	
Concentration of RDX in Recharge Water (µg/L)	31.182	280.650	4.136	47.932	BMMDL	23.725	0.197	16.175	241.615	66.047	28.463	83.524	BMMDL	BMMDL	7.814	2.182	930.187	50.713	137.350	79.246	51.180	0.100	0.099	3.055	16.447	10.147	0.259	0.287	BMMDL	0.416	231.637	Results from the initial groundwater screening analysis	
Concentration of TNT in Recharge Water (µg/L)	246.113	504.153	5.345	4.043	BMMDL	15.190	1.225	7.848	BMMDL	BMMDL	10.722	53.639	BMMDL	BMMDL	16.028	0.980	778.547	35.247	27.903	55.643	55.892	0.436	BMMDL	3.225	11.891	11.931	BMMDL	BMMDL	BMMDL	0.267	7.881	Results from the initial groundwater screening analysis	
Concentration of Perchlorate in Recharge Water (µg/L)	BMMDL	1.210	BMMDL	0.341	0.080	BMMDL	N/A	BMMDL	BMMDL	BMMDL	BMMDL	0.136	N/A	0.381	0.083	BMMDL	0.400	BMMDL	0.066	BMMDL	BMMDL	N/A	0.265	BMMDL	BMMDL	BMMDL	0.368	BMMDL	0.151	BMMDL	1.079	Results from the initial groundwater screening analysis	
Upper Boundary Vapor Condition (µg/L)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
Lower Boundary Vapor Condition (µg/L)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
Upper Cell Number (-)	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		
Lower Cell Number (-)	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10		
Initial Contaminant Concentration in Cells (µg/Kg)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		

Note:

BMMDL = concentration was estimated to be blow the median MDL in the initial screening assessment

N/A = not modeled, as the MC loading was estimated to be negligible

Table C-10: Chemical Properties of MC used in the VLEACH Vadose zone Model

CHEMICAL PARAMETER	HMX	RDX	TNT	PERCHLORATE	Rationale/Referece	Reference(s)
Organic Carbon Distribution Coefficient (mL/g)	3.47	7.76	525	6.91E-07	HQMC, 2009. Value for perchlorate is a conservative assumption	HQMC, 2009
Henry's Constant (-)	1.10357E-13	5.04E-04	4.61569E-07	7.95012E-11	equivalent to the Henry's constant divided by the ideal gas constant multiplied by the ambient temperature. Value for perchorate is a conservative assumption	HQMC, 2009
Water Solubility (mg/L)	5	42.2	130	200000	Walsh et al., 1995	Walsh et al., 1995
Free Air Diffusion Coefficient (m^2/day)	0.544	0.639	0.553	7.00E-10	HQMC, 2009. Value for perchlorate is estimated from the CalTOX model based on the chemical's vapor pressure and solubility	HQMC, 2009
Molecular Weight (g/mol)	296.2	222.1	227.1	99.45		

Table C-11: Aquifer and Chemical Parameters Used in BIOCHLOR

Parameters	Surficial Aquifer	Castle Hayne Aquifer	Rationale/Reference
Hydraulic conductivity (ft/d)	5	75	Baker Environmental, 1998
Effective porosity	0.2	0.14	McWhorter and Sunada, 1977
Longitudinal dispersion (ft)	3	3	Assumption
Ratio of transverse to longitudinal dispersion	0.1	0.1	Assumption
Ratio of vertical to longitudinal dispersion	1.00E-99	1.00E-99	Assumption
Soil bulk density (kg/L)	1.99	1.99	Fetter, 1994
Organic carbon fraction	0.0029	0.0029	Estimated based on surface soil organic content (USDA SCS, 1992)
Decay constant for HMX (yr^{-1})	4.93	4.93	HQMC, 2009
Decay constant for RDX (yr^{-1})	17.82	17.82	HQMC, 2009
Decay constant for TNT (yr^{-1})	10.95	10.95	HQMC, 2009
Decay constant for perchlorate (yr^{-1})	2.53E-05	2.53E-05	HQMC, 2009

Table C-12: BIOCHLOR Input parameters

MC Loading Area	G-10 A	G-19 Ranges	F-Ranges	K-510	L-5	ETA-1	ETA-3	ETA-5/5A	Combat Town	EOD-2	Mobile MOUT Complex	Devil Dog	Stone Bay Area	Rationale/Reference
Modeled area width (ft)	75	148	541	131	246	112	72	213	112	249	180	295	118	Width of the MC loading area perpendicular to groundwater flow direction
1) Surficial Aquifer														
Distance to nearest surface water receptor location (ft)	2821	1364	141	459	0	2	1719	72[a], 367[b]	623	0	7154	1115	328	Estimated from spatial data (MCIEAST-MCB CAMLEJ, 2014)
Hydraulic gradient	0.006	0.004	0.050	0.026	NM	5	0.001	0.236[a], 0.057[b]	0.002	NM	0.004	0.006	0.070	Estimated groundwater elevations at loading areas and known elevations at surface waters, groundwater discharge points
2) Castle Hayne Aquifer														
Distance to nearest drinking water well (ft)	4690	846	0	3657	9118	3116	4051	1525	3693	820	0	4264	10857	Spatial data (MCIEAST-MCB CAMLEJ, 2014)
Hydraulic gradient	6.40E-05	2.36E-03	BMMDL	2.73E-04	2.74E-03	6.42E-04	1.23E-04	1.31E-04	1.35E-04	1.22E-03	BMMDL	9.38E-04	1.20E-03	Estimated from the potentiometric surface map for the Castle Hayne aquifer

Notes:

[a] Surface water discharge point withint the subwatershed of New River between Town Creek and Stones Bay

[b] Surface water discharge point withint the subwatershed of New River between Stick Creek and whitehurst Creek

BMMDL = MC concentrations potentially reaching the Castle Hayne aquifer were estimated to be below median MDLs

NM = not modeled for transport through the saturated zone within the surficial aquifer because concentration reaching the water table was conservaively assumed to reach the nearest stream

Appendix D

Small Arms Range Assessments

Alpha, Bravo, Charlie Ranges
MCIEAST - MCB Camp Lejeune
Jacksonville, North Carolina

Date of SARAP update: 11/19/2014

DESCRIPTION

Range Mission:	Rifle Marksmanship Training
Training Start Date:	Mid 1980s
Direction of Fire:	North
Firing Positions:	150 (50 each)
Target Range:	25 yards – 600 yards
Impact Area(s):	☒ Open area ☐ Hillside ☐ Building ☐ Earthen berm ☐ Bullet trap
Existing BMPs:	☐ Basin/vault ☐ Control fabric ☐ Diversion ☐ Fencing ☐ Rip-rap ☐ Silt check ☐ Vegetation
	Other:
Reference(s):	

FINDINGS

Review Period		Periodic Review
Estimated Lead Deposition (lb/yr)		45,855
Surface Water / Sediment	***RANK***	Moderate
	Source	17
	Pathway	15
	Receptor	12
	TOTAL SCORE	44
Groundwater	***RANK***	Moderate
	Source	17
	Pathway	16
	Receptor	3
	TOTAL SCORE	36

RECOMMENDATIONS

☒ Periodically review operations for significant changes in training, management, and use.

☐ Gather additional data regarding ☐ range use, ☐ pathways, or ☐ receptors associated with the range: ______________________________

☒ Collect site-specific field data to further assess potential off-range migration.

Alpha, Bravo, Charlie Ranges
MCIEAST - MCB Camp Lejeune

Table 1: Range Use and Range Management (*Source)* Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
MC Loading Rates	*The amount of small arms ammunition expended on the range.* *Estimate the MC loading as average lead deposition rate.*	14 if MC loading > 8,000 pounds/year 11 if MC loading = 4,001-8,000 pounds/year 8 if MC loading = 2,001-4,000 pounds/year 5 if MC loading = 501-2,000 pounds/year 2 if MC loading < 501 pounds/year	14
Impact Area	*The bullet deposition scenario at the range.*	4 if projectiles are scattered in SDZ 3 if range has an impact berm 1 if range has a bullet trap	4
Lead Management	*Frequency of activities that result in the removal of lead from an EARTHERN BERM or SDZ.* *This includes MINOR removal (e.g. scraping and sifting of berm/area, soil amendments) as well as MAJOR removals (e.g. lead mining).*	0 if no notable mining -1 if a MINOR action completed once during either of the last two periodic reviews -2 if MINOR action completed during each of the two previous periodic reviews -3 if MAJOR action was completed once during either of the last two periodic reviews -4 if MAJOR action completed during each of the two previous periodic reviews	-3
	Frequency of activities that result in the significant removal of lead from a BULLET TRAP.	-3 if bullet trap was not been serviced during last two periodic reviews -5 if bullet trap was serviced once during either of the last two periodic reviews -7 if bullet trap was serviced during each of the last two periodic reviews	
Duration of Range Use	*Length of time the range has been used.*	2 if > 5 years 0 if ≤ 5 years	2
Source Element Score *Minimum: -4 Maximum: 20*			17
<u>Notes:</u> Annual lead deposition – 45,855 pounds/year. These ranges have been in use since the mid-1980s. Portions of the ranges were cleared, sifted, and landscaped between 2010-2011.			

Alpha, Bravo, Charlie Ranges
MCIEAST - MCB Camp Lejeune

Table 2: Surface Water / Sediment Pathways Characteristics Element
(These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)

Criteria	Evaluation Characteristics	Score Criteria	Site Score
Precipitation	*Rate of precipitation.*	8 if precipitation > 40 inches/year 6 if precipitation = 20-40 inches/year 4 if precipitation < 20 inches/year	8
Vegetation	*Approximate vegetation cover* ***within and directly downslope of the projectile deposition area.***	6 if vegetation cover < 10% 4 if vegetation cover = 10% to 90% 2 if vegetation cover > 90%	2
Slope of Range	*Average slope* ***from deposition area along the overland pathway to the first defined channel.***	5 if slope > 10% (5.71°) 3 if slope = 5% to 10% 2 if slope < 5% (2.86°)	2
pH of Soil	*pH below 6.5 and above 8.5 increases the rate of lead dissolution.*	3 if pH < 4 or >10 2 if pH ≥ 4 < 6.5 or > 8.5 ≤ 10 1 if pH 6.5 ≤ pH ≤ 8.5	2
Soil Type/ Erosion	*Erosion potential is greatest for fine sands and silt. Clay has the lowest erosion potential.* ***The area where projectiles are deposited should be scored.***	2 if soil type is fine sand / silt 1 if soil type is clayey sand or silt / coarse sands 0 if soil type is clay	2
	Erosion observed at the projectile deposition area.	5 if there is visual evidence of eroded material being transported from the projectile deposition area 3 if bullet pockets or other indicators of erosion were observed 1 if no erosion was observed	1
Engineering Controls	*The presence of engineering controls or BMPs to modify or control* ***surface water run-on.*** *Controls may include barriers or diversions that reduce run-on to the range.*	0 if no engineering controls -1 if partial engineering controls -2 if effective engineering controls	0

Alpha, Bravo, Charlie Ranges
MCIEAST - MCB Camp Lejeune

Table 2: Surface Water / Sediment Pathways Characteristics Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
	*The presence of engineering controls or BMPs to modify or control **surface water run-off or erosion.*** *Run-off controls may include silt fencing, rip-rap, sedimentation basins, or detention ponds that control run-off from the range. Erosion controls may include soil mix, irrigation, or netting.*	0 if no engineering controls -2 if partial engineering controls -4 if effective engineering controls	-2
Surface Water Pathway Score	*Minimum: 4*	*Maximum: 29*	15

Notes:

Jacksonville, NC averages 56" of rainfall per year (MCB Camp Lejeune, 2006).

The footprints of all three ranges are covered in vegetation.

The deposition area appears to drain to the north towards Stones Bay with a slope of approximately 4.1%.

The primary soil type located at the ranges is the Baymeade and/or Goldsboro series, both of which are mostly sand and have a pH between 4.5 and 6 (USDA, 1992).

Partial engineering controls consisting of vegetated perimeter berms that separate the ranges and help to control surface water run-off.

Alpha, Bravo, Charlie Ranges
MCIEAST - MCB Camp Lejeune

Table 3: Groundwater Pathways Characteristics Element
(These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)

Criteria	Evaluation Characteristics	Score Criteria	Site Score
Precipitation	*Intensity and frequency of precipitation.*	3 if precipitation > 40 inches/year 2 if precipitation = 20-40 inches/year 1 if precipitation < 20 inches/year	3
Depth to Groundwater	*The potential for impact to the groundwater decreases with an increasing depth to the water table.*	6 if depth to groundwater < 3 feet 3 if depth to groundwater = 3-20 feet 1 if depth to groundwater = 20-100 feet 0 if in a groundwater discharge area or depth to groundwater > 100 feet	6
Soil Type / Infiltration Conditions	*Soil with a higher porosity (sands/gravels) has more infiltration and less runoff compared to soil with low porosity (silts/clays).* ***Most hydraulically restrictive infiltration horizon between the surface and groundwater is scored.***	6 if soil type is sand / gravel 3 if soil type is sand and silt 1 if soil type is clay / clayey sand/silt	3
	Vegetation impedes infiltration and groundwater recharge.	6 if vegetation cover < 10% 3 if vegetation cover = 10% to 90% 1 if vegetation cover > 90%	1
	Average slope from deposition area along the overland pathway to the first defined channel.	3 if slope < 2% (1.15°) 1 if slope = 2% to 20% 0 if slope > 20% (11.31°)	1
pH of Soil	*Lead tends to stay dissolved at pH conditions less than 6.5 and greater than 8.5 but tends to attach to soil particles at pH conditions between these levels.*	3 if pH < 4 or >10 2 if pH ≥ 4 < 6.5 or > 8.5 ≤ 10 1 if pH 6.5 ≤ pH ≤ 8.5	2
Groundwater Pathway Score *Minimum: 4 Maximum: 27*			16

Notes:

Jacksonville, NC averages 56” of rainfall per year (MCB Camp Lejeune, 2006).

Based on measurements collected in the vicinity of these ranges, the depth to groundwater in this area ranges from 0.3 to 3.3 feet below ground surface.

Alpha, Bravo, Charlie Ranges
MCIEAST - MCB Camp Lejeune

Table 3: Groundwater Pathways Characteristics Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
The primary soil type located at the ranges is the Baymeade and/or Goldsboro series, both of which are mostly sand or fine sandy loam and have a pH between 4.5 and 6 (USDA, 1992). The footprints of all three ranges are covered in vegetation. The deposition area appears to drain to the north towards Stones Bay with a slope of approximately 4.1%.			

Alpha, Bravo, Charlie Ranges
MCIEAST - MCB Camp Lejeune

Table 4: Surface Water / Sediment Receptors Element
(These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)

Criteria	Evaluation Characteristics	Score Criteria	Site Score
Surface Water Body	*Identify if a nearby surface water body is present down gradient,* ***as defined on the National Hydrography Dataset (NHD) map****.*	8 if surface water body is located downgradient of the range within 1,500 feet 4 if surface water body is located downgradient of the range 1,500-5,000 feet 0 if surface water body is located downgradient of the range over 5,000 feet	8
Drinking Water Use	*Identify if a down gradient surface water body is used as a drinking water source (drainage distance).*	4 if surface water body used as a drinking water source is located downgradient of the range within 1 mile 2 if surface water body used as a drinking water source is located downgradient of the range within 1 to 6 miles 0 if no known drinking water intakes are identified within 6 miles of the range	0
Drainage Distance to Installation Boundary	*Identify downgradient drainage distance to first potential ecological exposure off installation (i.e., installation boundary).*	4 if the installation boundary is located downgradient of the range within 0.5 miles 2 if the installation boundary is located downgradient of the range within 0.5 to 3 miles 0 if the installation boundary is located downgradient of the range greater than 3 miles, or if surface water runoff from the range does not discharge off the installation	4
Surface Water Receptor Score *Minimum: 0 Maximum: 16*			12

Notes:

According to the USGS National Hydrography Map, there is one perennial stream on Charlie Range and two perennial streams immediately bordering these three ranges to the north and south. Two of these streams flow directly east towards Stones Bay and the stream to the north of the ranges flows north towards Stones Bay.

Drinking water is obtained from water supply wells throughout the installation. Surface water is not used as a drinking water source at the installation, nor are there any surface water bodies used as drinking water sources within 6 miles of these ranges.

Surface water from these three ranges generally flows north and east to Stones Bay. Following the perennial stream that flows directly east towards Stones Bay, the surface water drainage pathway reaches the installation boundary in approximately 0.2 miles.

Alpha, Bravo, Charlie Ranges
MCIEAST - MCB Camp Lejeune

<table>
<tr><th colspan="4">Table 5: Groundwater Receptors Element
(These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)</th></tr>
<tr><th>Criteria</th><th>Evaluation Characteristics</th><th>Score Criteria</th><th>Site Score</th></tr>
<tr><td rowspan="2">Wells Identified as Potable Water Sources</td><td>Number and location of potable water or potable water supply wells relative to the location of the range.</td><td>6 if a drinking water well is located within <50 feet of the range
3 if a drinking water well is located downgradient of the range within 50-1,500 feet
0 if there are no drinking water wells located within 1,500 feet downgradient of the range or if groundwater is not used as a drinking water source.</td><td>0</td></tr>
<tr><td>Into what type of aquifer is the well set</td><td>6 if unconfined
3 if semi-confined
0 if confined</td><td>3</td></tr>
<tr><td>Groundwater wells identified for purpose other than drinking water</td><td>Groundwater wells used for purposes other than drinking water supply identified down gradient of the range.</td><td>3 if a groundwater well is located within 50 feet of the range
1 if a groundwater well is located downgradient of the range within 50-1,500 feet
0 if groundwater well <1,500 feet downgradient of the range is not used for any purpose.</td><td>0</td></tr>
<tr><td colspan="3">Groundwater Receptor Score Minimum: 0 Maximum: 15</td><td>3</td></tr>
<tr><td colspan="4"><u>Notes:</u>
The closest well to these ranges is an off-installation county well located over 12,000 feet away.</td></tr>
</table>

Alpha, Bravo, Charlie Ranges
MCIEAST - MCB Camp Lejeune

Table 6: Evaluation Score
(These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)

Surface Water / Sediment		
Element	**Table**	**Score**
Range Use and Range Management (Source)	1	17
Surface Water / Sediment Pathways	2	15
Surface Water / Sediment Receptors	4	12
Sum of Surface Water / Sediment Element Scores *Minimum: 0 Maximum: 65*		**44**
Groundwater		
Element	**Table**	**Score**
Range Use and Range Management (Source)	1	17
Groundwater Pathways	3	16
Groundwater Receptors	5	3
Sum of Groundwater Element Scores *Minimum: 0 Maximum: 62*		**36**

Field Sampling and Observed Releases

Surface Water / Sediment	Surface water sampling conducted Yes ☒ No ☐ Sediment sampling conducted Yes ☐ No ☒ Results exceed DoD screening value Yes ☐ No ☒	**Surface Water / Sediment** ☒ No Modification ☐ High
Groundwater	Groundwater sampling conducted Yes ☐ No ☒ Results exceed DoD screening value Yes ☐ No ☐	**Groundwater** ☒ No Modification ☐ High

The relative evaluation ranking for each media is determined by selecting the appropriate score based on the data elements for that media:

Evaluation Ranking*	Score Range
High	45-65
Moderate	33-44
Minimal	0-32

Surface Water Evaluation Ranking	**Moderate**
Groundwater Evaluation Ranking	**Moderate**

Notes: An upper and lower interval surface water sample was collected in Stones Bay and analyzed for total and dissolved lead. Total lead was detected at 0.44 µg/L and 0.40 µg/L in the upper and lower intervals, respectively. Dissolved lead was detected only in the lower interval sample at a concentration of 2.5 µg/L. Results were below screening criteria.

D-30
MCIEAST - MCB Camp Lejeune
Jacksonville, North Carolina

Date of SARAP update: 11/19/2014

DESCRIPTION

Range Mission:	Pistol Qualification/Requalification Range
Training Start Date:	1958
Direction of Fire:	Southwest
Firing Positions:	32
Target Range:	7, 15, and 25 meters
Impact Area(s):	☐ Open area ☐ Hillside ☐ Building ☒ Earthen berm ☐ Bullet trap
Existing BMPs:	☐ Basin/vault ☐ Control fabric ☐ Diversion ☐ Fencing ☐ Rip-rap ☐ Silt check ☒ Vegetation
	Other:
Reference(s):	

FINDINGS

Review Period		**Periodic Review**
Estimated Lead Deposition (lb/yr)		3,016
Surface Water / Sediment	***RANK***	Moderate
	Source	13
	Pathway	16
	Receptor	12
	TOTAL SCORE	41
Groundwater	***RANK***	NA
	Source	---
	Pathway	---
	Receptor	---
	TOTAL SCORE	NA

RECOMMENDATIONS

☒ Periodically review operations for significant changes in training, management, and use.

☐ Gather additional data regarding ☐ range use, ☐ pathways, or ☐ receptors associated with the range: ____________________

☐ Collect site-specific field data to further assess potential off-range migration.

D-30
MCIEAST - MCB Camp Lejeune

Table 1: Range Use and Range Management (*Source)* Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
MC Loading Rates	*The amount of small arms ammunition expended on the range.* *Estimate the MC loading as average lead deposition rate.*	14 if MC loading > 8,000 pounds/year 11 if MC loading = 4,001-8,000 pounds/year 8 if MC loading = 2,001-4,000 pounds/year 5 if MC loading = 501-2,000 pounds/year 2 if MC loading < 501 pounds/year	8
Impact Area	*The bullet deposition scenario at the range.*	4 if projectiles are scattered in SDZ 3 if range has an impact berm 1 if range has a bullet trap	3
Lead Management	*Frequency of activities that result in the removal of lead from an EARTHERN BERM or SDZ.* *This includes MINOR removal (e.g. scraping and sifting of berm/area, soil amendments) as well as MAJOR removals (e.g. lead mining).*	0 if no notable mining -1 if a MINOR action completed once during either of the last two periodic reviews -2 if MINOR action completed during each of the two previous periodic reviews -3 if MAJOR action was completed once during either of the last two periodic reviews -4 if MAJOR action completed during each of the two previous periodic reviews	0
	Frequency of activities that result in the significant removal of lead from a BULLET TRAP.	-3 if bullet trap was not been serviced during last two periodic reviews -5 if bullet trap was serviced once during either of the last two periodic reviews -7 if bullet trap was serviced during each of the last two periodic reviews	
Duration of Range Use	*Length of time the range has been used.*	2 if > 5 years 0 if ≤ 5 years	2
Source Element Score *Minimum: -4 Maximum: 20*			13

<u>Notes:</u>

Annual lead deposition – 3,016 pounds/year.

This range has been in use since 1958.

D-30
MCIEAST - MCB Camp Lejeune

Table 2: Surface Water / Sediment Pathways Characteristics Element
(These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)

Criteria	Evaluation Characteristics	Score Criteria	Site Score
Precipitation	*Rate of precipitation.*	8 if precipitation > 40 inches/year 6 if precipitation = 20-40 inches/year 4 if precipitation < 20 inches/year	8
Vegetation	*Approximate vegetation cover **within and directly downslope of the projectile deposition area.***	6 if vegetation cover < 10% 4 if vegetation cover = 10% to 90% 2 if vegetation cover > 90%	4
Slope of Range	*Average slope **from deposition area along the overland pathway to the first defined channel.***	5 if slope > 10% (5.71°) 3 if slope = 5% to 10% 2 if slope < 5% (2.86°)	3
pH of Soil	*pH below 6.5 and above 8.5 increases the rate of lead dissolution.*	3 if pH < 4 or >10 2 if pH ≥ 4 < 6.5 or > 8.5 ≤ 10 1 if pH 6.5 ≤ pH ≤ 8.5	2
Soil Type/ Erosion	*Erosion potential is greatest for fine sands and silt. Clay has the lowest erosion potential. **The area where projectiles are deposited should be scored.***	2 if soil type is fine sand / silt 1 if soil type is clayey sand or silt / coarse sands 0 if soil type is clay	2
	Erosion observed at the projectile deposition area.	5 if there is visual evidence of eroded material being transported from the projectile deposition area 3 if bullet pockets or other indicators of erosion were observed 1 if no erosion was observed	1
Engineering Controls	*The presence of engineering controls or BMPs to modify or control **surface water run-on.*** *Controls may include barriers or diversions that reduce run-on to the range.*	0 if no engineering controls -1 if partial engineering controls -2 if effective engineering controls	-2

D-30
MCIEAST - MCB Camp Lejeune

Table 2: Surface Water / Sediment Pathways Characteristics Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
	*The presence of engineering controls or BMPs to modify or control **surface water run-off or erosion.*** *Run-off controls may include silt fencing, rip-rap, sedimentation basins, or detention ponds that control run-off from the range. Erosion controls may include soil mix, irrigation, or netting.*	0 if no engineering controls -2 if partial engineering controls -4 if effective engineering controls	-2
Surface Water Pathway Score *Minimum: 4 Maximum: 29*			16

<u>Notes:</u>

Jacksonville, NC averages 56” of rainfall per year (MCB Camp Lejeune, 2006).

The range has no vegetation and is a sand floor. The surrounding area is largely developed with interspersed plots of trees.

Immediately behind the impact berm of Range D-30 is the New River. The approximate slope from the berm to the river is approximately 6%.

The primary soil type at Range D-30 is the Baymeade series, which is mostly sand and has a pH between 3.6 to 6.5 (USDA, 1992).

Range D-30 is equipped with a baffled ceiling, side walls, and an earthen impact berm which help control surface water run-on and run-off.

D-30
MCIEAST - MCB Camp Lejeune

Table 3: Groundwater Pathways Characteristics Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
Precipitation	*Intensity and frequency of precipitation.*	3 if precipitation > 40 inches/year 2 if precipitation = 20-40 inches/year 1 if precipitation < 20 inches/year	N/A
Depth to Groundwater	*The potential for impact to the groundwater decreases with an increasing depth to the water table.*	6 if depth to groundwater < 3 feet 3 if depth to groundwater = 3-20 feet 1 if depth to groundwater = 20-100 feet 0 if in a groundwater discharge area or depth to groundwater > 100 feet	N/A
Soil Type / Infiltration Conditions	*Soil with a higher porosity (sands/gravels) has more infiltration and less runoff compared to soil with low porosity (silts/clays).* ***Most hydraulically restrictive infiltration horizon between the surface and groundwater is scored.***	6 if soil type is sand / gravel 3 if soil type is sand and silt 1 if soil type is clay / clayey sand/silt	N/A
	Vegetation impedes infiltration and groundwater recharge.	6 if vegetation cover < 10% 3 if vegetation cover = 10% to 90% 1 if vegetation cover > 90%	N/A
	Average slope from deposition area along the overland pathway to the first defined channel.	3 if slope < 2% (1.15°) 1 if slope = 2% to 20% 0 if slope > 20% (11.31°)	N/A
pH of Soil	*Lead tends to stay dissolved at pH conditions less than 6.5 and greater than 8.5 but tends to attach to soil particles at pH conditions between these levels.*	3 if pH < 4 or >10 2 if pH ≥ 4 < 6.5 or > 8.5 ≤ 10 1 if pH 6.5 ≤ pH ≤ 8.5	N/A
Groundwater Pathway Score *Minimum: 4* *Maximum: 27*			N/A
Notes: Based on screening evaluation, SARAP was not needed for groundwater.			

D-30
MCIEAST - MCB Camp Lejeune

Table 4: Surface Water / Sediment Receptors Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
Surface Water Body	*Identify if a nearby surface water body is present down gradient,* ***as defined on the National Hydrography Dataset (NHD) map****.*	8 if surface water body is located downgradient of the range within 1,500 feet 4 if surface water body is located downgradient of the range 1,500-5,000 feet 0 if surface water body is located downgradient of the range over 5,000 feet	8
Drinking Water Use	*Identify if a down gradient surface water body is used as a drinking water source (drainage distance).*	4 if surface water body used as a drinking water source is located downgradient of the range within 1 mile 2 if surface water body used as a drinking water source is located downgradient of the range within 1 to 6 miles 0 if no known drinking water intakes are identified within 6 miles of the range	0
Drainage Distance to Installation Boundary	*Identify downgradient drainage distance to first potential ecological exposure off installation (i.e., installation boundary).*	4 if the installation boundary is located downgradient of the range within 0.5 miles 2 if the installation boundary is located downgradient of the range within 0.5 to 3 miles 0 if the installation boundary is located downgradient of the range greater than 3 miles, or if surface water runoff from the range does not discharge off the installation	4
Surface Water Receptor Score *Minimum: 0 Maximum: 16*			12

Notes:

The closest surface water body to D-30 is Morgan Bay located downgradient approximately 90 feet to the southwest.

Drinking water is obtained from water supply wells throughout the installation. Surface water is not used as a drinking water source at the installation, nor are there any surface water bodies used as drinking water sources within 6 miles of this range.

Surface water from this range drains directly into Morgan Bay crossing the installation boundary approximately 90 feet from the range.

D-30
MCIEAST - MCB Camp Lejeune

Table 5: Groundwater Receptors Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
Wells Identified as Potable Water Sources	*Number and location of potable water or potable water supply wells relative to the location of the range.*	6 if a drinking water well is located within <50 feet of the range 3 if a drinking water well is located downgradient of the range within 50-1,500 feet 0 if there are no drinking water wells located within 1,500 feet downgradient of the range or if groundwater is not used as a drinking water source.	N/A
	*Into what **type of aquifer is the well set***	6 if unconfined 3 if semi-confined 0 if confined	N/A
Groundwater wells identified for purpose other than drinking water	*Groundwater wells used for purposes other than drinking water supply identified down gradient of the range.*	3 if a groundwater well is located within 50 feet of the range 1 if a groundwater well is located downgradient of the range within 50-1,500 feet 0 if groundwater well <1,500 feet downgradient of the range is not used for any purpose.	N/A
Groundwater Receptor Score *Minimum: 0* *Maximum: 15*			N/A
Notes: Based on screening evaluation, SARAP was not needed for groundwater.			

D-30
MCIEAST - MCB Camp Lejeune

Table 6: Evaluation Score (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Surface Water / Sediment			
Element		**Table**	**Score**
Range Use and Range Management (Source)		1	13
Surface Water / Sediment Pathways		2	16
Surface Water / Sediment Receptors		4	12
Sum of Surface Water / Sediment Element Scores *Minimum: 0 Maximum: 65*			**41**
Groundwater			
Element		**Table**	**Score**
Range Use and Range Management (Source)		1	NA
Groundwater Pathways		3	NA
Groundwater Receptors		5	NA
Sum of Groundwater Element Scores *Minimum: 0 Maximum: 62*			**NA**
Field Sampling and Observed Releases			
Surface Water / Sediment	Surface water sampling conducted Yes ☐ No ☒ Sediment sampling conducted Yes ☐ No ☒ Results exceed DoD screening value Yes ☐ No ☐		**Surface Water / Sediment** ☒ No Modification ☐ High
Groundwater	Groundwater sampling conducted Yes ☐ No ☒ Results exceed DoD screening value Yes ☐ No ☐		**Groundwater** ☒ No Modification ☐ High

The relative evaluation ranking for each media is determined by selecting the appropriate score based on the data elements for that media:

Evaluation Ranking*	Score Range
High	45-65
Moderate	33-44
Minimal	0-32

Surface Water Evaluation Ranking	**Moderate**
Groundwater Evaluation Ranking	**N/A**

Notes:

Based on screening evaluation indicating limited or no risk of groundwater receptor impacts, SARAP was not needed for groundwater.

Dodge City
MCIEAST - MCB Camp Lejeune
Jacksonville, North Carolina

Date of SARAP update: 11/19/2014

DESCRIPTION

Range Mission:	Basic Squad MOUT Range
Training Start Date:	1990
Direction of Fire:	Northwest
Firing Positions:	8 PITS Stations
Target Range:	Variable
Impact Area(s):	☒ Open area ☐ Hillside ☐ Building ☐ Earthen berm ☐ Bullet trap
Existing BMPs:	☐ Basin/vault ☐ Control fabric ☐ Diversion ☐ Fencing ☐ Rip-rap ☐ Silt check ☒ Vegetation *Other:*
Reference(s):	

FINDINGS

Review Period		**Periodic Review**
Estimated Lead Deposition (lb/yr)		1,478
Surface Water / Sediment	***RANK***	Moderate
	Source	11
	Pathway	17
	Receptor	12
	TOTAL SCORE	40
Groundwater	***RANK***	Moderate
	Source	11
	Pathway	18
	Receptor	3
	TOTAL SCORE	32

RECOMMENDATIONS

☒ Periodically review operations for significant changes in training, management, and use.

☐ Gather additional data regarding ☐ range use, ☐ pathways, or ☐ receptors associated with the range: ____________________

☐ Collect site-specific field data to further assess potential off-range migration.

Dodge City
MCIEAST - MCB Camp Lejeune

Table 1: Range Use and Range Management (*Source*) Element **(These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)**			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
MC Loading Rates	*The amount of small arms ammunition expended on the range.* *Estimate the MC loading as average lead deposition rate.*	14 if MC loading > 8,000 pounds/year 11 if MC loading = 4,001-8,000 pounds/year 8 if MC loading = 2,001-4,000 pounds/year 5 if MC loading = 501-2,000 pounds/year 2 if MC loading < 501 pounds/year	5
Impact Area	*The bullet deposition scenario at the range.*	4 if projectiles are scattered in SDZ 3 if range has an impact berm 1 if range has a bullet trap	4
Lead Management	*Frequency of activities that result in the removal of lead from an EARTHERN BERM or SDZ.* *This includes MINOR removal (e.g. scraping and sifting of berm/area, soil amendments) as well as MAJOR removals (e.g. lead mining).*	0 if no notable mining -1 if a MINOR action completed once during either of the last two periodic reviews -2 if MINOR action completed during each of the two previous periodic reviews -3 if MAJOR action was completed once during either of the last two periodic reviews -4 if MAJOR action completed during each of the two previous periodic reviews	0
	Frequency of activities that result in the significant removal of lead from a BULLET TRAP.	-3 if bullet trap was not been serviced during last two periodic reviews -5 if bullet trap was serviced once during either of the last two periodic reviews -7 if bullet trap was serviced during each of the last two periodic reviews	
Duration of Range Use	*Length of time the range has been used.*	2 if > 5 years 0 if ≤ 5 years	2
Source Element Score *Minimum: -4 Maximum: 20*			11

Notes:

Annual lead deposition – 1,478 pounds/year

This range has been in use since 1990.

Dodge City
MCIEAST - MCB Camp Lejeune

Table 2: Surface Water / Sediment Pathways Characteristics Element
(These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)

Criteria	Evaluation Characteristics	Score Criteria	Site Score
Precipitation	*Rate of precipitation.*	8 if precipitation > 40 inches/year 6 if precipitation = 20-40 inches/year 4 if precipitation < 20 inches/year	8
Vegetation	*Approximate vegetation cover **within and directly downslope of the projectile deposition area.***	6 if vegetation cover < 10% 4 if vegetation cover = 10% to 90% 2 if vegetation cover > 90%	4
Slope of Range	*Average slope **from deposition area along the overland pathway to the first defined channel.***	5 if slope > 10% (5.71°) 3 if slope = 5% to 10% 2 if slope < 5% (2.86°)	2
pH of Soil	*pH below 6.5 and above 8.5 increases the rate of lead dissolution.*	3 if pH < 4 or >10 2 if pH ≥ 4 < 6.5 or > 8.5 ≤ 10 1 if pH 6.5 ≤ pH ≤ 8.5	2
Soil Type/ Erosion	*Erosion potential is greatest for fine sands and silt. Clay has the lowest erosion potential. **The area where projectiles are deposited should be scored.***	2 if soil type is fine sand / silt 1 if soil type is clayey sand or silt / coarse sands 0 if soil type is clay	2
	Erosion observed at the projectile deposition area.	5 if there is visual evidence of eroded material being transported from the projectile deposition area 3 if bullet pockets or other indicators of erosion were observed 1 if no erosion was observed	1
Engineering Controls	*The presence of engineering controls or BMPs to modify or control **surface water run-on.*** *Controls may include barriers or diversions that reduce run-on to the range.*	0 if no engineering controls -1 if partial engineering controls -2 if effective engineering controls	0

Dodge City
MCIEAST - MCB Camp Lejeune

Table 2: Surface Water / Sediment Pathways Characteristics Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
	The presence of engineering controls or BMPs to modify or control ***surface water run-off or erosion.*** *Run-off controls may include silt fencing, rip-rap, sedimentation basins, or detention ponds that control run-off from the range. Erosion controls may include soil mix, irrigation, or netting.*	0 if no engineering controls -2 if partial engineering controls -4 if effective engineering controls	-2
Surface Water Pathway Score *Minimum: 4 Maximum: 29*			17

Notes:

Jacksonville, NC averages 56” of rainfall per year (MCB Camp Lejeune, 2006).

Dodge City has many sandy bare areas but is surrounded by thick wooded areas.

The range drains to the northwest towards a stream. The slope from the deposition area to the stream is approximately 2.8%.

The primary soil type located at the ranges is the Baymeade series, which is mostly sand and has a pH between 3.6 and 6.5 (USDA, 1992).

Dodge City is equipped with perimeter berms which help reduce surface water run-off.

Dodge City
MCIEAST - MCB Camp Lejeune

Table 3: Groundwater Pathways Characteristics Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
Precipitation	*Intensity and frequency of precipitation.*	3 if precipitation > 40 inches/year 2 if precipitation = 20-40 inches/year 1 if precipitation < 20 inches/year	3
Depth to Groundwater	*The potential for impact to the groundwater decreases with an increasing depth to the water table.*	6 if depth to groundwater < 3 feet 3 if depth to groundwater = 3-20 feet 1 if depth to groundwater = 20-100 feet 0 if in a groundwater discharge area or depth to groundwater > 100 feet	6
Soil Type / Infiltration Conditions	*Soil with a higher porosity (sands/gravels) has more infiltration and less runoff compared to soil with low porosity (silts/clays).* ***Most hydraulically restrictive infiltration horizon between the surface and groundwater is scored.***	6 if soil type is sand / gravel 3 if soil type is sand and silt 1 if soil type is clay / clayey sand/silt	3
	Vegetation impedes infiltration and groundwater recharge.	6 if vegetation cover < 10% 3 if vegetation cover = 10% to 90% 1 if vegetation cover > 90%	3
	Average slope from deposition area along the overland pathway to the first defined channel.	3 if slope < 2% (1.15°) 1 if slope = 2% to 20% 0 if slope > 20% (11.31°)	1
pH of Soil	*Lead tends to stay dissolved at pH conditions less than 6.5 and greater than 8.5 but tends to attach to soil particles at pH conditions between these levels.*	3 if pH < 4 or >10 2 if pH ≥ 4 < 6.5 or > 8.5 ≤ 10 1 if pH 6.5 ≤ pH ≤ 8.5	2
Groundwater Pathway Score *Minimum: 4 Maximum: 27*			18

Notes:

Jacksonville, NC averages 56” of rainfall per year (MCB Camp Lejeune, 2006).

Based on measurements collected in the vicinity of this range, the depth to groundwater in this area ranges from 0.3 to 3.3 feet below ground surface.

Dodge City

MCIEAST - MCB Camp Lejeune

Table 3: Groundwater Pathways Characteristics Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
The primary soil type located at the ranges is the Baymeade series, which is mostly sand. The soil pH in the area is between 3.6 and 6.5 (USDA, 1992). Dodge City has many sandy bare areas but is surrounded by thick forests. The range drains to the northwest towards a stream. The slope from the deposition area to the stream is approximately 2.8%.			

Dodge City
MCIEAST - MCB Camp Lejeune

Table 4: Surface Water / Sediment Receptors Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
Surface Water Body	*Identify if a nearby surface water body is present down gradient,* ***as defined on the National Hydrography Dataset (NHD) map****.*	8 if surface water body is located downgradient of the range within 1,500 feet 4 if surface water body is located downgradient of the range 1,500-5,000 feet 0 if surface water body is located downgradient of the range over 5,000 feet	8
Drinking Water Use	*Identify if a down gradient surface water body is used as a drinking water source (drainage distance).*	4 if surface water body used as a drinking water source is located downgradient of the range within 1 mile 2 if surface water body used as a drinking water source is located downgradient of the range within 1 to 6 miles 0 if no known drinking water intakes are identified within 6 miles of the range	0
Drainage Distance to Installation Boundary	*Identify downgradient drainage distance to first potential ecological exposure off installation (i.e., installation boundary).*	4 if the installation boundary is located downgradient of the range within 0.5 miles 2 if the installation boundary is located downgradient of the range within 0.5 to 3 miles 0 if the installation boundary is located downgradient of the range greater than 3 miles, or if surface water runoff from the range does not discharge off the installation	4
Surface Water Receptor Score *Minimum: 0 Maximum: 16*			12

Notes:

According to the USGS National Hydrography Map, a marsh is located approximately 420 feet downgradient to the northwest of Dodge City. The marsh borders Stones Creek which is located approximately 1,000 feet downgradient to the northwest from Dodge City.

Drinking water is obtained from water supply wells throughout the installation. Surface water is not used as a drinking water source at the installation, nor are there any surface water bodies used as drinking water sources within 6 miles of this range.

The downgradient drainage pathway from Dodge City leads to Stones Creek which is also the installation boundary. Therefore, the drainage pathway crosses the installation boundary approximately 0.2 miles from the range.

Dodge City
MCIEAST - MCB Camp Lejeune

Table 5: Groundwater Receptors Element
(These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)

Criteria	Evaluation Characteristics	Score Criteria	Site Score
Wells Identified as Potable Water Sources	*Number and location of potable water or potable water supply wells relative to the location of the range.*	6 if a drinking water well is located within <50 feet of the range 3 if a drinking water well is located downgradient of the range within 50-1,500 feet 0 if there are no drinking water wells located within 1,500 feet downgradient of the range or if groundwater is not used as a drinking water source.	0
	*Into what **type of aquifer is the well set***	6 if unconfined 3 if semi-confined 0 if confined	3
Groundwater wells identified for purpose other than drinking water	*Groundwater wells used for purposes other than drinking water supply identified down gradient of the range.*	3 if a groundwater well is located within 50 feet of the range 1 if a groundwater well is located downgradient of the range within 50-1,500 feet 0 if groundwater well <1,500 feet downgradient of the range is not used for any purpose.	0
Groundwater Receptor Score *Minimum: 0 Maximum: 15*			3

Notes:

The closest well to this range is an off-installation county well located over 12,000 feet away.

Dodge City
MCIEAST - MCB Camp Lejeune

Table 6: Evaluation Score
(These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)

Surface Water / Sediment		
Element	**Table**	**Score**
Range Use and Range Management (Source)	1	11
Surface Water / Sediment Pathways	2	17
Surface Water / Sediment Receptors	4	12
Sum of Surface Water / Sediment Element Scores *Minimum: 0 Maximum: 65*		**40**
Groundwater		
Element	**Table**	**Score**
Range Use and Range Management (Source)	1	11
Groundwater Pathways	3	18
Groundwater Receptors	5	3
Sum of Groundwater Element Scores *Minimum: 0 Maximum: 62*		**32**

Field Sampling and Observed Releases

Surface Water / Sediment	Surface water sampling conducted Yes ☒ No ☐ Sediment sampling conducted Yes ☐ No ☒ Results exceed DoD screening value Yes ☐ No ☐	**Surface Water / Sediment** ☒ No Modification ☐ High
Groundwater	Groundwater sampling conducted Yes ☐ No ☒ Results exceed DoD screening value Yes ☐ No ☐	**Groundwater** ☒ No Modification ☐ High

The relative evaluation ranking for each media is determined by selecting the appropriate score based on the data elements for that media:

Evaluation Ranking*	Score Range
High	45-65
Moderate	33-44
Minimal	0-32

Surface Water Evaluation Ranking	**Moderate**
Groundwater Evaluation Ranking	**Minimal**

Notes: An upper and lower interval surface water sample was collected in Stones Bay and analyzed for total and dissolved lead. Total lead was detected at 0.44 µg/L and 0.40 µg/L in the upper and lower intervals, respectively. Dissolved lead was detected only in the lower interval sample at a concentration of 2.5 µg/L. Results were below screening criteria.

F-18
MCIEAST - MCB Camp Lejeune
Jacksonville, North Carolina

Date of SARAP update: 11/19/2014

DESCRIPTION

Range Mission: Machinegun Field Firing Range	
Training Start Date: 1970	
Direction of Fire: East	
Firing Positions: 6	
Target Range: 646 – 912 meters	
Impact Area(s):	☐ Open area ☐ Hillside ☐ Building ☒ Earthen berm ☐ Bullet trap
Existing BMPs:	☐ Basin/vault ☐ Control fabric ☐ Diversion ☐ Fencing ☐ Rip-rap ☐ Silt check ☐ Vegetation
	Other:
Reference(s):	

FINDINGS

Review Period		Periodic Review
Estimated Lead Deposition (lb/yr)		4,673
Surface Water / Sediment	***RANK***	High
	Source	16
	Pathway	20
	Receptor	10
	TOTAL SCORE	46
Groundwater	***RANK***	Moderate
	Source	16
	Pathway	15
	Receptor	6
	TOTAL SCORE	37

RECOMMENDATIONS

☒ Periodically review operations for significant changes in training, management, and use.

☐ Gather additional data regarding ☐ range use, ☐ pathways, or ☐ receptors associated with the range: ______________________________

☒ Collect site-specific field data to further assess potential off-range migration.

F-18
MCIEAST - MCB Camp Lejeune

Table 1: Range Use and Range Management (*Source)* Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
MC Loading Rates	*The amount of small arms ammunition expended on the range.* *Estimate the MC loading as average lead deposition rate.*	14 if MC loading > 8,000 pounds/year 11 if MC loading = 4,001-8,000 pounds/year 8 if MC loading = 2,001-4,000 pounds/year 5 if MC loading = 501-2,000 pounds/year 2 if MC loading < 501 pounds/year	11
Impact Area	*The bullet deposition scenario at the range.*	4 if projectiles are scattered in SDZ 3 if range has an impact berm 1 if range has a bullet trap	3
Lead Management	*Frequency of activities that result in the removal of lead from an EARTHERN BERM or SDZ.* *This includes MINOR removal (e.g. scraping and sifting of berm/area, soil amendments) as well as MAJOR removals (e.g. lead mining).*	0 if no notable mining -1 if a MINOR action completed once during either of the last two periodic reviews -2 if MINOR action completed during each of the two previous periodic reviews -3 if MAJOR action was completed once during either of the last two periodic reviews -4 if MAJOR action completed during each of the two previous periodic reviews	0
	Frequency of activities that result in the significant removal of lead from a BULLET TRAP.	-3 if bullet trap was not been serviced during last two periodic reviews -5 if bullet trap was serviced once during either of the last two periodic reviews -7 if bullet trap was serviced during each of the last two periodic reviews	
Duration of Range Use	*Length of time the range has been used.*	2 if > 5 years 0 if ≤ 5 years	2
Source Element Score *Minimum: -4 Maximum: 20*			16

<u>Notes:</u>

Annual lead deposition – 4,673 pounds/year.

This range has been in use since 1970.

F-18
MCIEAST - MCB Camp Lejeune

Table 2: Surface Water / Sediment Pathways Characteristics Element
(These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)

Criteria	Evaluation Characteristics	Score Criteria	Site Score
Precipitation	*Rate of precipitation.*	8 if precipitation > 40 inches/year 6 if precipitation = 20-40 inches/year 4 if precipitation < 20 inches/year	8
Vegetation	*Approximate vegetation cover* ***within and directly downslope of the projectile deposition area.***	6 if vegetation cover < 10% 4 if vegetation cover = 10% to 90% 2 if vegetation cover > 90%	4
Slope of Range	*Average slope* ***from deposition area along the overland pathway to the first defined channel.***	5 if slope > 10% (5.71°) 3 if slope = 5% to 10% 2 if slope < 5% (2.86°)	3
pH of Soil	*pH below 6.5 and above 8.5 increases the rate of lead dissolution.*	3 if pH < 4 or >10 2 if pH ≥ 4 < 6.5 or > 8.5 ≤ 10 1 if pH 6.5 ≤ pH ≤ 8.5	2
Soil Type/ Erosion	*Erosion potential is greatest for fine sands and silt. Clay has the lowest erosion potential.* ***The area where projectiles are deposited should be scored.***	2 if soil type is fine sand / silt 1 if soil type is clayey sand or silt / coarse sands 0 if soil type is clay	2
	Erosion observed at the projectile deposition area.	5 if there is visual evidence of eroded material being transported from the projectile deposition area 3 if bullet pockets or other indicators of erosion were observed 1 if no erosion was observed	1
Engineering Controls	*The presence of engineering controls or BMPs to modify or control* ***surface water run-on.*** *Controls may include barriers or diversions that reduce run-on to the range.*	0 if no engineering controls -1 if partial engineering controls -2 if effective engineering controls	0

F-18
MCIEAST - MCB Camp Lejeune

Table 2: Surface Water / Sediment Pathways Characteristics Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
	The presence of engineering controls or BMPs to modify or control ***surface water run-off or erosion.*** *Run-off controls may include silt fencing, rip-rap, sedimentation basins, or detention ponds that control run-off from the range. Erosion controls may include soil mix, irrigation, or netting.*	0 if no engineering controls -2 if partial engineering controls -4 if effective engineering controls	0
Surface Water Pathway Score *Minimum: 4 Maximum: 29*			20

Notes:

Jacksonville, NC averages 56" of rainfall per year (MCB Camp Lejeune, 2006).

The area is mostly vegetated with tall grass and is surrounded by wooded areas.

The range drains partially to the northwest to a tributary of Wallace Creek and also to the south to a tributary of the New River. The approximate slope from the deposition area is 5%.

The primary soil type at F-18 is the Onslow series, which is a sand and silt mixture with an approximate pH of 3.6 to 6.5.

F-18
MCIEAST - MCB Camp Lejeune

Table 3: Groundwater Pathways Characteristics Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
Precipitation	*Intensity and frequency of precipitation.*	3 if precipitation > 40 inches/year 2 if precipitation = 20-40 inches/year 1 if precipitation < 20 inches/year	3
Depth to Groundwater	*The potential for impact to the groundwater decreases with an increasing depth to the water table.*	6 if depth to groundwater < 3 feet 3 if depth to groundwater = 3-20 feet 1 if depth to groundwater = 20-100 feet 0 if in a groundwater discharge area or depth to groundwater > 100 feet	3
Soil Type / Infiltration Conditions	*Soil with a higher porosity (sands/gravels) has more infiltration and less runoff compared to soil with low porosity (silts/clays).* ***Most hydraulically restrictive infiltration horizon between the surface and groundwater is scored.***	6 if soil type is sand / gravel 3 if soil type is sand and silt 1 if soil type is clay / clayey sand/silt	3
	Vegetation impedes infiltration and groundwater recharge.	6 if vegetation cover < 10% 3 if vegetation cover = 10% to 90% 1 if vegetation cover > 90%	3
	Average slope from deposition area along the overland pathway to the first defined channel.	3 if slope < 2% (1.15°) 1 if slope = 2% to 20% 0 if slope > 20% (11.31°)	1
pH of Soil	*Lead tends to stay dissolved at pH conditions less than 6.5 and greater than 8.5 but tends to attach to soil particles at pH conditions between these levels.*	3 if pH < 4 or >10 2 if pH ≥ 4 < 6.5 or > 8.5 ≤ 10 1 if pH 6.5 ≤ pH ≤ 8.5	2
Groundwater Pathway Score *Minimum: 4* *Maximum: 27*			15

Notes:

Jacksonville, NC averages 56” of rainfall per year (MCB Camp Lejeune, 2006).

Based on measurements collected in the vicinity of this range, the depth to groundwater in this area ranges from 6 – 11.6 feet below ground surface.

F-18
MCIEAST - MCB Camp Lejeune

Table 3: Groundwater Pathways Characteristics Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
The primary soil type at Range F-18 is the Onslow series, which is a sand and silt mixture with an approximate pH of 3.6 to 6.5. The range drains partially to the northwest to a tributary of Wallace Creek and also to the south to a tributary of the New River. The approximate slope from the deposition area is 5%.			

F-18
MCIEAST - MCB Camp Lejeune

Table 4: Surface Water / Sediment Receptors Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
Surface Water Body	*Identify if a nearby surface water body is present down gradient, **as defined on the National Hydrography Dataset (NHD) map**.*	8 if surface water body is located downgradient of the range within 1,500 feet 4 if surface water body is located downgradient of the range 1,500-5,000 feet 0 if surface water body is located downgradient of the range over 5,000 feet	8
Drinking Water Use	*Identify if a down gradient surface water body is used as a drinking water source (drainage distance).*	4 if surface water body used as a drinking water source is located downgradient of the range within 1 mile 2 if surface water body used as a drinking water source is located downgradient of the range within 1 to 6 miles 0 if no known drinking water intakes are identified within 6 miles of the range	0
Drainage Distance to Installation Boundary	*Identify downgradient drainage distance to first potential ecological exposure off installation (i.e., installation boundary).*	4 if the installation boundary is located downgradient of the range within 0.5 miles 2 if the installation boundary is located downgradient of the range within 0.5 to 3 miles 0 if the installation boundary is located downgradient of the range greater than 3 miles, or if surface water runoff from the range does not discharge off the installation	2
Surface Water Receptor Score *Minimum: 0 Maximum: 16*			10

Notes:

According to the USGS National Hydrography Map, the closest downgradient surface water F-18 is the Bearhead Creek located approximately 470 feet north of the range.

Drinking water is obtained from water supply wells throughout the installation. Surface water is not used as a drinking water source at the installation, nor are there any surface water bodies used as drinking water sources within 6 miles of this range.

The surface water from F-18 drains north towards Bearhead Creek. The Bearhead Creek then generally flows east and crosses the installation boundary as it reaches a marsh approximately 1.1 miles from F-18.

F-18
MCIEAST - MCB Camp Lejeune

Table 5: Groundwater Receptors Element
(These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)

Criteria	Evaluation Characteristics	Score Criteria	Site Score
Wells Identified as Potable Water Sources	*Number and location of potable water or potable water supply wells relative to the location of the range.*	6 if a drinking water well is located within <50 feet of the range 3 if a drinking water well is located downgradient of the range within 50-1,500 feet 0 if there are no drinking water wells located within 1,500 feet downgradient of the range or if groundwater is not used as a drinking water source.	3
	*Into what **type of aquifer is the well set***	6 if unconfined 3 if semi-confined 0 if confined	3
Groundwater wells identified for purpose other than drinking water	*Groundwater wells used for purposes other than drinking water supply identified down gradient of the range.*	3 if a groundwater well is located within 50 feet of the range 1 if a groundwater well is located downgradient of the range within 50-1,500 feet 0 if groundwater well <1,500 feet downgradient of the range is not used for any purpose.	0
Groundwater Receptor Score *Minimum: 0 Maximum: 15*			6

Notes:

There is a potable supply well located approximately 1,200 feet downgradient from F-18.

F-18
MCIEAST - MCB Camp Lejeune

Table 6: Evaluation Score
(These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)

Surface Water / Sediment

Element	Table	Score
Range Use and Range Management (Source)	1	16
Surface Water / Sediment Pathways	2	20
Surface Water / Sediment Receptors	4	10
Sum of Surface Water / Sediment Element Scores *Minimum: 0 Maximum: 65*		**46**

Groundwater

Element	Table	Score
Range Use and Range Management (Source)	1	16
Groundwater Pathways	3	15
Groundwater Receptors	5	6
Sum of Groundwater Element Scores *Minimum: 0 Maximum: 62*		**37**

Field Sampling and Observed Releases

Surface Water / Sediment	Surface water sampling conducted Yes ☒ No ☐ Sediment sampling conducted Yes ☐ No ☒ Results exceed DoD screening value Yes ☐ No ☒	**Surface Water / Sediment** ☒ No Modification ☐ High
Groundwater	Groundwater sampling conducted Yes ☐ No ☒ Results exceed DoD screening value Yes ☐ No ☐	**Groundwater** ☒ No Modification ☐ High

The relative evaluation ranking for each media is determined by selecting the appropriate score based on the data elements for that media:

Evaluation Ranking*	Score Range
High	45-65
Moderate	33-44
Minimal	0-32

Surface Water Evaluation Ranking	**High**
Groundwater Evaluation Ranking	**Moderate**

Notes: One surface water sample was collected in Wallace Creek and analyzed for total and dissolved lead. Neither were detected.

G-21
MCIEAST - MCB Camp Lejeune
Jacksonville, North Carolina

Date of SARAP update: 11/19/2014

DESCRIPTION

Range Mission:	Combat Marksmanship Program and Close Combat Range
Training Start Date:	2012
Direction of Fire:	Southeast
Firing Positions:	Variable
Target Range:	Variable
Impact Area(s):	☒ Open area ☐ Hillside ☐ Building ☐ Earthen berm ☐ Bullet trap
Existing BMPs:	☐ Basin/vault ☐ Control fabric ☐ Diversion ☐ Fencing ☐ Rip-rap ☐ Silt check ☐ Vegetation *Other:*
Reference(s):	

FINDINGS

Review Period		Periodic Review
Estimated Lead Deposition (lb/yr)		5,440
Surface Water / Sediment	***RANK***	Moderate
	Source	15
	Pathway	17
	Receptor	8
	TOTAL SCORE	40
Groundwater	***RANK***	Moderate
	Source	15
	Pathway	13
	Receptor	6
	TOTAL SCORE	34

RECOMMENDATIONS

☒ Periodically review operations for significant changes in training, management, and use.

☐ Gather additional data regarding ☐ range use, ☐ pathways, or ☐ receptors associated with the range: ____________________

☐ Collect site-specific field data to further assess potential off-range migration.

G-21
MCIEAST - MCB Camp Lejeune

Table 1: Range Use and Range Management (*Source*) Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
MC Loading Rates	*The amount of small arms ammunition expended on the range.* *Estimate the MC loading as average lead deposition rate.*	14 if MC loading > 8,000 pounds/year 11 if MC loading = 4,001-8,000 pounds/year 8 if MC loading = 2,001-4,000 pounds/year 5 if MC loading = 501-2,000 pounds/year 2 if MC loading < 501 pounds/year	11
Impact Area	*The bullet deposition scenario at the range.*	4 if projectiles are scattered in SDZ 3 if range has an impact berm 1 if range has a bullet trap	4
Lead Management	*Frequency of activities that result in the removal of lead from an EARTHERN BERM or SDZ.* *This includes MINOR removal (e.g. scraping and sifting of berm/area, soil amendments) as well as MAJOR removals (e.g. lead mining).*	0 if no notable mining -1 if a MINOR action completed once during either of the last two periodic reviews -2 if MINOR action completed during each of the two previous periodic reviews -3 if MAJOR action was completed once during either of the last two periodic reviews -4 if MAJOR action completed during each of the two previous periodic reviews	0
	Frequency of activities that result in the significant removal of lead from a BULLET TRAP.	-3 if bullet trap was not been serviced during last two periodic reviews -5 if bullet trap was serviced once during either of the last two periodic reviews -7 if bullet trap was serviced during each of the last two periodic reviews	
Duration of Range Use	*Length of time the range has been used.*	2 if > 5 years 0 if ≤ 5 years	0
Source Element Score *Minimum: -4 Maximum: 20*			15

Notes:

Annual lead deposition – 5,440 pounds/year.

This range has been in use since 2012.

G-21
MCIEAST - MCB Camp Lejeune

Table 2: Surface Water / Sediment Pathways Characteristics Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
Precipitation	*Rate of precipitation.*	8 if precipitation > 40 inches/year 6 if precipitation = 20-40 inches/year 4 if precipitation < 20 inches/year	8
Vegetation	*Approximate vegetation cover **within and directly downslope of the projectile deposition area.***	6 if vegetation cover < 10% 4 if vegetation cover = 10% to 90% 2 if vegetation cover > 90%	2
Slope of Range	*Average slope **from deposition area along the overland pathway to the first defined channel.***	5 if slope > 10% (5.71°) 3 if slope = 5% to 10% 2 if slope < 5% (2.86°)	2
pH of Soil	*pH below 6.5 and above 8.5 increases the rate of lead dissolution.*	3 if pH < 4 or >10 2 if pH ≥ 4 < 6.5 or > 8.5 ≤ 10 1 if pH 6.5 ≤ pH ≤ 8.5	2
Soil Type/ Erosion	*Erosion potential is greatest for fine sands and silt. Clay has the lowest erosion potential. **The area where projectiles are deposited should be scored.***	2 if soil type is fine sand / silt 1 if soil type is clayey sand or silt / coarse sands 0 if soil type is clay	2
	Erosion observed at the projectile deposition area.	5 if there is visual evidence of eroded material being transported from the projectile deposition area 3 if bullet pockets or other indicators of erosion were observed 1 if no erosion was observed	1
Engineering Controls	*The presence of engineering controls or BMPs to modify or control **surface water run-on.*** *Controls may include barriers or diversions that reduce run-on to the range.*	0 if no engineering controls -1 if partial engineering controls -2 if effective engineering controls	0

G-21
MCIEAST - MCB Camp Lejeune

Table 2: Surface Water / Sediment Pathways Characteristics Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
	*The presence of engineering controls or BMPs to modify or control **surface water run-off or erosion.*** *Run-off controls may include silt fencing, rip-rap, sedimentation basins, or detention ponds that control run-off from the range. Erosion controls may include soil mix, irrigation, or netting.*	0 if no engineering controls -2 if partial engineering controls -4 if effective engineering controls	0
Surface Water Pathway Score *Minimum: 4* *Maximum: 29*			17

Notes:

Jacksonville, NC averages 56" of rainfall per year (MCB Camp Lejeune, 2006).

The range area is primarily covered with grass with only small bare areas around protective target berms. The area surrounding the range is also heavily wooded.

A channel flows east through a portion of the G-21 deposition area to Freeman Creek. The approximate slope from the deposition area to the channel and onto Freeman Creek is 3.3%.

The soil at G-21 is combination of Baymead, Foreston, Stallings, Kureb, and Alpin fine sands. The pH range of these soils is 3.6 to 7.3.

G-21
MCIEAST - MCB Camp Lejeune

Table 3: Groundwater Pathways Characteristics Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
Precipitation	*Intensity and frequency of precipitation.*	3 if precipitation > 40 inches/year 2 if precipitation = 20-40 inches/year 1 if precipitation < 20 inches/year	3
Depth to Groundwater	*The potential for impact to the groundwater decreases with an increasing depth to the water table.*	6 if depth to groundwater < 3 feet 3 if depth to groundwater = 3-20 feet 1 if depth to groundwater = 20-100 feet 0 if in a groundwater discharge area or depth to groundwater > 100 feet	3
Soil Type / Infiltration Conditions	*Soil with a higher porosity (sands/gravels) has more infiltration and less runoff compared to soil with low porosity (silts/clays).* ***Most hydraulically restrictive infiltration horizon between the surface and groundwater is scored.***	6 if soil type is sand / gravel 3 if soil type is sand and silt 1 if soil type is clay / clayey sand/silt	3
	Vegetation impedes infiltration and groundwater recharge.	6 if vegetation cover < 10% 3 if vegetation cover = 10% to 90% 1 if vegetation cover > 90%	1
	Average slope from deposition area along the overland pathway to the first defined channel.	3 if slope < 2% (1.15°) 1 if slope = 2% to 20% 0 if slope > 20% (11.31°)	1
pH of Soil	*Lead tends to stay dissolved at pH conditions less than 6.5 and greater than 8.5 but tends to attach to soil particles at pH conditions between these levels.*	3 if pH < 4 or >10 2 if pH ≥ 4 < 6.5 or > 8.5 ≤ 10 1 if pH 6.5 ≤ pH ≤ 8.5	2
Groundwater Pathway Score *Minimum: 4* *Maximum: 27*			13

Notes:

Jacksonville, NC averages 56” of rainfall per year (MCB Camp Lejeune, 2006).

Based on measurements collect in the vicinity of this range, the depth to groundwater in this area ranges from 3.4 to 13 feet below ground surface.

G-21

MCIEAST - MCB Camp Lejeune

Table 3: Groundwater Pathways Characteristics Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
The soil at G-21 is combination of Baymead, Foreston, Stallings, Kureb, and Alpin fine sands. The pH range of these soils is 3.6 to 7.3. A channel flows east through a portion of the G-21 deposition area to Freeman Creek. The approximate slope from the deposition area to the channel and onto Freeman Creek is 3.3%.			

G-21
MCIEAST - MCB Camp Lejeune

Table 4: Surface Water / Sediment Receptors Element
(These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)

Criteria	Evaluation Characteristics	Score Criteria	Site Score
Surface Water Body	*Identify if a nearby surface water body is present down gradient,* ***as defined on the National Hydrography Dataset (NHD) map****.*	8 if surface water body is located downgradient of the range within 1,500 feet 4 if surface water body is located downgradient of the range 1,500-5,000 feet 0 if surface water body is located downgradient of the range over 5,000 feet	8
Drinking Water Use	*Identify if a down gradient surface water body is used as a drinking water source (drainage distance).*	4 if surface water body used as a drinking water source is located downgradient of the range within 1 mile 2 if surface water body used as a drinking water source is located downgradient of the range within 1 to 6 miles 0 if no known drinking water intakes are identified within 6 miles of the range	0
Drainage Distance to Installation Boundary	*Identify downgradient drainage distance to first potential ecological exposure off installation (i.e., installation boundary).*	4 if the installation boundary is located downgradient of the range within 0.5 miles 2 if the installation boundary is located downgradient of the range within 0.5 to 3 miles 0 if the installation boundary is located downgradient of the range greater than 3 miles, or if surface water runoff from the range does not discharge off the installation	0
Surface Water Receptor Score *Minimum: 0 Maximum: 16*			8

Table 4: Surface Water / Sediment Receptors Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	Evaluation Characteristics	Score Criteria	Site Score
Notes: According to the USGS National Hydrography Map, the Clay Bank Branch perennial stream is located within the bullet deposition area of G-21 and flows east towards the Freeman Creek. Drinking water is obtained from water supply wells throughout the installation. Surface water is not used as a drinking water source at the installation, nor are there any surface water bodies used as drinking water sources within 6 miles of this range. A watershed boundary splits the G-21 bullet deposition area into northern and southern drainage pathways. The northern drainage pathway follows the Clay Bank Branch stream towards Freeman Creek which then flows toward the Intracoastal Waterway and eventually to the Atlantic Ocean. This drainage pathway crosses the installation boundary approximately 4 miles southeast from G-21. The southern drainage pathway proceeds southeast towards a perennial stream leading towards Gillets Creek. Gillets Creek generally flows southeast towards the Intracoastal Waterway and eventually into the Atlantic Ocean where it crosses the installation boundary approximately 6 miles from G-21.			

G-21
MCIEAST - MCB Camp Lejeune

Table 5: Groundwater Receptors Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
Wells Identified as Potable Water Sources	*Number and location of potable water or potable water supply wells relative to the location of the range.*	6 if a drinking water well is located within <50 feet of the range 3 if a drinking water well is located downgradient of the range within 50-1,500 feet 0 if there are no drinking water wells located within 1,500 feet downgradient of the range or if groundwater is not used as a drinking water source.	3
	Into what ***type of aquifer is the well set***	6 if unconfined 3 if semi-confined 0 if confined	3
Groundwater wells identified for purpose other than drinking water	*Groundwater wells used for purposes other than drinking water supply identified down gradient of the range.*	3 if a groundwater well is located within 50 feet of the range 1 if a groundwater well is located downgradient of the range within 50-1,500 feet 0 if groundwater well <1,500 feet downgradient of the range is not used for any purpose.	0
Groundwater Receptor Score *Minimum: 0* *Maximum: 15*			6
Notes: A potable supply well is located approximately 1,380 feet downgradient from G-21.			

G-21
MCIEAST - MCB Camp Lejeune

Table 6: Evaluation Score (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)		
Surface Water / Sediment		
Element	**Table**	**Score**
Range Use and Range Management (Source)	1	15
Surface Water / Sediment Pathways	2	17
Surface Water / Sediment Receptors	4	8
Sum of Surface Water / Sediment Element Scores *Minimum: 0 Maximum: 65*		**40**
Groundwater		
Element	**Table**	**Score**
Range Use and Range Management (Source)	1	15
Groundwater Pathways	3	13
Groundwater Receptors	5	6
Sum of Groundwater Element Scores *Minimum: 0 Maximum: 62*		**34**

Field Sampling and Observed Releases

Surface Water / Sediment	Surface water sampling conducted Yes ☐ No ☒ Sediment sampling conducted Yes ☐ No ☒ Results exceed DoD screening value Yes ☐ No ☐	**Surface Water / Sediment** ☒ No Modification ☐ High
Groundwater	Groundwater sampling conducted Yes ☐ No ☒ Results exceed DoD screening value Yes ☐ No ☐	**Groundwater** ☒ No Modification ☐ High

The relative evaluation ranking for each media is determined by selecting the appropriate score based on the data elements for that media:

Evaluation Ranking*	Score Range
High	45-65
Moderate	33-44
Minimal	0-32

Surface Water Evaluation Ranking	**Moderate**
Groundwater Evaluation Ranking	**Moderate**

Notes:

Hathcock Range
MCIEAST - MCB Camp Lejeune
Jacksonville, North Carolina

Date of SARAP update: 11/19/2014

DESCRIPTION

Range Mission:	Sniper Live Fire Range
Training Start Date:	Mid-1980s
Direction of Fire:	North
Firing Positions:	25
Target Range:	50 – 1000 yards
Impact Area(s):	☐ Open area ☐ Hillside ☐ Building ☒ Earthen berm ☐ Bullet trap
Existing BMPs:	☐ Basin/vault ☐ Control fabric ☐ Diversion ☐ Fencing ☐ Rip-rap ☐ Silt check ☐ Vegetation
	Other:
Reference(s):	

FINDINGS

Review Period		**Periodic Review**
Estimated Lead Deposition (lb/yr)		2,356
Surface Water / Sediment	***RANK***	Moderate
	Source	13
	Pathway	17
	Receptor	12
	TOTAL SCORE	42
Groundwater	***RANK***	Moderate
	Source	13
	Pathway	18
	Receptor	3
	TOTAL SCORE	34

RECOMMENDATIONS

☒ Periodically review operations for significant changes in training, management, and use.

☐ Gather additional data regarding ☐ range use, ☐ pathways, or ☐ receptors associated with the range: ____________________

☐ Collect site-specific field data to further assess potential off-range migration.

Hathcock Range
MCIEAST - MCB Camp Lejeune

Table 1: Range Use and Range Management (*Source)* Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
MC Loading Rates	*The amount of small arms ammunition expended on the range.* *Estimate the MC loading as average lead deposition rate.*	14 if MC loading > 8,000 pounds/year 11 if MC loading = 4,001-8,000 pounds/year 8 if MC loading = 2,001-4,000 pounds/year 5 if MC loading = 501-2,000 pounds/year 2 if MC loading < 501 pounds/year	8
Impact Area	*The bullet deposition scenario at the range.*	4 if projectiles are scattered in SDZ 3 if range has an impact berm 1 if range has a bullet trap	3
Lead Management	*Frequency of activities that result in the removal of lead from an EARTHERN BERM or SDZ.* *This includes MINOR removal (e.g. scraping and sifting of berm/area, soil amendments) as well as MAJOR removals (e.g. lead mining).*	0 if no notable mining -1 if a MINOR action completed once during either of the last two periodic reviews -2 if MINOR action completed during each of the two previous periodic reviews -3 if MAJOR action was completed once during either of the last two periodic reviews -4 if MAJOR action completed during each of the two previous periodic reviews	0
	Frequency of activities that result in the significant removal of lead from a BULLET TRAP.	-3 if bullet trap was not been serviced during last two periodic reviews -5 if bullet trap was serviced once during either of the last two periodic reviews -7 if bullet trap was serviced during each of the last two periodic reviews	
Duration of Range Use	*Length of time the range has been used.*	2 if > 5 years 0 if ≤ 5 years	2
Source Element Score *Minimum: -4 Maximum: 20*			13
Notes: Annual lead deposition – 2,356 pounds/year. This range has been in use since the mid-1980s.			

Hathcock Range
MCIEAST - MCB Camp Lejeune

Table 2: Surface Water / Sediment Pathways Characteristics Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
Precipitation	*Rate of precipitation.*	8 if precipitation > 40 inches/year 6 if precipitation = 20-40 inches/year 4 if precipitation < 20 inches/year	8
Vegetation	*Approximate vegetation cover **within and directly downslope of the projectile deposition area.***	6 if vegetation cover < 10% 4 if vegetation cover = 10% to 90% 2 if vegetation cover > 90%	4
Slope of Range	*Average slope **from deposition area along the overland pathway to the first defined channel.***	5 if slope > 10% (5.71°) 3 if slope = 5% to 10% 2 if slope < 5% (2.86°)	2
pH of Soil	*pH below 6.5 and above 8.5 increases the rate of lead dissolution.*	3 if pH < 4 or >10 2 if pH ≥ 4 < 6.5 or > 8.5 ≤ 10 1 if pH 6.5 ≤ pH ≤ 8.5	2
Soil Type/ Erosion	*Erosion potential is greatest for fine sands and silt. Clay has the lowest erosion potential. **The area where projectiles are deposited should be scored.***	2 if soil type is fine sand / silt 1 if soil type is clayey sand or silt / coarse sands 0 if soil type is clay	2
	Erosion observed at the projectile deposition area.	5 if there is visual evidence of eroded material being transported from the projectile deposition area 3 if bullet pockets or other indicators of erosion were observed 1 if no erosion was observed	1
Engineering Controls	*The presence of engineering controls or BMPs to modify or control **surface water run-on.*** *Controls may include barriers or diversions that reduce run-on to the range.*	0 if no engineering controls -1 if partial engineering controls -2 if effective engineering controls	0

Hathcock Range
MCIEAST - MCB Camp Lejeune

Table 2: Surface Water / Sediment Pathways Characteristics Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
	The presence of engineering controls or BMPs to modify or control ***surface water run-off or erosion.*** *Run-off controls may include silt fencing, rip-rap, sedimentation basins, or detention ponds that control run-off from the range. Erosion controls may include soil mix, irrigation, or netting.*	0 if no engineering controls -2 if partial engineering controls -4 if effective engineering controls	-2
Surface Water Pathway Score *Minimum: 4 Maximum: 29*			17

Notes:

Jacksonville, NC averages 56” of rainfall per year (MCB Camp Lejeune, 2006).

The majority of the range surface is covered in grass with some small bare areas near target locations.

The Hathcock Range deposition area drains to the east into the adjacent Stones Bay with an approximate slope of 2%.

The primary soil types located at the Hathcock Range are Goldsboro and Marvyn series soils. Both of these are primarily fine sandy loams with a pH range of 4.5 to 6.0.

Engineering controls observed at the Hathcock Range include short vegetated side berms which help control surface water run-off.

Hathcock Range
MCIEAST - MCB Camp Lejeune

Table 3: Groundwater Pathways Characteristics Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
Precipitation	*Intensity and frequency of precipitation.*	3 if precipitation > 40 inches/year 2 if precipitation = 20-40 inches/year 1 if precipitation < 20 inches/year	3
Depth to Groundwater	*The potential for impact to the groundwater decreases with an increasing depth to the water table.*	6 if depth to groundwater < 3 feet 3 if depth to groundwater = 3-20 feet 1 if depth to groundwater = 20-100 feet 0 if in a groundwater discharge area or depth to groundwater > 100 feet	6
Soil Type / Infiltration Conditions	*Soil with a higher porosity (sands/gravels) has more infiltration and less runoff compared to soil with low porosity (silts/clays).* ***Most hydraulically restrictive infiltration horizon between the surface and groundwater is scored.***	6 if soil type is sand / gravel 3 if soil type is sand and silt 1 if soil type is clay / clayey sand/silt	3
	Vegetation impedes infiltration and groundwater recharge.	6 if vegetation cover < 10% 3 if vegetation cover = 10% to 90% 1 if vegetation cover > 90%	3
	Average slope from deposition area along the overland pathway to the first defined channel.	3 if slope < 2% (1.15°) 1 if slope = 2% to 20% 0 if slope > 20% (11.31°)	1
pH of Soil	*Lead tends to stay dissolved at pH conditions less than 6.5 and greater than 8.5 but tends to attach to soil particles at pH conditions between these levels.*	3 if pH < 4 or >10 2 if pH ≥ 4 < 6.5 or > 8.5 ≤ 10 1 if pH 6.5 ≤ pH ≤ 8.5	2
Groundwater Pathway Score *Minimum: 4 Maximum: 27*			18

Notes:

Jacksonville, NC averages 56” of rainfall per year (MCB Camp Lejeune, 2006).

Based on measurements collected in the vicinity of this range, the depth to groundwater in this area ranges from 0.3 to 3.3 feet below ground surface.

Hathcock Range
MCIEAST - MCB Camp Lejeune

Table 3: Groundwater Pathways Characteristics Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
The primary soil types located at the Hathcock Range are Goldsboro and Marvyn series soils. Both of these are primarily fine sandy loams with a pH range of 4.5 to 6.0. The majority of the range surface is covered in grass with some small bare areas near target locations. The Hathcock Range deposition area drains to the east into the immediately adjacent Stones Bay with an approximate slope of 2%.			

Hathcock Range
MCIEAST - MCB Camp Lejeune

Table 4: Surface Water / Sediment Receptors Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
Surface Water Body	*Identify if a nearby surface water body is present down gradient,* ***as defined on the National Hydrography Dataset (NHD) map****.*	8 if surface water body is located downgradient of the range within 1,500 feet 4 if surface water body is located downgradient of the range 1,500-5,000 feet 0 if surface water body is located downgradient of the range over 5,000 feet	8
Drinking Water Use	*Identify if a down gradient surface water body is used as a drinking water source (drainage distance).*	4 if surface water body used as a drinking water source is located downgradient of the range within 1 mile 2 if surface water body used as a drinking water source is located downgradient of the range within 1 to 6 miles 0 if no known drinking water intakes are identified within 6 miles of the range	0
Drainage Distance to Installation Boundary	*Identify downgradient drainage distance to first potential ecological exposure off installation (i.e., installation boundary).*	4 if the installation boundary is located downgradient of the range within 0.5 miles 2 if the installation boundary is located downgradient of the range within 0.5 to 3 miles 0 if the installation boundary is located downgradient of the range greater than 3 miles, or if surface water runoff from the range does not discharge off the installation	4
Surface Water Receptor Score *Minimum: 0 Maximum: 16*			12

Notes:

According to the USGS National Hydrography Map, there is a perennial stream that flows east across the Hathcock Range directly into Stones Bay located approximately 380 feet east of the range.

Drinking water is obtained from water supply wells throughout the installation. Surface water is not used as a drinking water source at the installation, nor are there any surface water bodies used as drinking water sources within 6 miles of this range.

The drainage pathway from the Hathcock Range generally flows east into Stones Bay. As the drainage enters Stones Bay, it also crosses the installation boundary which is approximately 0.07 miles from the range.

Hathcock Range
MCIEAST - MCB Camp Lejeune

Table 5: Groundwater Receptors Element
(These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)

Criteria	Evaluation Characteristics	Score Criteria	Site Score
Wells Identified as Potable Water Sources	*Number and location of potable water or potable water supply wells relative to the location of the range.*	6 if a drinking water well is located within <50 feet of the range 3 if a drinking water well is located downgradient of the range within 50-1,500 feet 0 if there are no drinking water wells located within 1,500 feet downgradient of the range or if groundwater is not used as a drinking water source.	0
	*Into what **type of aquifer is the well set***	6 if unconfined 3 if semi-confined 0 if confined	3
Groundwater wells identified for purpose other than drinking water	*Groundwater wells used for purposes other than drinking water supply identified down gradient of the range.*	3 if a groundwater well is located within 50 feet of the range 1 if a groundwater well is located downgradient of the range within 50-1,500 feet 0 if groundwater well <1,500 feet downgradient of the range is not used for any purpose.	0
Groundwater Receptor Score *Minimum: 0 Maximum: 15*			3

Notes:

The closest well to this range is an off-installation county well that is more than 13,000 feet away.

Hathcock Range
MCIEAST - MCB Camp Lejeune

Table 6: Evaluation Score (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)		
Surface Water / Sediment		
Element	**Table**	**Score**
Range Use and Range Management (Source)	1	13
Surface Water / Sediment Pathways	2	17
Surface Water / Sediment Receptors	4	12
Sum of Surface Water / Sediment Element Scores *Minimum: 0 Maximum: 65*		**42**
Groundwater		
Element	**Table**	**Score**
Range Use and Range Management (Source)	1	13
Groundwater Pathways	3	18
Groundwater Receptors	5	3
Sum of Groundwater Element Scores *Minimum: 0 Maximum: 62*		**34**

Field Sampling and Observed Releases		
Surface Water / Sediment	Surface water sampling conducted Yes ☒ No ☐ Sediment sampling conducted Yes ☐ No ☒ Results exceed DoD screening value Yes ☐ No ☐	**Surface Water / Sediment** ☒ No Modification ☐ High
Groundwater	Groundwater sampling conducted Yes ☐ No ☒ Results exceed DoD screening value Yes ☐ No ☐	**Groundwater** ☒ No Modification ☐ High

The relative evaluation ranking for each media is determined by selecting the appropriate score based on the data elements for that media:

Evaluation Ranking*	Score Range
High	45-65
Moderate	33-44
Minimal	0-32

Surface Water Evaluation Ranking	**Moderate**
Groundwater Evaluation Ranking	**Moderate**

Notes: An upper and lower interval surface water sample was collected in Stones Bay and analyzed for total and dissolved lead. Total lead was detected at 0.44 µg/L and 0.40 µg/L in the upper and lower intervals, respectively. Dissolved lead was detected only in the lower interval sample at a concentration of 2.5 µg/L. Results were below screening criteria.

K-325
MCIEAST - MCB Camp Lejeune
Jacksonville, North Carolina

Date of SARAP update: 11/19/2014

DESCRIPTION

Range Mission:	Combat Marksmanship Program Range
Training Start Date:	1970
Direction of Fire:	Southwest
Firing Positions:	8 firing bunkers
Target Range:	Up to 100 meters
Impact Area(s):	☒ Open area ☐ Hillside ☐ Building ☐ Earthen berm ☐ Bullet trap
Existing BMPs:	☐ Basin/vault ☐ Control fabric ☐ Diversion ☐ Fencing ☐ Rip-rap ☐ Silt check ☒ Vegetation
	Other:
Reference(s):	

FINDINGS

Review Period		**Periodic Review**
Estimated Lead Deposition (lb/yr)		4,723
Surface Water / Sediment	***RANK***	High
	Source	17
	Pathway	19
	Receptor	12
	TOTAL SCORE	48
Groundwater	***RANK***	Moderate
	Source	17
	Pathway	15
	Receptor	3
	TOTAL SCORE	35

RECOMMENDATIONS

☒ Periodically review operations for significant changes in training, management, and use.

☐ Gather additional data regarding ☐ range use, ☐ pathways, or ☐ receptors associated with the range: ______________________________

☒ Collect site-specific field data to further assess potential off-range migration.

K-325
MCIEAST - MCB Camp Lejeune

Table 1: Range Use and Range Management (*Source)* Element **(These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)**			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
MC Loading Rates	*The amount of small arms ammunition expended on the range.* *Estimate the MC loading as average lead deposition rate.*	14 if MC loading > 8,000 pounds/year 11 if MC loading = 4,001-8,000 pounds/year 8 if MC loading = 2,001-4,000 pounds/year 5 if MC loading = 501-2,000 pounds/year 2 if MC loading < 501 pounds/year	11
Impact Area	*The bullet deposition scenario at the range.*	4 if projectiles are scattered in SDZ 3 if range has an impact berm 1 if range has a bullet trap	4
Lead Management	*Frequency of activities that result in the removal of lead from an EARTHERN BERM or SDZ.* *This includes MINOR removal (e.g. scraping and sifting of berm/area, soil amendments) as well as MAJOR removals (e.g. lead mining).*	0 if no notable mining -1 if a MINOR action completed once during either of the last two periodic reviews -2 if MINOR action completed during each of the two previous periodic reviews -3 if MAJOR action was completed once during either of the last two periodic reviews -4 if MAJOR action completed during each of the two previous periodic reviews	0
	Frequency of activities that result in the significant removal of lead from a BULLET TRAP.	-3 if bullet trap was not been serviced during last two periodic reviews -5 if bullet trap was serviced once during either of the last two periodic reviews -7 if bullet trap was serviced during each of the last two periodic reviews	
Duration of Range Use	*Length of time the range has been used.*	2 if > 5 years 0 if ≤ 5 years	2
Source Element Score *Minimum: -4 Maximum: 20*			17
Notes: Annual lead deposition – 4,723 pounds/year. This range has been in use since 1970.			

K-325
MCIEAST - MCB Camp Lejeune

<table>
<tr><th colspan="4">Table 2: Surface Water / Sediment Pathways Characteristics Element
(These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)</th></tr>
<tr><th>Criteria</th><th>Evaluation Characteristics</th><th>Score Criteria</th><th>Site Score</th></tr>
<tr><td>Precipitation</td><td>Rate of precipitation.</td><td>8 if precipitation > 40 inches/year
6 if precipitation = 20-40 inches/year
4 if precipitation < 20 inches/year</td><td>8</td></tr>
<tr><td>Vegetation</td><td>Approximate vegetation cover within and directly downslope of the projectile deposition area.</td><td>6 if vegetation cover < 10%
4 if vegetation cover = 10% to 90%
2 if vegetation cover > 90%</td><td>4</td></tr>
<tr><td>Slope of Range</td><td>Average slope from deposition area along the overland pathway to the first defined channel.</td><td>5 if slope > 10% (5.71°)
3 if slope = 5% to 10%
2 if slope < 5% (2.86°)</td><td>2</td></tr>
<tr><td>pH of Soil</td><td>pH below 6.5 and above 8.5 increases the rate of lead dissolution.</td><td>3 if pH < 4 or >10
2 if pH ≥ 4 < 6.5 or > 8.5 ≤ 10
1 if pH 6.5 ≤ pH ≤ 8.5</td><td>2</td></tr>
<tr><td rowspan="2">Soil Type/ Erosion</td><td>Erosion potential is greatest for fine sands and silt. Clay has the lowest erosion potential. The area where projectiles are deposited should be scored.</td><td>2 if soil type is fine sand / silt
1 if soil type is clayey sand or silt / coarse sands
0 if soil type is clay</td><td>2</td></tr>
<tr><td>Erosion observed at the projectile deposition area.</td><td>5 if there is visual evidence of eroded material being transported from the projectile deposition area
3 if bullet pockets or other indicators of erosion were observed
1 if no erosion was observed</td><td>1</td></tr>
<tr><td>Engineering Controls</td><td>The presence of engineering controls or BMPs to modify or control surface water run-on.
Controls may include barriers or diversions that reduce run-on to the range.</td><td>0 if no engineering controls
-1 if partial engineering controls
-2 if effective engineering controls</td><td>0</td></tr>
</table>

K-325
MCIEAST - MCB Camp Lejeune

Table 2: Surface Water / Sediment Pathways Characteristics Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
	The presence of engineering controls or BMPs to modify or control ***surface water run-off or erosion.*** *Run-off controls may include silt fencing, rip-rap, sedimentation basins, or detention ponds that control run-off from the range. Erosion controls may include soil mix, irrigation, or netting.*	0 if no engineering controls -2 if partial engineering controls -4 if effective engineering controls	0
Surface Water Pathway Score *Minimum: 4 Maximum: 29*			19

Notes:

Jacksonville, NC averages 56” of rainfall per year (MCB Camp Lejeune, 2006).

The majority of the range is covered with grass with some bare areas downrange in what appears to be the bullet impact area. A heavily wooded area exists between the range and the New River.

The K-325 deposition area drains to the south towards the immediately adjacent New River with an approximate slope of 2%.

The primary soil types located at K-325 are the Baymean, Foreston, and Stallings series soils. These are mostly composed of loamy fine sand and have a pH range of 3.6 to 6.5 (USDA, 1992).

K-325
MCIEAST - MCB Camp Lejeune

Table 3: Groundwater Pathways Characteristics Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
Precipitation	*Intensity and frequency of precipitation.*	3 if precipitation > 40 inches/year 2 if precipitation = 20-40 inches/year 1 if precipitation < 20 inches/year	3
Depth to Groundwater	*The potential for impact to the groundwater decreases with an increasing depth to the water table.*	6 if depth to groundwater < 3 feet 3 if depth to groundwater = 3-20 feet 1 if depth to groundwater = 20-100 feet 0 if in a groundwater discharge area or depth to groundwater > 100 feet	3
Soil Type / Infiltration Conditions	*Soil with a higher porosity (sands/gravels) has more infiltration and less runoff compared to soil with low porosity (silts/clays).* ***Most hydraulically restrictive infiltration horizon between the surface and groundwater is scored.***	6 if soil type is sand / gravel 3 if soil type is sand and silt 1 if soil type is clay / clayey sand/silt	3
	Vegetation impedes infiltration and groundwater recharge.	6 if vegetation cover < 10% 3 if vegetation cover = 10% to 90% 1 if vegetation cover > 90%	3
	Average slope from deposition area along the overland pathway to the first defined channel.	3 if slope < 2% (1.15°) 1 if slope = 2% to 20% 0 if slope > 20% (11.31°)	1
pH of Soil	*Lead tends to stay dissolved at pH conditions less than 6.5 and greater than 8.5 but tends to attach to soil particles at pH conditions between these levels.*	3 if pH < 4 or >10 2 if pH ≥ 4 < 6.5 or > 8.5 ≤ 10 1 if pH 6.5 ≤ pH ≤ 8.5	2
Groundwater Pathway Score *Minimum: 4 Maximum: 27*			15

Notes:

Jacksonville, NC averages 56” of rainfall per year (MCB Camp Lejeune, 2006).

Based on measurements collected in the vicinity of this range, the depth to groundwater in this

K-325

MCIEAST - MCB Camp Lejeune

Table 3: Groundwater Pathways Characteristics Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	Evaluation Characteristics	Score Criteria	Site Score
area ranges from 1 to 3 feet below ground surface. The primary soil types located at K-325 are the Baymean, Foreston, and Stallings series soils. These are mostly composed of loamy fine sand and have a pH range of 3.6 to 6.5 (USDA, 1992). The majority of the range is covered with grass with some bare areas downrange in what appears to be the bullet impact area. A heavily wooded area exists between the range and the New River. The K-325 deposition area drains to the south towards the immediately adjacent New River with an approximate slope of 2%.			

K-325
MCIEAST - MCB Camp Lejeune

Table 4: Surface Water / Sediment Receptors Element
(These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)

Criteria	Evaluation Characteristics	Score Criteria	Site Score
Surface Water Body	*Identify if a nearby surface water body is present down gradient, **as defined on the National Hydrography Dataset (NHD) map**.*	8 if surface water body is located downgradient of the range within 1,500 feet 4 if surface water body is located downgradient of the range 1,500-5,000 feet 0 if surface water body is located downgradient of the range over 5,000 feet	8
Drinking Water Use	*Identify if a down gradient surface water body is used as a drinking water source (drainage distance).*	4 if surface water body used as a drinking water source is located downgradient of the range within 1 mile 2 if surface water body used as a drinking water source is located downgradient of the range within 1 to 6 miles 0 if no known drinking water intakes are identified within 6 miles of the range	0
Drainage Distance to Installation Boundary	*Identify downgradient drainage distance to first potential ecological exposure off installation (i.e., installation boundary).*	4 if the installation boundary is located downgradient of the range within 0.5 miles 2 if the installation boundary is located downgradient of the range within 0.5 to 3 miles 0 if the installation boundary is located downgradient of the range greater than 3 miles, or if surface water runoff from the range does not discharge off the installation	4
Surface Water Receptor Score *Minimum: 0 Maximum: 16*			12

Notes:

According to the USGS National Hydrography Map, there is a downgradient marsh located approximately 560 feet southwest of the bullet deposition area. Additionally, the New River is downgradient approximately 600 feet southeast of the bullet deposition area.

Drinking water is obtained from water supply wells throughout the installation. Surface water is not used as a drinking water source at the installation, nor are there any surface water bodies used as drinking water sources within 6 miles of this range.

The drainage pathway can proceed either southwest towards the marsh or southeast directly towards the New River. Assuming the shortest downgradient pathway towards the New River, the surface water drainage can reach the installation boundary approximately 0.13 miles from K-325.

K-325
MCIEAST - MCB Camp Lejeune

Table 5: Groundwater Receptors Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
Wells Identified as Potable Water Sources	*Number and location of potable water or potable water supply wells relative to the location of the range.*	6 if a drinking water well is located within <50 feet of the range 3 if a drinking water well is located downgradient of the range within 50-1,500 feet 0 if there are no drinking water wells located within 1,500 feet downgradient of the range or if groundwater is not used as a drinking water source.	0
	*Into what **type of aquifer is the well set***	6 if unconfined 3 if semi-confined 0 if confined	3
Groundwater wells identified for purpose other than drinking water	*Groundwater wells used for purposes other than drinking water supply identified down gradient of the range.*	3 if a groundwater well is located within 50 feet of the range 1 if a groundwater well is located downgradient of the range within 50-1,500 feet 0 if groundwater well <1,500 feet downgradient of the range is not used for any purpose.	0
Groundwater Receptor Score *Minimum: 0 Maximum: 15*			3

Notes:

The closest well is a non-potable well that is over 2,000 feet from the range.

K-325
MCIEAST - MCB Camp Lejeune

Table 6: Evaluation Score
(These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)

Surface Water / Sediment		
Element	**Table**	**Score**
Range Use and Range Management (Source)	1	17
Surface Water / Sediment Pathways	2	19
Surface Water / Sediment Receptors	4	12
Sum of Surface Water / Sediment Element Scores *Minimum: 0 Maximum: 65*		**48**

Groundwater		
Element	**Table**	**Score**
Range Use and Range Management (Source)	1	17
Groundwater Pathways	3	15
Groundwater Receptors	5	3
Sum of Groundwater Element Scores *Minimum: 0 Maximum: 62*		**35**

Field Sampling and Observed Releases

Surface Water / Sediment	Surface water sampling conducted Yes ☒ No ☐ Sediment sampling conducted Yes ☐ No ☒ Results exceed DoD screening value Yes ☐ No ☒	**Surface Water / Sediment** ☒ No Modification ☐ High
Groundwater	Groundwater sampling conducted Yes ☒ No ☐ Results exceed DoD screening value Yes ☐ No ☒	**Groundwater** ☒ No Modification ☐ High

The relative evaluation ranking for each media is determined by selecting the appropriate score based on the data elements for that media:

Evaluation Ranking*	Score Range
High	45-65
Moderate	33-44
Minimal	0-32

Surface Water Evaluation Ranking	**High**
Groundwater Evaluation Ranking	**Moderate**

Notes: One surface water sample (K2_SW-05) was collected at the confluence of Whitehurst Creek and Stones Bay. Total and dissolved lead were detected at concentrations of 2.1 µg/L and 0.79 µg/L, respectively. Results were below screening criteria.

Two groundwater samples (K2_MW-06 and K2_MW-07) were collected on the downgradient side of the K2 Impact Area. Total lead was detected at concentrations of 0.96 µg/L and 1.7 µg/L. Dissolved lead was detected at concentrations of 1.5 µg/L and 0.26 µg/L. All results were below screening criteria of 15 µg/L.

K-402 and K-402A
MCIEAST - MCB Camp Lejeune
Jacksonville, North Carolina

Date of SARAP update: 11/19/2014

DESCRIPTION

Range Mission:	Individual Tactical Training Range
Training Start Date:	1970
Direction of Fire:	Southeast
Firing Positions:	10
Target Range:	50, 100, 150, 200, 250, and 300 meters
Impact Area(s):	☐ Open area ☐ Hillside ☐ Building ☒ Earthen berm ☐ Bullet trap
Existing BMPs:	☐ Basin/vault ☐ Control fabric ☐ Diversion ☐ Fencing ☐ Rip-rap ☐ Silt check ☐ Vegetation
	Other:
Reference(s):	

FINDINGS

Review Period		**Periodic Review**
Estimated Lead Deposition (lb/yr)		2,274
Surface Water / Sediment	***RANK***	Moderate
	Source	13
	Pathway	19
	Receptor	12
	TOTAL SCORE	44
Groundwater	***RANK***	Minimal
	Source	13
	Pathway	15
	Receptor	3
	TOTAL SCORE	31

RECOMMENDATIONS

☒ Periodically review operations for significant changes in training, management, and use.

☐ Gather additional data regarding ☐ range use, ☐ pathways, or ☐ receptors associated with the range: ______________________________

☐ Collect site-specific field data to further assess potential off-range migration.

K-402 and K-402A
MCIEAST - MCB Camp Lejeune

Table 1: Range Use and Range Management (*Source)* Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
MC Loading Rates	*The amount of small arms ammunition expended on the range.* *Estimate the MC loading as average lead deposition rate.*	14 if MC loading > 8,000 pounds/year 11 if MC loading = 4,001-8,000 pounds/year 8 if MC loading = 2,001-4,000 pounds/year 5 if MC loading = 501-2,000 pounds/year 2 if MC loading < 501 pounds/year	8
Impact Area	*The bullet deposition scenario at the range.*	4 if projectiles are scattered in SDZ 3 if range has an impact berm 1 if range has a bullet trap	3
Lead Management	*Frequency of activities that result in the removal of lead from an EARTHERN BERM or SDZ.* *This includes MINOR removal (e.g. scraping and sifting of berm/area, soil amendments) as well as MAJOR removals (e.g. lead mining).*	0 if no notable mining -1 if a MINOR action completed once during either of the last two periodic reviews -2 if MINOR action completed during each of the two previous periodic reviews -3 if MAJOR action was completed once during either of the last two periodic reviews -4 if MAJOR action completed during each of the two previous periodic reviews	0
	Frequency of activities that result in the significant removal of lead from a BULLET TRAP.	-3 if bullet trap was not been serviced during last two periodic reviews -5 if bullet trap was serviced once during either of the last two periodic reviews -7 if bullet trap was serviced during each of the last two periodic reviews	
Duration of Range Use	*Length of time the range has been used.*	2 if > 5 years 0 if ≤ 5 years	2
Source Element Score *Minimum: -4 Maximum: 20*			13

Notes:

Annual lead deposition – 2,274 pounds/year.

This range has been in use since 1970.

K-402 and K-402A
MCIEAST - MCB Camp Lejeune

Table 2: Surface Water / Sediment Pathways Characteristics Element
(These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)

Criteria	Evaluation Characteristics	Score Criteria	Site Score
Precipitation	*Rate of precipitation.*	8 if precipitation > 40 inches/year 6 if precipitation = 20-40 inches/year 4 if precipitation < 20 inches/year	8
Vegetation	*Approximate vegetation cover **within and directly downslope of the projectile deposition area.***	6 if vegetation cover < 10% 4 if vegetation cover = 10% to 90% 2 if vegetation cover > 90%	4
Slope of Range	*Average slope **from deposition area along the overland pathway to the first defined channel.***	5 if slope > 10% (5.71°) 3 if slope = 5% to 10% 2 if slope < 5% (2.86°)	2
pH of Soil	*pH below 6.5 and above 8.5 increases the rate of lead dissolution.*	3 if pH < 4 or >10 2 if pH ≥ 4 < 6.5 or > 8.5 ≤ 10 1 if pH 6.5 ≤ pH ≤ 8.5	2
Soil Type/ Erosion	*Erosion potential is greatest for fine sands and silt. Clay has the lowest erosion potential. **The area where projectiles are deposited should be scored.***	2 if soil type is fine sand / silt 1 if soil type is clayey sand or silt / coarse sands 0 if soil type is clay	2
	Erosion observed at the projectile deposition area.	5 if there is visual evidence of eroded material being transported from the projectile deposition area 3 if bullet pockets or other indicators of erosion were observed 1 if no erosion was observed	1
Engineering Controls	*The presence of engineering controls or BMPs to modify or control **surface water run-on.*** *Controls may include barriers or diversions that reduce run-on to the range.*	0 if no engineering controls -1 if partial engineering controls -2 if effective engineering controls	0

K-402 and K-402A
MCIEAST - MCB Camp Lejeune

Table 2: Surface Water / Sediment Pathways Characteristics Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
	The presence of engineering controls or BMPs to modify or control ***surface water run-off or erosion.*** *Run-off controls may include silt fencing, rip-rap, sedimentation basins, or detention ponds that control run-off from the range. Erosion controls may include soil mix, irrigation, or netting.*	0 if no engineering controls -2 if partial engineering controls -4 if effective engineering controls	0
Surface Water Pathway Score *Minimum: 4 Maximum: 29*			19

Notes:

Jacksonville, NC averages 56” of rainfall per year (MCB Camp Lejeune, 2006).

The majority of both ranges contain grass with some bare areas around target locations.

The deposition area of these ranges drains south to the tributary of Mill Creek with an approximate slope of 3.9%.

The primary type of soil located at these ranges is the Alpin series which is mostly fine sand and has a pH range of 4.5 to 6.5 (USDA, 1992).

K-402 and K-402A
MCIEAST - MCB Camp Lejeune

Table 3: Groundwater Pathways Characteristics Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
Precipitation	*Intensity and frequency of precipitation.*	3 if precipitation > 40 inches/year 2 if precipitation = 20-40 inches/year 1 if precipitation < 20 inches/year	3
Depth to Groundwater	*The potential for impact to the groundwater decreases with an increasing depth to the water table.*	6 if depth to groundwater < 3 feet 3 if depth to groundwater = 3-20 feet 1 if depth to groundwater = 20-100 feet 0 if in a groundwater discharge area or depth to groundwater > 100 feet	3
Soil Type / Infiltration Conditions	*Soil with a higher porosity (sands/gravels) has more infiltration and less runoff compared to soil with low porosity (silts/clays).* ***Most hydraulically restrictive infiltration horizon between the surface and groundwater is scored.***	6 if soil type is sand / gravel 3 if soil type is sand and silt 1 if soil type is clay / clayey sand/silt	3
	Vegetation impedes infiltration and groundwater recharge.	6 if vegetation cover < 10% 3 if vegetation cover = 10% to 90% 1 if vegetation cover > 90%	3
	Average slope from deposition area along the overland pathway to the first defined channel.	3 if slope < 2% (1.15°) 1 if slope = 2% to 20% 0 if slope > 20% (11.31°)	1
pH of Soil	*Lead tends to stay dissolved at pH conditions less than 6.5 and greater than 8.5 but tends to attach to soil particles at pH conditions between these levels.*	3 if pH < 4 or >10 2 if pH ≥ 4 < 6.5 or > 8.5 ≤ 10 1 if pH 6.5 ≤ pH ≤ 8.5	2
Groundwater Pathway Score *Minimum: 4* *Maximum: 27*			15

Notes:

Jacksonville, NC averages 56" of rainfall per year (MCB Camp Lejeune, 2006).

Based on measurements collected in the vicinity of these ranges, the depth to groundwater in this area is approximately 5 feet below ground surface.

K-402 and K-402A
MCIEAST - MCB Camp Lejeune

Table 3: Groundwater Pathways Characteristics Element
(These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)

Criteria	Evaluation Characteristics	Score Criteria	Site Score
The primary type of soil located at these ranges is the Alpin series which is mostly fine sand and has a pH range of 4.5 to 6.5 (USDA, 1992). The majority of both ranges contain grass with some bare areas around target locations. The deposition area of these ranges drains south to the tributary of Mill Creek with an approximate slope of 3.9%.			

K-402 and K-402A
MCIEAST - MCB Camp Lejeune

Table 4: Surface Water / Sediment Receptors Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
Surface Water Body	*Identify if a nearby surface water body is present down gradient, **as defined on the National Hydrography Dataset (NHD) map**.*	8 if surface water body is located downgradient of the range within 1,500 feet 4 if surface water body is located downgradient of the range 1,500-5,000 feet 0 if surface water body is located downgradient of the range over 5,000 feet	8
Drinking Water Use	*Identify if a down gradient surface water body is used as a drinking water source (drainage distance).*	4 if surface water body used as a drinking water source is located downgradient of the range within 1 mile 2 if surface water body used as a drinking water source is located downgradient of the range within 1 to 6 miles 0 if no known drinking water intakes are identified within 6 miles of the range	0
Drainage Distance to Installation Boundary	*Identify downgradient drainage distance to first potential ecological exposure off installation (i.e., installation boundary).*	4 if the installation boundary is located downgradient of the range within 0.5 miles 2 if the installation boundary is located downgradient of the range within 0.5 to 3 miles 0 if the installation boundary is located downgradient of the range greater than 3 miles, or if surface water runoff from the range does not discharge off the installation	4
Surface Water Receptor Score *Minimum: 0 Maximum: 16*			12

Notes:

According to the USGS National Hydrography Map, there is a downgradient perennial stream located approximately 400 feet southeast of the bullet deposition area.

Drinking water is obtained from water supply wells throughout the installation. Surface water is not used as a drinking water source at the installation, nor are there any surface water bodies used as drinking water sources within 6 miles of these ranges.

The drainage pathway from K-402 and K-402A proceeds southeast from the bullet deposition area to a perennial stream that generally flows south towards the New River. This drainage pathway crosses the installation boundary approximately 0.4 miles from the ranges.

K-402 and K-402A
MCIEAST - MCB Camp Lejeune

Table 5: Groundwater Receptors Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
Wells Identified as Potable Water Sources	*Number and location of potable water or potable water supply wells relative to the location of the range.*	6 if a drinking water well is located within <50 feet of the range 3 if a drinking water well is located downgradient of the range within 50-1,500 feet 0 if there are no drinking water wells located within 1,500 feet downgradient of the range or if groundwater is not used as a drinking water source.	0
	*Into what **type of aquifer is the well set***	6 if unconfined 3 if semi-confined 0 if confined	3
Groundwater wells identified for purpose other than drinking water	*Groundwater wells used for purposes other than drinking water supply identified down gradient of the range.*	3 if a groundwater well is located within 50 feet of the range 1 if a groundwater well is located downgradient of the range within 50-1,500 feet 0 if groundwater well <1,500 feet downgradient of the range is not used for any purpose.	0
Groundwater Receptor Score *Minimum: 0 Maximum: 15*			3

<u>Notes:</u>

The closest well is a non-potable well that is located more than 6,000 feet from the ranges.

K-402 and K-402A
MCIEAST - MCB Camp Lejeune

Table 6: Evaluation Score
(These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)

Surface Water / Sediment

Element	Table	Score
Range Use and Range Management (Source)	1	13
Surface Water / Sediment Pathways	2	19
Surface Water / Sediment Receptors	4	12
Sum of Surface Water / Sediment Element Scores *Minimum: 0 Maximum: 65*		**44**

Groundwater

Element	Table	Score
Range Use and Range Management (Source)	1	13
Groundwater Pathways	3	15
Groundwater Receptors	5	3
Sum of Groundwater Element Scores *Minimum: 0 Maximum: 62*		**31**

Field Sampling and Observed Releases

Surface Water / Sediment	Surface water sampling conducted Yes ☒ No ☐ Sediment sampling conducted Yes ☐ No ☒ Results exceed DoD screening value Yes ☐ No ☒	**Surface Water / Sediment** ☒ No Modification ☐ High
Groundwater	Groundwater sampling conducted Yes ☐ No ☒ Results exceed DoD screening value Yes ☐ No ☐	**Groundwater** ☒ No Modification ☐ High

The relative evaluation ranking for each media is determined by selecting the appropriate score based on the data elements for that media:

Evaluation Ranking*	Score Range
High	45-65
Moderate	33-44
Minimal	0-32

Surface Water Evaluation Ranking	**Moderate**
Groundwater Evaluation Ranking	**Minimal**

Notes: One surface water sample (K2_SW-02) was collected at the confluence of Mill Creek and Stones Bay. Total and dissolved lead were detected at concentrations of 3.3 μg/L and 2.5 μg/L, respectively. Results were below screening criteria.

K-406A and K-406B
MCIEAST - MCB Camp Lejeune
Jacksonville, North Carolina

Date of SARAP update: 11/19/2014

DESCRIPTION

Range Mission:	Combat Marksmanship Program and Close Combat Range
Training Start Date:	1970
Direction of Fire:	Southeast
Firing Positions:	Variable
Target Range:	Variable
Impact Area(s):	☒ Open area ☐ Hillside ☐ Building ☐ Earthen berm ☐ Bullet trap
Existing BMPs:	☐ Basin/vault ☐ Control fabric ☐ Diversion ☐ Fencing ☐ Rip-rap ☐ Silt check ☐ Vegetation
	Other:
Reference(s):	

FINDINGS

Review Period		**Periodic Review**
Estimated Lead Deposition (lb/yr)		8,254
Surface Water / Sediment	***RANK***	High
	Source	20
	Pathway	19
	Receptor	12
	TOTAL SCORE	51
Groundwater	***RANK***	Moderate
	Source	20
	Pathway	17
	Receptor	3
	TOTAL SCORE	40

RECOMMENDATIONS

☒ Periodically review operations for significant changes in training, management, and use.

☐ Gather additional data regarding ☐ range use, ☐ pathways, or ☐ receptors associated with the range: ____________________

☒ Collect site-specific field data to further assess potential off-range migration.

K-406A and K-406B
MCIEAST - MCB Camp Lejeune

Table 1: Range Use and Range Management (*Source)* Element
(These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)

Criteria	Evaluation Characteristics	Score Criteria	Site Score
MC Loading Rates	*The amount of small arms ammunition expended on the range.* *Estimate the MC loading as average lead deposition rate.*	14 if MC loading > 8,000 pounds/year 11 if MC loading = 4,001-8,000 pounds/year 8 if MC loading = 2,001-4,000 pounds/year 5 if MC loading = 501-2,000 pounds/year 2 if MC loading < 501 pounds/year	14
Impact Area	*The bullet deposition scenario at the range.*	4 if projectiles are scattered in SDZ 3 if range has an impact berm 1 if range has a bullet trap	4
Lead Management	*Frequency of activities that result in the removal of lead from an EARTHERN BERM or SDZ.* *This includes MINOR removal (e.g. scraping and sifting of berm/area, soil amendments) as well as MAJOR removals (e.g. lead mining).*	0 if no notable mining -1 if a MINOR action completed once during either of the last two periodic reviews -2 if MINOR action completed during each of the two previous periodic reviews -3 if MAJOR action was completed once during either of the last two periodic reviews -4 if MAJOR action completed during each of the two previous periodic reviews	0
	Frequency of activities that result in the significant removal of lead from a BULLET TRAP.	-3 if bullet trap was not been serviced during last two periodic reviews -5 if bullet trap was serviced once during either of the last two periodic reviews -7 if bullet trap was serviced during each of the last two periodic reviews	
Duration of Range Use	*Length of time the range has been used.*	2 if > 5 years 0 if ≤ 5 years	2
Source Element Score *Minimum: -4 Maximum: 20*			20

Notes:

Annual lead deposition – 8,254 pounds/year.

These ranges have been in use since 1970.

K-406A and K-406B
MCIEAST - MCB Camp Lejeune

Table 2: Surface Water / Sediment Pathways Characteristics Element
(These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)

Criteria	Evaluation Characteristics	Score Criteria	Site Score
Precipitation	*Rate of precipitation.*	8 if precipitation > 40 inches/year 6 if precipitation = 20-40 inches/year 4 if precipitation < 20 inches/year	8
Vegetation	*Approximate vegetation cover **within and directly downslope of the projectile deposition area.***	6 if vegetation cover < 10% 4 if vegetation cover = 10% to 90% 2 if vegetation cover > 90%	4
Slope of Range	*Average slope **from deposition area along the overland pathway to the first defined channel.***	5 if slope > 10% (5.71°) 3 if slope = 5% to 10% 2 if slope < 5% (2.86°)	2
pH of Soil	*pH below 6.5 and above 8.5 increases the rate of lead dissolution.*	3 if pH < 4 or >10 2 if pH ≥ 4 < 6.5 or > 8.5 ≤ 10 1 if pH 6.5 ≤ pH ≤ 8.5	2
Soil Type/ Erosion	*Erosion potential is greatest for fine sands and silt. Clay has the lowest erosion potential. **The area where projectiles are deposited should be scored.***	2 if soil type is fine sand / silt 1 if soil type is clayey sand or silt / coarse sands 0 if soil type is clay	2
	Erosion observed at the projectile deposition area.	5 if there is visual evidence of eroded material being transported from the projectile deposition area 3 if bullet pockets or other indicators of erosion were observed 1 if no erosion was observed	1
Engineering Controls	*The presence of engineering controls or BMPs to modify or control **surface water run-on.*** *Controls may include barriers or diversions that reduce run-on to the range.*	0 if no engineering controls -1 if partial engineering controls -2 if effective engineering controls	0

K-406A and K-406B
MCIEAST - MCB Camp Lejeune

Table 2: Surface Water / Sediment Pathways Characteristics Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
	The presence of engineering controls or BMPs to modify or control ***surface water run-off or erosion.*** *Run-off controls may include silt fencing, rip-rap, sedimentation basins, or detention ponds that control run-off from the range. Erosion controls may include soil mix, irrigation, or netting.*	0 if no engineering controls -2 if partial engineering controls -4 if effective engineering controls	0
Surface Water Pathway Score *Minimum: 4 Maximum: 29*			19

Notes:

Jacksonville, NC averages 56" of rainfall per year (MCB Camp Lejeune, 2006).

The majority of K-406A and K-406B contain grass with some bare areas around target locations.

The deposition areas of these ranges drain southeast to a tributary stream of Mill Creek with an approximate slope of 0.4%.

The primary soil types located at K-406A and K406B consist of Baymean, Foreston, and Stallings series soils. These are mostly composed of loamy fine sand and have a pH range of 3.6 to 6.5 (USDA, 1992).

K-406A and K-406B
MCIEAST - MCB Camp Lejeune

Table 3: Groundwater Pathways Characteristics Element
(These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)

Criteria	Evaluation Characteristics	Score Criteria	Site Score
Precipitation	*Intensity and frequency of precipitation.*	3 if precipitation > 40 inches/year 2 if precipitation = 20-40 inches/year 1 if precipitation < 20 inches/year	3
Depth to Groundwater	*The potential for impact to the groundwater decreases with an increasing depth to the water table.*	6 if depth to groundwater < 3 feet 3 if depth to groundwater = 3-20 feet 1 if depth to groundwater = 20-100 feet 0 if in a groundwater discharge area or depth to groundwater > 100 feet	3
Soil Type / Infiltration Conditions	*Soil with a higher porosity (sands/gravels) has more infiltration and less runoff compared to soil with low porosity (silts/clays).* ***Most hydraulically restrictive infiltration horizon between the surface and groundwater is scored.***	6 if soil type is sand / gravel 3 if soil type is sand and silt 1 if soil type is clay / clayey sand/silt	3
	Vegetation impedes infiltration and groundwater recharge.	6 if vegetation cover < 10% 3 if vegetation cover = 10% to 90% 1 if vegetation cover > 90%	3
	Average slope from deposition area along the overland pathway to the first defined channel.	3 if slope < 2% (1.15°) 1 if slope = 2% to 20% 0 if slope > 20% (11.31°)	3
pH of Soil	*Lead tends to stay dissolved at pH conditions less than 6.5 and greater than 8.5 but tends to attach to soil particles at pH conditions between these levels.*	3 if pH < 4 or >10 2 if pH ≥ 4 < 6.5 or > 8.5 ≤ 10 1 if pH 6.5 ≤ pH ≤ 8.5	2
Groundwater Pathway Score *Minimum: 4 Maximum: 27*			17

Notes:

Jacksonville, NC averages 56" of rainfall per year (MCB Camp Lejeune, 2006).

Based on measurements collected in the vicinity of these ranges, the depth to groundwater in this area is approximately 5 feet below ground surface.

K-406A and K-406B
MCIEAST - MCB Camp Lejeune

Table 3: Groundwater Pathways Characteristics Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	Evaluation Characteristics	Score Criteria	Site Score

The primary soil types located at K-406A and K406B consist of Baymean, Foreston, and Stallings series soils. These are mostly composed of loamy fine sand and have a pH range of 3.6 to 6.5 (USDA, 1992).

The majority of K-406A and K-406B contain grass with some bare areas around target locations.

The deposition areas of these ranges drain southeast to a tributary stream of Mill Creek with an approximate slope of 0.4%.

K-406A and K-406B
MCIEAST - MCB Camp Lejeune

Table 4: Surface Water / Sediment Receptors Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
Surface Water Body	*Identify if a nearby surface water body is present down gradient, **as defined on the National Hydrography Dataset (NHD) map**.*	8 if surface water body is located downgradient of the range within 1,500 feet 4 if surface water body is located downgradient of the range 1,500-5,000 feet 0 if surface water body is located downgradient of the range over 5,000 feet	8
Drinking Water Use	*Identify if a down gradient surface water body is used as a drinking water source (drainage distance).*	4 if surface water body used as a drinking water source is located downgradient of the range within 1 mile 2 if surface water body used as a drinking water source is located downgradient of the range within 1 to 6 miles 0 if no known drinking water intakes are identified within 6 miles of the range	0
Drainage Distance to Installation Boundary	*Identify downgradient drainage distance to first potential ecological exposure off installation (i.e., installation boundary).*	4 if the installation boundary is located downgradient of the range within 0.5 miles 2 if the installation boundary is located downgradient of the range within 0.5 to 3 miles 0 if the installation boundary is located downgradient of the range greater than 3 miles, or if surface water runoff from the range does not discharge off the installation	4
Surface Water Receptor Score *Minimum: 0 Maximum: 16*			12

Notes:

According to the USGS National Hydrography Map, there is a downgradient perennial stream located approximately 540 feet southeast of the bullet deposition area.

Drinking water is obtained from water supply wells throughout the installation. Surface water is not used as a drinking water source at the installation, nor are there any surface water bodies used as drinking water sources within 6 miles of these ranges.

The drainage pathway from K-406A and K-406B proceeds southeast from the bullet deposition area to a perennial stream that generally flows south towards the New River. This drainage pathway crosses the installation boundary approximately 0.25 miles from the ranges.

K-406A and K-406B
MCIEAST - MCB Camp Lejeune

Table 5: Groundwater Receptors Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
Wells Identified as Potable Water Sources	*Number and location of potable water or potable water supply wells relative to the location of the range.*	6 if a drinking water well is located within <50 feet of the range 3 if a drinking water well is located downgradient of the range within 50-1,500 feet 0 if there are no drinking water wells located within 1,500 feet downgradient of the range or if groundwater is not used as a drinking water source.	0
	*Into what **type of aquifer is the well set***	6 if unconfined 3 if semi-confined 0 if confined	3
Groundwater wells identified for purpose other than drinking water	*Groundwater wells used for purposes other than drinking water supply identified down gradient of the range.*	3 if a groundwater well is located within 50 feet of the range 1 if a groundwater well is located downgradient of the range within 50-1,500 feet 0 if groundwater well <1,500 feet downgradient of the range is not used for any purpose.	0
Groundwater Receptor Score *Minimum: 0 Maximum: 15*			3
Notes: The closest well is a non-potable well that is located more than 6,000 feet from the ranges.			

K-406A and K-406B
MCIEAST - MCB Camp Lejeune

Table 6: Evaluation Score
(These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)

Surface Water / Sediment		
Element	**Table**	**Score**
Range Use and Range Management (Source)	1	20
Surface Water / Sediment Pathways	2	19
Surface Water / Sediment Receptors	4	12
Sum of Surface Water / Sediment Element Scores *Minimum: 0 Maximum: 65*		**51**
Groundwater		
Element	**Table**	**Score**
Range Use and Range Management (Source)	1	20
Groundwater Pathways	3	17
Groundwater Receptors	5	3
Sum of Groundwater Element Scores *Minimum: 0 Maximum: 62*		**40**

Field Sampling and Observed Releases

Surface Water / Sediment	Surface water sampling conducted Yes ☒ No ☐ Sediment sampling conducted Yes ☐ No ☒ Results exceed DoD screening value Yes ☐ No ☒	**Surface Water / Sediment** ☒ No Modification ☐ High
Groundwater	Groundwater sampling conducted Yes ☐ No ☒ Results exceed DoD screening value Yes ☐ No ☐	**Groundwater** ☒ No Modification ☐ High

The relative evaluation ranking for each media is determined by selecting the appropriate score based on the data elements for that media:

Evaluation Ranking*	Score Range
High	45-65
Moderate	33-44
Minimal	0-32

Surface Water Evaluation Ranking	**High**
Groundwater Evaluation Ranking	**Moderate**

Notes: One surface water sample (K2_SW-02) was collected at the confluence of Mill Creek and Stones Bay. Total and dissolved lead were detected at concentrations of 3.3 μg/L and 2.5 μg/L, respectively. Results were below screening criteria.

K-501 and K-501A
MCIEAST - MCB Camp Lejeune
Jacksonville, North Carolina

Date of SARAP update: 11/19/2014

DESCRIPTION

Range Mission:	Combat Marksmanship Program and Close Combat Range
Training Start Date:	2010
Direction of Fire:	Southeast
Firing Positions:	Variable
Target Range:	Variable
Impact Area(s):	☒ Open area ☐ Hillside ☐ Building ☐ Earthen berm ☐ Bullet trap
Existing BMPs:	☐ Basin/vault ☐ Control fabric ☐ Diversion ☐ Fencing ☐ Rip-rap ☐ Silt check ☐ Vegetation *Other:*
Reference(s):	

FINDINGS

Review Period		**Periodic Review**
Estimated Lead Deposition (lb/yr)		8,133
Surface Water / Sediment	***RANK***	Moderate
	Source	18
	Pathway	16
	Receptor	10
	TOTAL SCORE	44
Groundwater	***RANK***	Moderate
	Source	18
	Pathway	17
	Receptor	4
	TOTAL SCORE	39

RECOMMENDATIONS

☒ Periodically review operations for significant changes in training, management, and use.

☐ Gather additional data regarding ☐ range use, ☐ pathways, or ☐ receptors associated with the range: ____________________

☒ Collect site-specific field data to further assess potential off-range migration.

K-501 and K-501A
MCIEAST - MCB Camp Lejeune

Table 1: Range Use and Range Management (*Source)* Element
(These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)

Criteria	Evaluation Characteristics	Score Criteria	Site Score
MC Loading Rates	*The amount of small arms ammunition expended on the range.* *Estimate the MC loading as average lead deposition rate.*	14 if MC loading > 8,000 pounds/year 11 if MC loading = 4,001-8,000 pounds/year 8 if MC loading = 2,001-4,000 pounds/year 5 if MC loading = 501-2,000 pounds/year 2 if MC loading < 501 pounds/year	14
Impact Area	*The bullet deposition scenario at the range.*	4 if projectiles are scattered in SDZ 3 if range has an impact berm 1 if range has a bullet trap	4
Lead Management	*Frequency of activities that result in the removal of lead from an EARTHERN BERM or SDZ.* *This includes MINOR removal (e.g. scraping and sifting of berm/area, soil amendments) as well as MAJOR removals (e.g. lead mining).*	0 if no notable mining -1 if a MINOR action completed once during either of the last two periodic reviews -2 if MINOR action completed during each of the two previous periodic reviews -3 if MAJOR action was completed once during either of the last two periodic reviews -4 if MAJOR action completed during each of the two previous periodic reviews	0
	Frequency of activities that result in the significant removal of lead from a BULLET TRAP.	-3 if bullet trap was not been serviced during last two periodic reviews -5 if bullet trap was serviced once during either of the last two periodic reviews -7 if bullet trap was serviced during each of the last two periodic reviews	
Duration of Range Use	*Length of time the range has been used.*	2 if > 5 years 0 if ≤ 5 years	0
Source Element Score *Minimum: -4 Maximum: 20*			18

Notes:

Annual lead deposition – 8,133 pounds/year.

There are protective berms in place to protect the target systems but no impact berms or bullet traps are present.

These ranges have been in use since 2010.

K-501 and K-501A
MCIEAST - MCB Camp Lejeune

Table 2: Surface Water / Sediment Pathways Characteristics Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
Precipitation	*Rate of precipitation.*	8 if precipitation > 40 inches/year 6 if precipitation = 20-40 inches/year 4 if precipitation < 20 inches/year	8
Vegetation	*Approximate vegetation cover **within and directly downslope of the projectile deposition area.***	6 if vegetation cover < 10% 4 if vegetation cover = 10% to 90% 2 if vegetation cover > 90%	4
Slope of Range	*Average slope **from deposition area along the overland pathway to the first defined channel.***	5 if slope > 10% (5.71°) 3 if slope = 5% to 10% 2 if slope < 5% (2.86°)	2
pH of Soil	*pH below 6.5 and above 8.5 increases the rate of lead dissolution.*	3 if pH < 4 or >10 2 if pH ≥ 4 < 6.5 or > 8.5 ≤ 10 1 if pH 6.5 ≤ pH ≤ 8.5	2
Soil Type/ Erosion	*Erosion potential is greatest for fine sands and silt. Clay has the lowest erosion potential. **The area where projectiles are deposited should be scored.***	2 if soil type is fine sand / silt 1 if soil type is clayey sand or silt / coarse sands 0 if soil type is clay	2
	Erosion observed at the projectile deposition area.	5 if there is visual evidence of eroded material being transported from the projectile deposition area 3 if bullet pockets or other indicators of erosion were observed 1 if no erosion was observed	1
Engineering Controls	*The presence of engineering controls or BMPs to modify or control **surface water run-on.*** *Controls may include barriers or diversions that reduce run-on to the range.*	0 if no engineering controls -1 if partial engineering controls -2 if effective engineering controls	-1

K-501 and K-501A
MCIEAST - MCB Camp Lejeune

Criteria	Evaluation Characteristics	Score Criteria	Site Score
Table 2: Surface Water / Sediment Pathways Characteristics Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
	The presence of engineering controls or BMPs to modify or control ***surface water run-off or erosion.*** *Run-off controls may include silt fencing, rip-rap, sedimentation basins, or detention ponds that control run-off from the range. Erosion controls may include soil mix, irrigation, or netting.*	0 if no engineering controls -2 if partial engineering controls -4 if effective engineering controls	-2
Surface Water Pathway Score *Minimum: 4 Maximum: 29*			16

Notes:

Jacksonville, NC averages 56" of rainfall per year (MCB Camp Lejeune, 2006).

The majority of both ranges contain grass with some bare areas on the protective target berms.

The deposition areas of K-501 and K-501A drain southeast to a drainage channel that eventually drains to Town Creek and Whitehurst creek within two separate subwatersheds. The slope from the deposition area to the drainage channel is approximately 1.2%.

The primary soil types located at K-501 and K-501A consist of Norfolk and Pantego series soils. These are mostly composed of loamy fine sand and mucky loam and have a pH range of 3.6 to 6 (USDA, 1992).

A drainage channel runs along the western edge of the ranges which diverts surface water flow around the ranges to the south and helps to prevent run-on. Additionally, vegetated drainage features are present around each elevated row of targets to contain and slow surface water run-off.

K-501 and K-501A
MCIEAST - MCB Camp Lejeune

Table 3: Groundwater Pathways Characteristics Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
Precipitation	*Intensity and frequency of precipitation.*	3 if precipitation > 40 inches/year 2 if precipitation = 20-40 inches/year 1 if precipitation < 20 inches/year	3
Depth to Groundwater	*The potential for impact to the groundwater decreases with an increasing depth to the water table.*	6 if depth to groundwater < 3 feet 3 if depth to groundwater = 3-20 feet 1 if depth to groundwater = 20-100 feet 0 if in a groundwater discharge area or depth to groundwater > 100 feet	3
Soil Type / Infiltration Conditions	*Soil with a higher porosity (sands/gravels) has more infiltration and less runoff compared to soil with low porosity (silts/clays).* ***Most hydraulically restrictive infiltration horizon between the surface and groundwater is scored.***	6 if soil type is sand / gravel 3 if soil type is sand and silt 1 if soil type is clay / clayey sand/silt	3
	Vegetation impedes infiltration and groundwater recharge.	6 if vegetation cover < 10% 3 if vegetation cover = 10% to 90% 1 if vegetation cover > 90%	3
	Average slope from deposition area along the overland pathway to the first defined channel.	3 if slope < 2% (1.15°) 1 if slope = 2% to 20% 0 if slope > 20% (11.31°)	3
pH of Soil	*Lead tends to stay dissolved at pH conditions less than 6.5 and greater than 8.5 but tends to attach to soil particles at pH conditions between these levels.*	3 if pH < 4 or >10 2 if pH ≥ 4 < 6.5 or > 8.5 ≤ 10 1 if pH 6.5 ≤ pH ≤ 8.5	2
Groundwater Pathway Score *Minimum: 4* *Maximum: 27*			17

<u>Notes:</u>

Jacksonville, NC averages 56” of rainfall per year (MCB Camp Lejeune, 2006).

Based on measurements collected in the vicinity of these ranges, the depth to groundwater in this area is approximately 5 feet below ground surface.

K-501 and K-501A
MCIEAST - MCB Camp Lejeune

Table 3: Groundwater Pathways Characteristics Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	Evaluation Characteristics	Score Criteria	Site Score
The primary soil types located at K-501 and K-501A consist of Norfolk and Pantego series soils. These are mostly composed of loamy fine sand and mucky loam and have a pH range of 3.6 to 6 (USDA, 1992). The majority of both ranges contain grass with some bare areas on the protective target berms. The deposition areas of K-501 and K-501A drain southeast to a drainage channel that eventually drains to Town Creek and Whitehurst creek within two separate subwatersheds. The slope from the deposition area to the drainage channel is approximately 1.2%.			

K-501 and K-501A
MCIEAST - MCB Camp Lejeune

Table 4: Surface Water / Sediment Receptors Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
Surface Water Body	*Identify if a nearby surface water body is present down gradient,* ***as defined on the National Hydrography Dataset (NHD) map****.*	8 if surface water body is located downgradient of the range within 1,500 feet 4 if surface water body is located downgradient of the range 1,500-5,000 feet 0 if surface water body is located downgradient of the range over 5,000 feet	8
Drinking Water Use	*Identify if a down gradient surface water body is used as a drinking water source (drainage distance).*	4 if surface water body used as a drinking water source is located downgradient of the range within 1 mile 2 if surface water body used as a drinking water source is located downgradient of the range within 1 to 6 miles 0 if no known drinking water intakes are identified within 6 miles of the range	0
Drainage Distance to Installation Boundary	*Identify downgradient drainage distance to first potential ecological exposure off installation (i.e., installation boundary).*	4 if the installation boundary is located downgradient of the range within 0.5 miles 2 if the installation boundary is located downgradient of the range within 0.5 to 3 miles 0 if the installation boundary is located downgradient of the range greater than 3 miles, or if surface water runoff from the range does not discharge off the installation	2
Surface Water Receptor Score *Minimum: 0 Maximum: 16*			10

Notes:

According to the USGS National Hydrography Map, there is a downgradient tributary of the Whitehurst Creek located approximately 1,400 feet southeast of the bullet deposition area.

Drinking water is obtained from water supply wells throughout the installation. Surface water is not used as a drinking water source at the installation, nor are there any surface water bodies used as drinking water sources within 6 miles of these ranges.

The drainage pathway from K-501 and K-501A proceeds southeast from the bullet deposition area to a tributary of Whitehurst Creek that generally flows east towards the New River. This drainage pathway crosses the installation boundary approximately 1.7 miles from the ranges.

K-501 and K-501A
MCIEAST - MCB Camp Lejeune

Table 5: Groundwater Receptors Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
Wells Identified as Potable Water Sources	*Number and location of potable water or potable water supply wells relative to the location of the range.*	6 if a drinking water well is located within <50 feet of the range 3 if a drinking water well is located downgradient of the range within 50-1,500 feet 0 if there are no drinking water wells located within 1,500 feet downgradient of the range or if groundwater is not used as a drinking water source.	0
	*Into what **type of aquifer is the well set***	6 if unconfined 3 if semi-confined 0 if confined	3
Groundwater wells identified for purpose other than drinking water	*Groundwater wells used for purposes other than drinking water supply identified down gradient of the range.*	3 if a groundwater well is located within 50 feet of the range 1 if a groundwater well is located downgradient of the range within 50-1,500 feet 0 if groundwater well <1,500 feet downgradient of the range is not used for any purpose.	1
Groundwater Receptor Score *Minimum: 0 Maximum: 15*			4
Notes: The closest well is a non-potable well located approximately 1,200 feet from the ranges.			

K-501 and K-501A
MCIEAST - MCB Camp Lejeune

Table 6: Evaluation Score (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)		
Surface Water / Sediment		
Element	**Table**	**Score**
Range Use and Range Management (Source)	1	18
Surface Water / Sediment Pathways	2	16
Surface Water / Sediment Receptors	4	10
Sum of Surface Water / Sediment Element Scores *Minimum: 0 Maximum: 65*		**44**
Groundwater		
Element	**Table**	**Score**
Range Use and Range Management (Source)	1	18
Groundwater Pathways	3	17
Groundwater Receptors	5	4
Sum of Groundwater Element Scores *Minimum: 0 Maximum: 62*		**39**

Field Sampling and Observed Releases		
Surface Water / Sediment	Surface water sampling conducted Yes ☒ No ☐ Sediment sampling conducted Yes ☐ No ☒ Results exceed DoD screening value Yes ☐ No ☒	**Surface Water / Sediment** ☒ No Modification ☐ High
Groundwater	Groundwater sampling conducted Yes ☒ No ☐ Results exceed DoD screening value Yes ☐ No ☒	**Groundwater** ☒ No Modification ☐ High

The relative evaluation ranking for each media is determined by selecting the appropriate score based on the data elements for that media:

Evaluation Ranking*	Score Range
High	45-65
Moderate	33-44
Minimal	0-32

Surface Water Evaluation Ranking	**Moderate**
Groundwater Evaluation Ranking	**Moderate**

Notes: One surface water sample (K2_SW-05) was collected at the confluence of Whitehurst Creek and Stones Bay. Total and dissolved lead were detected at concentrations of 2.1 µg/L and 0.79 µg/L, respectively. Results were below screening criteria.

Two groundwater samples (K2_MW-06 and K2_MW-07) were collected on the downgradient side of the K2 Impact Area. Total lead was detected at concentrations of 0.96 µg/L and 1.7 µg/L. Dissolved lead was detected at concentrations of 1.5 µg/L and 0.26 µg/L. All results were below screening criteria of 15 µg/L.

K-503 and K-503A
MCIEAST - MCB Camp Lejeune
Jacksonville, North Carolina

Date of SARAP update: 11/19/2014

DESCRIPTION

Range Mission:	Combat Marksmanship Program and Close Combat Range
Training Start Date:	2009
Direction of Fire:	Southeast
Firing Positions:	Variable
Target Range:	Variable
Impact Area(s):	☒ Open area ☐ Hillside ☐ Building ☐ Earthen berm ☐ Bullet trap
Existing BMPs:	☐ Basin/vault ☐ Control fabric ☐ Diversion ☐ Fencing ☐ Rip-rap ☐ Silt check ☐ Vegetation *Other:*
Reference(s):	

FINDINGS

Review Period		**Periodic Review**
Estimated Lead Deposition (lb/yr)		9,203
Surface Water / Sediment	***RANK***	High
	Source	20
	Pathway	18
	Receptor	10
	TOTAL SCORE	48
Groundwater	***RANK***	Moderate
	Source	20
	Pathway	15
	Receptor	4
	TOTAL SCORE	39

RECOMMENDATIONS

☒ Periodically review operations for significant changes in training, management, and use.

☐ Gather additional data regarding ☐ range use, ☐ pathways, or ☐ receptors associated with the range: ______________________________

☒ Collect site-specific field data to further assess potential off-range migration.

K-503 and K-503A
MCIEAST - MCB Camp Lejeune

Table 1: Range Use and Range Management (*Source)* Element
(These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)

Criteria	Evaluation Characteristics	Score Criteria	Site Score
MC Loading Rates	*The amount of small arms ammunition expended on the range.* *Estimate the MC loading as average lead deposition rate.*	14 if MC loading > 8,000 pounds/year 11 if MC loading = 4,001-8,000 pounds/year 8 if MC loading = 2,001-4,000 pounds/year 5 if MC loading = 501-2,000 pounds/year 2 if MC loading < 501 pounds/year	14
Impact Area	*The bullet deposition scenario at the range.*	4 if projectiles are scattered in SDZ 3 if range has an impact berm 1 if range has a bullet trap	4
Lead Management	*Frequency of activities that result in the removal of lead from an EARTHERN BERM or SDZ.* *This includes MINOR removal (e.g. scraping and sifting of berm/area, soil amendments) as well as MAJOR removals (e.g. lead mining).*	0 if no notable mining -1 if a MINOR action completed once during either of the last two periodic reviews -2 if MINOR action completed during each of the two previous periodic reviews -3 if MAJOR action was completed once during either of the last two periodic reviews -4 if MAJOR action completed during each of the two previous periodic reviews	0
	Frequency of activities that result in the significant removal of lead from a BULLET TRAP.	-3 if bullet trap was not been serviced during last two periodic reviews -5 if bullet trap was serviced once during either of the last two periodic reviews -7 if bullet trap was serviced during each of the last two periodic reviews	
Duration of Range Use	*Length of time the range has been used.*	2 if > 5 years 0 if ≤ 5 years	2
Source Element Score *Minimum: -4 Maximum: 20*			20

Notes:

Annual lead deposition – 9,203 pounds/year.

There are protective berms in place for the target systems however there are no earthen berms or bullet traps present.

This range has been in use since 2009.

K-503 and K-503A
MCIEAST - MCB Camp Lejeune

Table 2: Surface Water / Sediment Pathways Characteristics Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
Precipitation	*Rate of precipitation.*	8 if precipitation > 40 inches/year 6 if precipitation = 20-40 inches/year 4 if precipitation < 20 inches/year	8
Vegetation	*Approximate vegetation cover* ***within and directly downslope of the projectile deposition area.***	6 if vegetation cover < 10% 4 if vegetation cover = 10% to 90% 2 if vegetation cover > 90%	4
Slope of Range	*Average slope* ***from deposition area along the overland pathway to the first defined channel.***	5 if slope > 10% (5.71°) 3 if slope = 5% to 10% 2 if slope < 5% (2.86°)	2
pH of Soil	*pH below 6.5 and above 8.5 increases the rate of lead dissolution.*	3 if pH < 4 or >10 2 if pH ≥ 4 < 6.5 or > 8.5 ≤ 10 1 if pH 6.5 ≤ pH ≤ 8.5	2
Soil Type/ Erosion	*Erosion potential is greatest for fine sands and silt. Clay has the lowest erosion potential.* ***The area where projectiles are deposited should be scored.***	2 if soil type is fine sand / silt 1 if soil type is clayey sand or silt / coarse sands 0 if soil type is clay	2
	Erosion observed at the projectile deposition area.	5 if there is visual evidence of eroded material being transported from the projectile deposition area 3 if bullet pockets or other indicators of erosion were observed 1 if no erosion was observed	3
Engineering Controls	*The presence of engineering controls or BMPs to modify or control* ***surface water run-on.*** *Controls may include barriers or diversions that reduce run-on to the range.*	0 if no engineering controls -1 if partial engineering controls -2 if effective engineering controls	-1

K-503 and K-503A
MCIEAST - MCB Camp Lejeune

Table 2: Surface Water / Sediment Pathways Characteristics Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
	The presence of engineering controls or BMPs to modify or control ***surface water run-off or erosion.*** *Run-off controls may include silt fencing, rip-rap, sedimentation basins, or detention ponds that control run-off from the range. Erosion controls may include soil mix, irrigation, or netting.*	0 if no engineering controls -2 if partial engineering controls -4 if effective engineering controls	-2
Surface Water Pathway Score *Minimum: 4 Maximum: 29*			18

Notes:

Jacksonville, NC averages 56” of rainfall per year (MCB Camp Lejeune, 2006).

The majority of both ranges contain grass with some bare areas on the protective target berms and roadways.

The deposition areas of K-503 and K-503A drain primarily south/southeast to a tributary of Whitehurst Creek with an approximate slope of 2%.

The primary soil types located at K-503 and K-503A consist of Kureb, Baymead, Foreston, and Stallings series soils. These are mostly composed of loamy fine sand and have a pH range of 3.6 to 7.3.

Minor signs of erosion were present on protective target berms from bullet impact.

A drainage channel runs along the eastern edge of the ranges which diverts surface water flow around the ranges to south and helps prevent run-on. Additionally, vegetated drainage features are present around each elevated row of targets to contain and slow surface water run-off.

K-503 and K-503A
MCIEAST - MCB Camp Lejeune

Table 3: Groundwater Pathways Characteristics Element
(These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)

Criteria	Evaluation Characteristics	Score Criteria	Site Score
Precipitation	*Intensity and frequency of precipitation.*	3 if precipitation > 40 inches/year 2 if precipitation = 20-40 inches/year 1 if precipitation < 20 inches/year	3
Depth to Groundwater	*The potential for impact to the groundwater decreases with an increasing depth to the water table.*	6 if depth to groundwater < 3 feet 3 if depth to groundwater = 3-20 feet 1 if depth to groundwater = 20-100 feet 0 if in a groundwater discharge area or depth to groundwater > 100 feet	3
Soil Type / Infiltration Conditions	*Soil with a higher porosity (sands/gravels) has more infiltration and less runoff compared to soil with low porosity (silts/clays).* ***Most hydraulically restrictive infiltration horizon between the surface and groundwater is scored.***	6 if soil type is sand / gravel 3 if soil type is sand and silt 1 if soil type is clay / clayey sand/silt	3
	Vegetation impedes infiltration and groundwater recharge.	6 if vegetation cover < 10% 3 if vegetation cover = 10% to 90% 1 if vegetation cover > 90%	3
	Average slope from deposition area along the overland pathway to the first defined channel.	3 if slope < 2% (1.15°) 1 if slope = 2% to 20% 0 if slope > 20% (11.31°)	1
pH of Soil	*Lead tends to stay dissolved at pH conditions less than 6.5 and greater than 8.5 but tends to attach to soil particles at pH conditions between these levels.*	3 if pH < 4 or >10 2 if pH ≥ 4 < 6.5 or > 8.5 ≤ 10 1 if pH 6.5 ≤ pH ≤ 8.5	2
Groundwater Pathway Score *Minimum: 4* *Maximum: 27*			15

Notes:

Jacksonville, NC averages 56” of rainfall per year (MCB Camp Lejeune, 2006).

Based on measurements collected in the vicinity of these ranges, the depth to groundwater in this area is approximately 5 feet below ground surface.

The primary soil types located at K-503 and K-503A consist of Kureb, Baymead, Foreston, and

K-503 and K-503A
MCIEAST - MCB Camp Lejeune

Table 3: Groundwater Pathways Characteristics Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	Evaluation Characteristics	Score Criteria	Site Score
Stallings series soils. These are mostly composed of loamy fine sand and have a pH range of 3.6 to 7.3. The majority of both ranges contain grass with some bare areas on the protective target berms and roadways. The deposition areas of K-503 and K-503A drain primarily south/southeast to a tributary of Whitehurst Creek with an approximate slope of 2%.			

K-503 and K-503A
MCIEAST - MCB Camp Lejeune

Table 4: Surface Water / Sediment Receptors Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
Surface Water Body	*Identify if a nearby surface water body is present down gradient, **as defined on the National Hydrography Dataset (NHD) map**.*	8 if surface water body is located downgradient of the range within 1,500 feet 4 if surface water body is located downgradient of the range 1,500-5,000 feet 0 if surface water body is located downgradient of the range over 5,000 feet	8
Drinking Water Use	*Identify if a down gradient surface water body is used as a drinking water source (drainage distance).*	4 if surface water body used as a drinking water source is located downgradient of the range within 1 mile 2 if surface water body used as a drinking water source is located downgradient of the range within 1 to 6 miles 0 if no known drinking water intakes are identified within 6 miles of the range	0
Drainage Distance to Installation Boundary	*Identify downgradient drainage distance to first potential ecological exposure off installation (i.e., installation boundary).*	4 if the installation boundary is located downgradient of the range within 0.5 miles 2 if the installation boundary is located downgradient of the range within 0.5 to 3 miles 0 if the installation boundary is located downgradient of the range greater than 3 miles, or if surface water runoff from the range does not discharge off the installation	2
Surface Water Receptor Score *Minimum: 0 Maximum: 16*			10

Notes:

According to the USGS National Hydrography Map, there is a downgradient tributary of the Whitehurst Creek located approximately 1,400 feet southwest of the bullet deposition area.

Drinking water is obtained from water supply wells throughout the installation. Surface water is not used as a drinking water source at the installation, nor are there any surface water bodies used as drinking water sources within 6 miles of these ranges.

The drainage pathway from K-503 and K-503A proceeds southwest from the bullet deposition area to a tributary of Whitehurst Creek that generally flows east towards the New River. This drainage pathway crosses the installation boundary approximately 1.6 miles from the ranges.

K-503 and K-503A
MCIEAST - MCB Camp Lejeune

Table 5: Groundwater Receptors Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
Wells Identified as Potable Water Sources	*Number and location of potable water or potable water supply wells relative to the location of the range.*	6 if a drinking water well is located within <50 feet of the range 3 if a drinking water well is located downgradient of the range within 50-1,500 feet 0 if there are no drinking water wells located within 1,500 feet downgradient of the range or if groundwater is not used as a drinking water source.	0
	Into what ***type of aquifer is the well set***	6 if unconfined 3 if semi-confined 0 if confined	3
Groundwater wells identified for purpose other than drinking water	*Groundwater wells used for purposes other than drinking water supply identified down gradient of the range.*	3 if a groundwater well is located within 50 feet of the range 1 if a groundwater well is located downgradient of the range within 50-1,500 feet 0 if groundwater well <1,500 feet downgradient of the range is not used for any purpose.	1
Groundwater Receptor Score *Minimum: 0 Maximum: 15*			4

Notes:

The closest well is a non-potable well that is located approximately 1,100 feet from the ranges.

K-503 and K-503A
MCIEAST - MCB Camp Lejeune

Table 6: Evaluation Score
(These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)

Surface Water / Sediment		
Element	**Table**	**Score**
Range Use and Range Management (Source)	1	20
Surface Water / Sediment Pathways	2	18
Surface Water / Sediment Receptors	4	10
Sum of Surface Water / Sediment Element Scores *Minimum: 0 Maximum: 65*		**48**

Groundwater		
Element	**Table**	**Score**
Range Use and Range Management (Source)	1	20
Groundwater Pathways	3	15
Groundwater Receptors	5	4
Sum of Groundwater Element Scores *Minimum: 0 Maximum: 62*		**39**

Field Sampling and Observed Releases		
Surface Water / Sediment	Surface water sampling conducted Yes ☒ No ☐ Sediment sampling conducted Yes ☐ No ☒ Results exceed DoD screening value Yes ☐ No ☒	**Surface Water / Sediment** ☒ No Modification ☐ High
Groundwater	Groundwater sampling conducted Yes ☒ No ☐ Results exceed DoD screening value Yes ☐ No ☒	**Groundwater** ☒ No Modification ☐ High

The relative evaluation ranking for each media is determined by selecting the appropriate score based on the data elements for that media:

Evaluation Ranking*	Score Range
High	45-65
Moderate	33-44
Minimal	0-32

Surface Water Evaluation Ranking	**High**
Groundwater Evaluation Ranking	**Moderate**

Notes: One surface water sample (K2_SW-05) was collected at the confluence of Whitehurst Creek and Stones Bay. Total and dissolved lead were detected at concentrations of 2.1 µg/L and 0.79 µg/L, respectively. Results were below screening criteria.

Two groundwater samples (K2_MW-06 and K2_MW-07) were collected on the downgradient side of the K2 Impact Area. Total lead was detected at concentrations of 0.96 µg/L and 1.7 µg/L. Dissolved lead was detected at concentrations of 1.5 µg/L and 0.26 µg/L. All results were below screening criteria of 15 µg/L.

K-506
MCIEAST - MCB Camp Lejeune
Jacksonville, North Carolina

Date of SARAP update: 11/19/2014

DESCRIPTION

Range Mission:	Combat Marksmanship Program and Close Combat Range
Training Start Date:	2013
Direction of Fire:	Southeast
Firing Positions:	Variable
Target Range:	Variable
Impact Area(s):	☒ Open area ☐ Hillside ☐ Building ☐ Earthen berm ☐ Bullet trap
Existing BMPs:	☐ Basin/vault ☐ Control fabric ☐ Diversion ☐ Fencing ☐ Rip-rap ☐ Silt check ☐ Vegetation
	Other:
Reference(s):	

FINDINGS

Review Period		**Periodic Review**
Estimated Lead Deposition (lb/yr)		1,227
Surface Water / Sediment	***RANK***	Moderate
	Source	9
	Pathway	19
	Receptor	12
	TOTAL SCORE	40
Groundwater	***RANK***	Minimal
	Source	9
	Pathway	15
	Receptor	3
	TOTAL SCORE	27

RECOMMENDATIONS

☒ Periodically review operations for significant changes in training, management, and use.

☐ Gather additional data regarding ☐ range use, ☐ pathways, or ☐ receptors associated with the range: ______________________________

☐ Collect site-specific field data to further assess potential off-range migration.

K-506
MCIEAST - MCB Camp Lejeune

Table 1: Range Use and Range Management (*Source*) Element
(These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)

Criteria	Evaluation Characteristics	Score Criteria	Site Score
MC Loading Rates	*The amount of small arms ammunition expended on the range.* *Estimate the MC loading as average lead deposition rate.*	14 if MC loading > 8,000 pounds/year 11 if MC loading = 4,001-8,000 pounds/year 8 if MC loading = 2,001-4,000 pounds/year 5 if MC loading = 501-2,000 pounds/year 2 if MC loading < 501 pounds/year	5
Impact Area	*The bullet deposition scenario at the range.*	4 if projectiles are scattered in SDZ 3 if range has an impact berm 1 if range has a bullet trap	4
Lead Management	*Frequency of activities that result in the removal of lead from an EARTHERN BERM or SDZ.* *This includes MINOR removal (e.g. scraping and sifting of berm/area, soil amendments) as well as MAJOR removals (e.g. lead mining).*	0 if no notable mining -1 if a MINOR action completed once during either of the last two periodic reviews -2 if MINOR action completed during each of the two previous periodic reviews -3 if MAJOR action was completed once during either of the last two periodic reviews -4 if MAJOR action completed during each of the two previous periodic reviews	0
	Frequency of activities that result in the significant removal of lead from a BULLET TRAP.	-3 if bullet trap was not been serviced during last two periodic reviews -5 if bullet trap was serviced once during either of the last two periodic reviews -7 if bullet trap was serviced during each of the last two periodic reviews	
Duration of Range Use	*Length of time the range has been used.*	2 if > 5 years 0 if ≤ 5 years	0
Source Element Score	*Minimum: -4*	*Maximum: 20*	9

Notes:

Annual lead deposition – 1,227 pounds/year.

There is a protective berm in place to preserve the target frames however there is no impact berm or bullet trap present.

Range has been in use since 2013.

K-506 was constructed partially in the footprint of K-315 which became inactive in 2010.

K-506
MCIEAST - MCB Camp Lejeune

Table 2: Surface Water / Sediment Pathways Characteristics Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
Precipitation	*Rate of precipitation.*	8 if precipitation > 40 inches/year 6 if precipitation = 20-40 inches/year 4 if precipitation < 20 inches/year	8
Vegetation	*Approximate vegetation cover **within and directly downslope of the projectile deposition area.***	6 if vegetation cover < 10% 4 if vegetation cover = 10% to 90% 2 if vegetation cover > 90%	4
Slope of Range	*Average slope **from deposition area along the overland pathway to the first defined channel.***	5 if slope > 10% (5.71°) 3 if slope = 5% to 10% 2 if slope < 5% (2.86°)	2
pH of Soil	*pH below 6.5 and above 8.5 increases the rate of lead dissolution.*	3 if pH < 4 or >10 2 if pH ≥ 4 < 6.5 or > 8.5 ≤ 10 1 if pH 6.5 ≤ pH ≤ 8.5	2
Soil Type/ Erosion	*Erosion potential is greatest for fine sands and silt. Clay has the lowest erosion potential. **The area where projectiles are deposited should be scored.***	2 if soil type is fine sand / silt 1 if soil type is clayey sand or silt / coarse sands 0 if soil type is clay	2
	Erosion observed at the projectile deposition area.	5 if there is visual evidence of eroded material being transported from the projectile deposition area 3 if bullet pockets or other indicators of erosion were observed 1 if no erosion was observed	1
Engineering Controls	*The presence of engineering controls or BMPs to modify or control **surface water run-on.*** *Controls may include barriers or diversions that reduce run-on to the range.*	0 if no engineering controls -1 if partial engineering controls -2 if effective engineering controls	0

K-506

MCIEAST - MCB Camp Lejeune

Table 2: Surface Water / Sediment Pathways Characteristics Element
(These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)

Criteria	Evaluation Characteristics	Score Criteria	Site Score
	The presence of engineering controls or BMPs to modify or control ***surface water run-off or erosion.*** *Run-off controls may include silt fencing, rip-rap, sedimentation basins, or detention ponds that control run-off from the range. Erosion controls may include soil mix, irrigation, or netting.*	0 if no engineering controls -2 if partial engineering controls -4 if effective engineering controls	0
Surface Water Pathway Score *Minimum: 4 Maximum: 29*			19

Notes:

Jacksonville, NC averages 56” of rainfall per year (MCB Camp Lejeune, 2006).

Approximately 60% of K-506 is vegetated with grass. The remaining 40% is sparsely vegetated or bare sand.

The deposition area of K-506 drains south towards the Whitehurst Creek with an approximate slope of 4.7%.

The primary soil types located at K-506 consist of Baymean, Foreston, and Stallings series soils. These are mostly composed of loamy fine sand and have a pH range of 3.6 to 6.5 (USDA, 1992).

K-506
MCIEAST - MCB Camp Lejeune

Table 3: Groundwater Pathways Characteristics Element
(These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)

Criteria	Evaluation Characteristics	Score Criteria	Site Score
Precipitation	*Intensity and frequency of precipitation.*	3 if precipitation > 40 inches/year 2 if precipitation = 20-40 inches/year 1 if precipitation < 20 inches/year	3
Depth to Groundwater	*The potential for impact to the groundwater decreases with an increasing depth to the water table.*	6 if depth to groundwater < 3 feet 3 if depth to groundwater = 3-20 feet 1 if depth to groundwater = 20-100 feet 0 if in a groundwater discharge area or depth to groundwater > 100 feet	3
Soil Type / Infiltration Conditions	*Soil with a higher porosity (sands/gravels) has more infiltration and less runoff compared to soil with low porosity (silts/clays).* ***Most hydraulically restrictive infiltration horizon between the surface and groundwater is scored.***	6 if soil type is sand / gravel 3 if soil type is sand and silt 1 if soil type is clay / clayey sand/silt	3
	Vegetation impedes infiltration and groundwater recharge.	6 if vegetation cover < 10% 3 if vegetation cover = 10% to 90% 1 if vegetation cover > 90%	3
	Average slope from deposition area along the overland pathway to the first defined channel.	3 if slope < 2% (1.15°) 1 if slope = 2% to 20% 0 if slope > 20% (11.31°)	1
pH of Soil	*Lead tends to stay dissolved at pH conditions less than 6.5 and greater than 8.5 but tends to attach to soil particles at pH conditions between these levels.*	3 if pH < 4 or >10 2 if pH ≥ 4 < 6.5 or > 8.5 ≤ 10 1 if pH 6.5 ≤ pH ≤ 8.5	2
Groundwater Pathway Score *Minimum: 4 Maximum: 27*			15

Notes:

Jacksonville, NC averages 56” of rainfall per year (MCB Camp Lejeune, 2006).

K-506

MCIEAST - MCB Camp Lejeune

Table 3: Groundwater Pathways Characteristics Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
Based on measurements collected in the vicinity of these ranges, the depth to groundwater in this area is approximately 5 feet below ground surface. The primary soil types located at K-506 consist of Baymean, Foreston, and Stallings series soils. These are mostly composed of loamy fine sand and have a pH range of 3.6 to 6.5 (USDA, 1992). Approximately 60% of K-506 is vegetated with grass. The remaining 40% is sparsely vegetated or bare sand. The deposition area of K-506 drains south towards the Whitehurst Creek with an approximate slope of 4.7%.			

K-506
MCIEAST - MCB Camp Lejeune

Table 4: Surface Water / Sediment Receptors Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
Surface Water Body	*Identify if a nearby surface water body is present down gradient, **as defined on the National Hydrography Dataset (NHD) map**.*	8 if surface water body is located downgradient of the range within 1,500 feet 4 if surface water body is located downgradient of the range 1,500-5,000 feet 0 if surface water body is located downgradient of the range over 5,000 feet	8
Drinking Water Use	*Identify if a down gradient surface water body is used as a drinking water source (drainage distance).*	4 if surface water body used as a drinking water source is located downgradient of the range within 1 mile 2 if surface water body used as a drinking water source is located downgradient of the range within 1 to 6 miles 0 if no known drinking water intakes are identified within 6 miles of the range	0
Drainage Distance to Installation Boundary	*Identify downgradient drainage distance to first potential ecological exposure off installation (i.e., installation boundary).*	4 if the installation boundary is located downgradient of the range within 0.5 miles 2 if the installation boundary is located downgradient of the range within 0.5 to 3 miles 0 if the installation boundary is located downgradient of the range greater than 3 miles, or if surface water runoff from the range does not discharge off the installation	4
Surface Water Receptor Score *Minimum: 0 Maximum: 16*			12

Notes:

According to the USGS National Hydrography Map, there is a downgradient marsh which boarders a tributary to the New River approximately 200 feet south of the bullet deposition area.

Drinking water is obtained from water supply wells throughout the installation. Surface water is not used as a drinking water source at the installation, nor are there any surface water bodies used as drinking water sources within 6 miles of this range.

The drainage pathway from K-506 proceeds south from the bullet deposition area to a marsh which drains south to a tributary of New River. This drainage pathway crosses the installation boundary upon reaching the tributary of the New River approximately 0.08 miles from the range.

K-506
MCIEAST - MCB Camp Lejeune

Table 5: Groundwater Receptors Element
(These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)

Criteria	Evaluation Characteristics	Score Criteria	Site Score
Wells Identified as Potable Water Sources	*Number and location of potable water or potable water supply wells relative to the location of the range.*	6 if a drinking water well is located within <50 feet of the range 3 if a drinking water well is located downgradient of the range within 50-1,500 feet 0 if there are no drinking water wells located within 1,500 feet downgradient of the range or if groundwater is not used as a drinking water source.	0
	Into what ***type of aquifer is the well set***	6 if unconfined 3 if semi-confined 0 if confined	3
Groundwater wells identified for purpose other than drinking water	*Groundwater wells used for purposes other than drinking water supply identified down gradient of the range.*	3 if a groundwater well is located within 50 feet of the range 1 if a groundwater well is located downgradient of the range within 50-1,500 feet 0 if groundwater well <1,500 feet downgradient of the range is not used for any purpose.	0
Groundwater Receptor Score *Minimum: 0 Maximum: 15*			3

Notes:

The closest well is a non-potable well that is located approximately 3,000 feet from the range.

K-506
MCIEAST - MCB Camp Lejeune

Table 6: Evaluation Score
(These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)

Surface Water / Sediment		
Element	**Table**	**Score**
Range Use and Range Management (Source)	1	9
Surface Water / Sediment Pathways	2	19
Surface Water / Sediment Receptors	4	12
Sum of Surface Water / Sediment Element Scores *Minimum: 0 Maximum: 65*		**40**

Groundwater		
Element	**Table**	**Score**
Range Use and Range Management (Source)	1	9
Groundwater Pathways	3	15
Groundwater Receptors	5	3
Sum of Groundwater Element Scores *Minimum: 0 Maximum: 62*		**27**

Field Sampling and Observed Releases		
Surface Water / Sediment	Surface water sampling conducted Yes ☒ No ☐ Sediment sampling conducted Yes ☐ No ☒ Results exceed DoD screening value Yes ☐ No ☒	**Surface Water / Sediment** ☒ No Modification ☐ High **Groundwater** ☒ No Modification ☐ High
Groundwater	Groundwater sampling conducted Yes ☒ No ☐ Results exceed DoD screening value Yes ☐ No ☒	

The relative evaluation ranking for each media is determined by selecting the appropriate score based on the data elements for that media:

Evaluation Ranking*	Score Range
High	45-65
Moderate	33-44
Minimal	0-32

Surface Water Evaluation Ranking	**Moderate**
Groundwater Evaluation Ranking	**Minimal**

Notes: One surface water sample (K2_SW-05) was collected at the confluence of Whitehurst Creek and Stones Bay. Total and dissolved lead were detected at concentrations of 2.1 µg/L and 0.79 µg/L, respectively. Results were below screening criteria.

Two groundwater samples (K2_MW-06 and K2_MW-07) were collected on the downgradient side of the K2 Impact Area. Total lead was detected at concentrations of 0.96 µg/L and 1.7 µg/L. Dissolved lead was detected at concentrations of 1.5 µg/L and 0.26 µg/L. All results were below screening criteria of 15 µg/L.

K-507
MCIEAST - MCB Camp Lejeune
Jacksonville, North Carolina

Date of SARAP update: 11/19/2014

DESCRIPTION

Range Mission:	Combat Marksmanship Program and Close Combat Range
Training Start Date:	2013
Direction of Fire:	Southeast
Firing Positions:	Variable
Target Range:	Variable
Impact Area(s):	☒ Open area ☐ Hillside ☐ Building ☐ Earthen berm ☐ Bullet trap
Existing BMPs:	☐ Basin/vault ☐ Control fabric ☐ Diversion ☐ Fencing ☐ Rip-rap ☐ Silt check ☐ Vegetation
	Other:
Reference(s):	

FINDINGS

Review Period		**Periodic Review**
Estimated Lead Deposition (lb/yr)		0
Surface Water / Sediment	***RANK***	Moderate
	Source	6
	Pathway	19
	Receptor	12
	TOTAL SCORE	37
Groundwater	***RANK***	Minimal
	Source	6
	Pathway	15
	Receptor	3
	TOTAL SCORE	27

RECOMMENDATIONS

☒ Periodically review operations for significant changes in training, management, and use.

☐ Gather additional data regarding ☐ range use, ☐ pathways, or ☐ receptors associated with the range: ______________________________

☐ Collect site-specific field data to further assess potential off-range migration.

K-507
MCIEAST - MCB Camp Lejeune

Table 1: Range Use and Range Management (*Source)* Element
(These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)

Criteria	Evaluation Characteristics	Score Criteria	Site Score
MC Loading Rates	*The amount of small arms ammunition expended on the range.* *Estimate the MC loading as average lead deposition rate.*	14 if MC loading > 8,000 pounds/year 11 if MC loading = 4,001-8,000 pounds/year 8 if MC loading = 2,001-4,000 pounds/year 5 if MC loading = 501-2,000 pounds/year 2 if MC loading < 501 pounds/year	2
Impact Area	*The bullet deposition scenario at the range.*	4 if projectiles are scattered in SDZ 3 if range has an impact berm 1 if range has a bullet trap	4
Lead Management	*Frequency of activities that result in the removal of lead from an EARTHERN BERM or SDZ.* *This includes MINOR removal (e.g. scraping and sifting of berm/area, soil amendments) as well as MAJOR removals (e.g. lead mining).*	0 if no notable mining -1 if a MINOR action completed once during either of the last two periodic reviews -2 if MINOR action completed during each of the two previous periodic reviews -3 if MAJOR action was completed once during either of the last two periodic reviews -4 if MAJOR action completed during each of the two previous periodic reviews	0
	Frequency of activities that result in the significant removal of lead from a BULLET TRAP.	-3 if bullet trap was not been serviced during last two periodic reviews -5 if bullet trap was serviced once during either of the last two periodic reviews -7 if bullet trap was serviced during each of the last two periodic reviews	
Duration of Range Use	*Length of time the range has been used.*	2 if > 5 years 0 if ≤ 5 years	0
Source Element Score	*Minimum: -4 Maximum: 20*		6

Notes:

Annual lead deposition – No expenditure data for this range was observed in the RFMSS data provided by the installation for the periodic review period.

There is a small protective berm in front of the target area however there is no impact berm or bullet trap present.

This range has been in use since 2013.

K-507 was constructed partially in the footprint of K-317 which became inactive in 2010.

K-507
MCIEAST - MCB Camp Lejeune

Table 2: Surface Water / Sediment Pathways Characteristics Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
Precipitation	*Rate of precipitation.*	8 if precipitation > 40 inches/year 6 if precipitation = 20-40 inches/year 4 if precipitation < 20 inches/year	8
Vegetation	*Approximate vegetation cover **within and directly downslope of the projectile deposition area.***	6 if vegetation cover < 10% 4 if vegetation cover = 10% to 90% 2 if vegetation cover > 90%	4
Slope of Range	*Average slope **from deposition area along the overland pathway to the first defined channel.***	5 if slope > 10% (5.71°) 3 if slope = 5% to 10% 2 if slope < 5% (2.86°)	2
pH of Soil	*pH below 6.5 and above 8.5 increases the rate of lead dissolution.*	3 if pH < 4 or >10 2 if pH ≥ 4 < 6.5 or > 8.5 ≤ 10 1 if pH 6.5 ≤ pH ≤ 8.5	2
Soil Type/ Erosion	*Erosion potential is greatest for fine sands and silt. Clay has the lowest erosion potential. **The area where projectiles are deposited should be scored.***	2 if soil type is fine sand / silt 1 if soil type is clayey sand or silt / coarse sands 0 if soil type is clay	2
	Erosion observed at the projectile deposition area.	5 if there is visual evidence of eroded material being transported from the projectile deposition area 3 if bullet pockets or other indicators of erosion were observed 1 if no erosion was observed	1
Engineering Controls	*The presence of engineering controls or BMPs to modify or control **surface water run-on.*** *Controls may include barriers or diversions that reduce run-on to the range.*	0 if no engineering controls -1 if partial engineering controls -2 if effective engineering controls	0

K-507

MCIEAST - MCB Camp Lejeune

Table 2: Surface Water / Sediment Pathways Characteristics Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
	*The presence of engineering controls or BMPs to modify or control **surface water run-off or erosion.*** *Run-off controls may include silt fencing, rip-rap, sedimentation basins, or detention ponds that control run-off from the range. Erosion controls may include soil mix, irrigation, or netting.*	0 if no engineering controls -2 if partial engineering controls -4 if effective engineering controls	0
Surface Water Pathway Score *Minimum: 4 Maximum: 29*			19

Notes:

Jacksonville, NC averages 56" of rainfall per year (MCB Camp Lejeune, 2006).

Approximately 15% of K-507 is vegetated with grass. The remaining 85% is sparsely vegetated or bare sand.

The deposition area of K-507 drains south towards the Whitehurst Creek with an approximate slope of 2.1%.

The primary soil types located at K-507 consist of Baymean, Foreston, and Stallings series soils. These are mostly composed of loamy fine sand and have a pH range of 3.6 to 6.5 (USDA, 1992).

K-507
MCIEAST - MCB Camp Lejeune

Table 3: Groundwater Pathways Characteristics Element
(These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)

Criteria	Evaluation Characteristics	Score Criteria	Site Score
Precipitation	*Intensity and frequency of precipitation.*	3 if precipitation > 40 inches/year 2 if precipitation = 20-40 inches/year 1 if precipitation < 20 inches/year	3
Depth to Groundwater	*The potential for impact to the groundwater decreases with an increasing depth to the water table.*	6 if depth to groundwater < 3 feet 3 if depth to groundwater = 3-20 feet 1 if depth to groundwater = 20-100 feet 0 if in a groundwater discharge area or depth to groundwater > 100 feet	3
Soil Type / Infiltration Conditions	*Soil with a higher porosity (sands/gravels) has more infiltration and less runoff compared to soil with low porosity (silts/clays).* ***Most hydraulically restrictive infiltration horizon between the surface and groundwater is scored.***	6 if soil type is sand / gravel 3 if soil type is sand and silt 1 if soil type is clay / clayey sand/silt	3
	Vegetation impedes infiltration and groundwater recharge.	6 if vegetation cover < 10% 3 if vegetation cover = 10% to 90% 1 if vegetation cover > 90%	3
	Average slope from deposition area along the overland pathway to the first defined channel.	3 if slope < 2% (1.15°) 1 if slope = 2% to 20% 0 if slope > 20% (11.31°)	1
pH of Soil	*Lead tends to stay dissolved at pH conditions less than 6.5 and greater than 8.5 but tends to attach to soil particles at pH conditions between these levels.*	3 if pH < 4 or >10 2 if pH ≥ 4 < 6.5 or > 8.5 ≤ 10 1 if pH 6.5 ≤ pH ≤ 8.5	2
Groundwater Pathway Score *Minimum: 4* *Maximum: 27*			15

<u>Notes:</u>

Jacksonville, NC averages 56” of rainfall per year (MCB Camp Lejeune, 2006).

Based on measurements collected in the vicinity of these ranges, the depth to groundwater in this area is approximately 5 feet below ground surface.

K-507
MCIEAST - MCB Camp Lejeune

Table 3: Groundwater Pathways Characteristics Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	Evaluation Characteristics	Score Criteria	Site Score
The primary soil types located at K-507 consist of Baymean, Foreston, and Stallings series soils. These are mostly composed of loamy fine sand and have a pH range of 3.6 to 6.5 (USDA, 1992). Approximately 15% of K-507 is vegetated with grass. The remaining 85% is sparsely vegetated or bare sand. The deposition area of K-507 drains south towards the Whitehurst Creek with an approximate slope of 2.1%.			

K-507
MCIEAST - MCB Camp Lejeune

Table 4: Surface Water / Sediment Receptors Element **(These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)**			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
Surface Water Body	*Identify if a nearby surface water body is present down gradient,* ***as defined on the National Hydrography Dataset (NHD) map****.*	8 if surface water body is located downgradient of the range within 1,500 feet 4 if surface water body is located downgradient of the range 1,500-5,000 feet 0 if surface water body is located downgradient of the range over 5,000 feet	8
Drinking Water Use	*Identify if a down gradient surface water body is used as a drinking water source (drainage distance).*	4 if surface water body used as a drinking water source is located downgradient of the range within 1 mile 2 if surface water body used as a drinking water source is located downgradient of the range within 1 to 6 miles 0 if no known drinking water intakes are identified within 6 miles of the range	0
Drainage Distance to Installation Boundary	*Identify downgradient drainage distance to first potential ecological exposure off installation (i.e., installation boundary).*	4 if the installation boundary is located downgradient of the range within 0.5 miles 2 if the installation boundary is located downgradient of the range within 0.5 to 3 miles 0 if the installation boundary is located downgradient of the range greater than 3 miles, or if surface water runoff from the range does not discharge off the installation	4
Surface Water Receptor Score *Minimum: 0 Maximum: 16*			12

Notes:

According to the USGS National Hydrography Map, there is a downgradient marsh which boarders a tributary to the New River approximately 340 feet southwest of the bullet deposition area.

Drinking water is obtained from water supply wells throughout the installation. Surface water is not used as a drinking water source at the installation, nor are there any surface water bodies used as drinking water sources within 6 miles of this range.

The drainage pathway from K-507 proceeds southwest from the bullet deposition area to a marsh which drains south to a tributary of New River. This drainage pathway crosses the installation boundary upon reaching the tributary of the New River approximately 0.1 miles from the range.

K-507
MCIEAST - MCB Camp Lejeune

Table 5: Groundwater Receptors Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
Wells Identified as Potable Water Sources	*Number and location of potable water or potable water supply wells relative to the location of the range.*	6 if a drinking water well is located within <50 feet of the range 3 if a drinking water well is located downgradient of the range within 50-1,500 feet 0 if there are no drinking water wells located within 1,500 feet downgradient of the range or if groundwater is not used as a drinking water source.	0
	Into what ***type of aquifer is the well set***	6 if unconfined 3 if semi-confined 0 if confined	3
Groundwater wells identified for purpose other than drinking water	*Groundwater wells used for purposes other than drinking water supply identified down gradient of the range.*	3 if a groundwater well is located within 50 feet of the range 1 if a groundwater well is located downgradient of the range within 50-1,500 feet 0 if groundwater well <1,500 feet downgradient of the range is not used for any purpose.	0
Groundwater Receptor Score *Minimum: 0 Maximum: 15*			3

Notes:

The closest well is a non-potable well that is located approximately 2,000 feet from the range.

K-507
MCIEAST - MCB Camp Lejeune

Table 6: Evaluation Score
(These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)

Surface Water / Sediment		
Element	**Table**	**Score**
Range Use and Range Management (Source)	1	6
Surface Water / Sediment Pathways	2	19
Surface Water / Sediment Receptors	4	12
Sum of Surface Water / Sediment Element Scores *Minimum: 0 Maximum: 65*		**37**

Groundwater		
Element	**Table**	**Score**
Range Use and Range Management (Source)	1	6
Groundwater Pathways	3	15
Groundwater Receptors	5	3
Sum of Groundwater Element Scores *Minimum: 0 Maximum: 62*		**24**

Field Sampling and Observed Releases		
Surface Water / Sediment	Surface water sampling conducted Yes ☒ No ☐ Sediment sampling conducted Yes ☐ No ☒ Results exceed DoD screening value Yes ☐ No ☒	**Surface Water / Sediment** ☒ No Modification ☐ High
Groundwater	Groundwater sampling conducted Yes ☒ No ☐ Results exceed DoD screening value Yes ☐ No ☒	**Groundwater** ☒ No Modification ☐ High

The relative evaluation ranking for each media is determined by selecting the appropriate score based on the data elements for that media:

Evaluation Ranking*	Score Range
High	45-65
Moderate	33-44
Minimal	0-32

Surface Water Evaluation Ranking	**Moderate**
Groundwater Evaluation Ranking	**Minimal**

Notes: One surface water sample (K2_SW-05) was collected at the confluence of Whitehurst Creek and Stones Bay. Total and dissolved lead were detected at concentrations of 2.1 µg/L and 0.79 µg/L, respectively. Results were below screening criteria.

Two groundwater samples (K2_MW-06 and K2_MW-07) were collected on the downgradient side of the K2 Impact Area. Total lead was detected at concentrations of 0.96 µg/L and 1.7 µg/L. Dissolved lead was detected at concentrations of 1.5 µg/L and 0.26 µg/L. All results were below screening criteria of 15 µg/L.

K-508
MCIEAST - MCB Camp Lejeune
Jacksonville, North Carolina

Date of SARAP update: 11/19/2014

DESCRIPTION

Range Mission:	Combat Marksmanship Program and Close Combat Range
Training Start Date:	2013
Direction of Fire:	Southeast
Firing Positions:	Variable
Target Range:	Variable
Impact Area(s):	☒ Open area ☐ Hillside ☐ Building ☐ Earthen berm ☐ Bullet trap
Existing BMPs:	☐ Basin/vault ☐ Control fabric ☐ Diversion ☐ Fencing ☐ Rip-rap ☐ Silt check ☐ Vegetation
	Other:
Reference(s):	

FINDINGS

Review Period		Periodic Review
Estimated Lead Deposition (lb/yr)		7,438
Surface Water / Sediment	***RANK***	High
	Source	15
	Pathway	20
	Receptor	12
	TOTAL SCORE	47
Groundwater	***RANK***	Moderate
	Source	15
	Pathway	18
	Receptor	3
	TOTAL SCORE	36

RECOMMENDATIONS

☒ Periodically review operations for significant changes in training, management, and use.

☐ Gather additional data regarding ☐ range use, ☐ pathways, or ☐ receptors associated with the range: ____________________

☒ Collect site-specific field data to further assess potential off-range migration.

K-508
MCIEAST - MCB Camp Lejeune

Table 1: Range Use and Range Management (*Source)* Element
(These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)

Criteria	Evaluation Characteristics	Score Criteria	Site Score
MC Loading Rates	*The amount of small arms ammunition expended on the range.* *Estimate the MC loading as average lead deposition rate.*	14 if MC loading > 8,000 pounds/year 11 if MC loading = 4,001-8,000 pounds/year 8 if MC loading = 2,001-4,000 pounds/year 5 if MC loading = 501-2,000 pounds/year 2 if MC loading < 501 pounds/year	11
Impact Area	*The bullet deposition scenario at the range.*	4 if projectiles are scattered in SDZ 3 if range has an impact berm 1 if range has a bullet trap	4
Lead Management	*Frequency of activities that result in the removal of lead from an EARTHERN BERM or SDZ.* *This includes MINOR removal (e.g. scraping and sifting of berm/area, soil amendments) as well as MAJOR removals (e.g. lead mining).*	0 if no notable mining -1 if a MINOR action completed once during either of the last two periodic reviews -2 if MINOR action completed during each of the two previous periodic reviews -3 if MAJOR action was completed once during either of the last two periodic reviews -4 if MAJOR action completed during each of the two previous periodic reviews	0
	Frequency of activities that result in the significant removal of lead from a BULLET TRAP.	-3 if bullet trap was not been serviced during last two periodic reviews -5 if bullet trap was serviced once during either of the last two periodic reviews -7 if bullet trap was serviced during each of the last two periodic reviews	
Duration of Range Use	*Length of time the range has been used.*	2 if > 5 years 0 if ≤ 5 years	0
Source Element Score *Minimum: -4 Maximum: 20*			15

Notes:

Annual lead deposition – 7,438 pounds/year.

This range has been in use since 2013.

K-508 was constructed partially in the footprint of K-319 which became inactive in 2010.

K-508
MCIEAST - MCB Camp Lejeune

Table 2: Surface Water / Sediment Pathways Characteristics Element
(These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)

Criteria	Evaluation Characteristics	Score Criteria	Site Score
Precipitation	*Rate of precipitation.*	8 if precipitation > 40 inches/year 6 if precipitation = 20-40 inches/year 4 if precipitation < 20 inches/year	8
Vegetation	*Approximate vegetation cover **within and directly downslope of the projectile deposition area.***	6 if vegetation cover < 10% 4 if vegetation cover = 10% to 90% 2 if vegetation cover > 90%	4
Slope of Range	*Average slope **from deposition area along the overland pathway to the first defined channel.***	5 if slope > 10% (5.71°) 3 if slope = 5% to 10% 2 if slope < 5% (2.86°)	3
pH of Soil	*pH below 6.5 and above 8.5 increases the rate of lead dissolution.*	3 if pH < 4 or >10 2 if pH ≥ 4 < 6.5 or > 8.5 ≤ 10 1 if pH 6.5 ≤ pH ≤ 8.5	2
Soil Type/ Erosion	*Erosion potential is greatest for fine sands and silt. Clay has the lowest erosion potential. **The area where projectiles are deposited should be scored.***	2 if soil type is fine sand / silt 1 if soil type is clayey sand or silt / coarse sands 0 if soil type is clay	2
	Erosion observed at the projectile deposition area.	5 if there is visual evidence of eroded material being transported from the projectile deposition area 3 if bullet pockets or other indicators of erosion were observed 1 if no erosion was observed	1
Engineering Controls	*The presence of engineering controls or BMPs to modify or control **surface water run-on.*** *Controls may include barriers or diversions that reduce run-on to the range.*	0 if no engineering controls -1 if partial engineering controls -2 if effective engineering controls	0

K-508
MCIEAST - MCB Camp Lejeune

Table 2: Surface Water / Sediment Pathways Characteristics Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
	*The presence of engineering controls or BMPs to modify or control **surface water run-off or erosion.*** *Run-off controls may include silt fencing, rip-rap, sedimentation basins, or detention ponds that control run-off from the range. Erosion controls may include soil mix, irrigation, or netting.*	0 if no engineering controls -2 if partial engineering controls -4 if effective engineering controls	0
Surface Water Pathway Score *Minimum: 4* *Maximum: 29*			20

<u>Notes:</u>

Jacksonville, NC averages 56” of rainfall per year (MCB Camp Lejeune, 2006).

Approximately 70% of K-508 is vegetated with grass. The remaining 30% is sparsely vegetated or bare sand.

The deposition area of K-508 drains south towards the Whitehurst Creek with an approximate slope of 7%.

The primary soil types located at K-508 consist of Baymean, Foreston, and Stallings series soils. These are mostly composed of loamy fine sand and have a pH range of 3.6 to 6.5 (USDA, 1992).

K-508
MCIEAST - MCB Camp Lejeune

Table 3: Groundwater Pathways Characteristics Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
Precipitation	*Intensity and frequency of precipitation.*	3 if precipitation > 40 inches/year 2 if precipitation = 20-40 inches/year 1 if precipitation < 20 inches/year	3
Depth to Groundwater	*The potential for impact to the groundwater decreases with an increasing depth to the water table.*	6 if depth to groundwater < 3 feet 3 if depth to groundwater = 3-20 feet 1 if depth to groundwater = 20-100 feet 0 if in a groundwater discharge area or depth to groundwater > 100 feet	3
Soil Type / Infiltration Conditions	*Soil with a higher porosity (sands/gravels) has more infiltration and less runoff compared to soil with low porosity (silts/clays).* ***Most hydraulically restrictive infiltration horizon between the surface and groundwater is scored.***	6 if soil type is sand / gravel 3 if soil type is sand and silt 1 if soil type is clay / clayey sand/silt	3
	Vegetation impedes infiltration and groundwater recharge.	6 if vegetation cover < 10% 3 if vegetation cover = 10% to 90% 1 if vegetation cover > 90%	6
	Average slope from deposition area along the overland pathway to the first defined channel.	3 if slope < 2% (1.15°) 1 if slope = 2% to 20% 0 if slope > 20% (11.31°)	1
pH of Soil	*Lead tends to stay dissolved at pH conditions less than 6.5 and greater than 8.5 but tends to attach to soil particles at pH conditions between these levels.*	3 if pH < 4 or >10 2 if pH ≥ 4 < 6.5 or > 8.5 ≤ 10 1 if pH 6.5 ≤ pH ≤ 8.5	2
Groundwater Pathway Score *Minimum: 4* *Maximum: 27*			18
Notes: Jacksonville, NC averages 56" of rainfall per year (MCB Camp Lejeune, 2006). Based on measurements collected in the vicinity of these ranges, the depth to groundwater in			

K-508

MCIEAST - MCB Camp Lejeune

Table 3: Groundwater Pathways Characteristics Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
this area is approximately 5 feet below ground surface. The primary soil types located at K-508 consist of Baymean, Foreston, and Stallings series soils. These are mostly composed of loamy fine sand and have a pH range of 3.6 to 6.5 (USDA, 1992). Approximately 70% of K-508 is vegetated with grass. The remaining 30% is sparsely vegetated or bare sand. The deposition area of K-508 drains south towards the Whitehurst Creek with an approximate slope of 7%.			

K-508
MCIEAST - MCB Camp Lejeune

Table 4: Surface Water / Sediment Receptors Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
Surface Water Body	*Identify if a nearby surface water body is present down gradient,* ***as defined on the National Hydrography Dataset (NHD) map****.*	8 if surface water body is located downgradient of the range within 1,500 feet 4 if surface water body is located downgradient of the range 1,500-5,000 feet 0 if surface water body is located downgradient of the range over 5,000 feet	8
Drinking Water Use	*Identify if a down gradient surface water body is used as a drinking water source (drainage distance).*	4 if surface water body used as a drinking water source is located downgradient of the range within 1 mile 2 if surface water body used as a drinking water source is located downgradient of the range within 1 to 6 miles 0 if no known drinking water intakes are identified within 6 miles of the range	0
Drainage Distance to Installation Boundary	*Identify downgradient drainage distance to first potential ecological exposure off installation (i.e., installation boundary).*	4 if the installation boundary is located downgradient of the range within 0.5 miles 2 if the installation boundary is located downgradient of the range within 0.5 to 3 miles 0 if the installation boundary is located downgradient of the range greater than 3 miles, or if surface water runoff from the range does not discharge off the installation	4
Surface Water Receptor Score *Minimum: 0 Maximum: 16*			12

Notes:

According to the USGS National Hydrography Map, there is a downgradient marsh which boarders a tributary to the New River approximately 370 feet southwest of the bullet deposition area.

Drinking water is obtained from water supply wells throughout the installation. Surface water is not used as a drinking water source at the installation, nor are there any surface water bodies used as drinking water sources within 6 miles of this range.

The drainage pathway from K-508 proceeds southwest from the bullet deposition area to a marsh which drains south to a tributary of New River. This drainage pathway crosses the installation boundary upon reaching the tributary of the New River approximately 0.13 miles from the range.

K-508
MCIEAST - MCB Camp Lejeune

Table 5: Groundwater Receptors Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
Wells Identified as Potable Water Sources	*Number and location of potable water or potable water supply wells relative to the location of the range.*	6 if a drinking water well is located within <50 feet of the range 3 if a drinking water well is located downgradient of the range within 50-1,500 feet 0 if there are no drinking water wells located within 1,500 feet downgradient of the range or if groundwater is not used as a drinking water source.	0
	Into what ***type of aquifer is the well set***	6 if unconfined 3 if semi-confined 0 if confined	3
Groundwater wells identified for purpose other than drinking water	*Groundwater wells used for purposes other than drinking water supply identified down gradient of the range.*	3 if a groundwater well is located within 50 feet of the range 1 if a groundwater well is located downgradient of the range within 50-1,500 feet 0 if groundwater well <1,500 feet downgradient of the range is not used for any purpose.	0
Groundwater Receptor Score *Minimum: 0 Maximum: 15*			3

Notes:

The closest well is a non-potable well that is located approximately 1,600 feet from range.

K-508
MCIEAST - MCB Camp Lejeune

Table 6: Evaluation Score
(These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)

Surface Water / Sediment		
Element	**Table**	**Score**
Range Use and Range Management (Source)	1	15
Surface Water / Sediment Pathways	2	20
Surface Water / Sediment Receptors	4	12
Sum of Surface Water / Sediment Element Scores *Minimum: 0 Maximum: 65*		**47**
Groundwater		
Element	**Table**	**Score**
Range Use and Range Management (Source)	1	15
Groundwater Pathways	3	18
Groundwater Receptors	5	3
Sum of Groundwater Element Scores *Minimum: 0 Maximum: 62*		**36**

Field Sampling and Observed Releases

Surface Water / Sediment	Surface water sampling conducted Yes ☒ No ☐ Sediment sampling conducted Yes ☐ No ☒ Results exceed DoD screening value Yes ☐ No ☒	**Surface Water / Sediment** ☒ No Modification ☐ High
Groundwater	Groundwater sampling conducted Yes ☒ No ☐ Results exceed DoD screening value Yes ☐ No ☒	**Groundwater** ☒ No Modification ☐ High

The relative evaluation ranking for each media is determined by selecting the appropriate score based on the data elements for that media:

Evaluation Ranking*	Score Range
High	45-65
Moderate	33-44
Minimal	0-32

Surface Water Evaluation Ranking	**High**
Groundwater Evaluation Ranking	**Moderate**

Notes: One surface water sample (K2_SW-05) was collected at the confluence of Whitehurst Creek and Stones Bay. Total and dissolved lead were detected at concentrations of 2.1 µg/L and 0.79 µg/L, respectively. Results were below screening criteria.

Two groundwater samples (K2_MW-06 and K2_MW-07) were collected on the downgradient side of the K2 Impact Area. Total lead was detected at concentrations of 0.96 µg/L and 1.7 µg/L. Dissolved lead was detected at concentrations of 1.5 µg/L and 0.26 µg/L. All results were below screening criteria of 15 µg/L.

K-509
MCIEAST - MCB Camp Lejeune
Jacksonville, North Carolina

Date of SARAP update: 11/19/2014

DESCRIPTION

Range Mission:	Combat Marksmanship Program and Close Combat Range
Training Start Date:	2013
Direction of Fire:	Southeast
Firing Positions:	Variable
Target Range:	Variable
Impact Area(s):	☒ Open area ☐ Hillside ☐ Building ☐ Earthen berm ☐ Bullet trap
Existing BMPs:	☐ Basin/vault ☐ Control fabric ☐ Diversion ☐ Fencing ☐ Rip-rap ☐ Silt check ☐ Vegetation
	Other:
Reference(s):	

FINDINGS

Review Period		**Periodic Review**
Estimated Lead Deposition (lb/yr)		1,337
Surface Water / Sediment	***RANK***	Moderate
	Source	9
	Pathway	13
	Receptor	12
	TOTAL SCORE	34
Groundwater	***RANK***	Minimal
	Source	9
	Pathway	15
	Receptor	1
	TOTAL SCORE	25

RECOMMENDATIONS

☒ Periodically review operations for significant changes in training, management, and use.

☐ Gather additional data regarding ☐ range use, ☐ pathways, or ☐ receptors associated with the range: ______________________

☐ Collect site-specific field data to further assess potential off-range migration.

K-509
MCIEAST - MCB Camp Lejeune

Table 1: Range Use and Range Management (*Source)* Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
MC Loading Rates	*The amount of small arms ammunition expended on the range.* *Estimate the MC loading as average lead deposition rate.*	14 if MC loading > 8,000 pounds/year 11 if MC loading = 4,001-8,000 pounds/year 8 if MC loading = 2,001-4,000 pounds/year 5 if MC loading = 501-2,000 pounds/year 2 if MC loading < 501 pounds/year	5
Impact Area	*The bullet deposition scenario at the range.*	4 if projectiles are scattered in SDZ 3 if range has an impact berm 1 if range has a bullet trap	4
Lead Management	*Frequency of activities that result in the removal of lead from an EARTHERN BERM or SDZ.* *This includes MINOR removal (e.g. scraping and sifting of berm/area, soil amendments) as well as MAJOR removals (e.g. lead mining).*	0 if no notable mining -1 if a MINOR action completed once during either of the last two periodic reviews -2 if MINOR action completed during each of the two previous periodic reviews -3 if MAJOR action was completed once during either of the last two periodic reviews -4 if MAJOR action completed during each of the two previous periodic reviews	0
	Frequency of activities that result in the significant removal of lead from a BULLET TRAP.	-3 if bullet trap was not been serviced during last two periodic reviews -5 if bullet trap was serviced once during either of the last two periodic reviews -7 if bullet trap was serviced during each of the last two periodic reviews	
Duration of Range Use	*Length of time the range has been used.*	2 if > 5 years 0 if ≤ 5 years	0
Source Element Score *Minimum: -4 Maximum: 20*			9

Notes:

Annual lead deposition – 1,337 pounds/year.

There are protective berms in place for the target systems however there are no impact berms or bullet traps present.

This range has been in use since 2013.

K-509 was constructed partially in the footprint of K-321/A which became inactive in 2010.

K-509
MCIEAST - MCB Camp Lejeune

Table 2: Surface Water / Sediment Pathways Characteristics Element
(These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)

Criteria	Evaluation Characteristics	Score Criteria	Site Score
Precipitation	*Rate of precipitation.*	8 if precipitation > 40 inches/year 6 if precipitation = 20-40 inches/year 4 if precipitation < 20 inches/year	8
Vegetation	*Approximate vegetation cover **within and directly downslope of the projectile deposition area.***	6 if vegetation cover < 10% 4 if vegetation cover = 10% to 90% 2 if vegetation cover > 90%	2
Slope of Range	*Average slope **from deposition area along the overland pathway to the first defined channel.***	5 if slope > 10% (5.71°) 3 if slope = 5% to 10% 2 if slope < 5% (2.86°)	2
pH of Soil	*pH below 6.5 and above 8.5 increases the rate of lead dissolution.*	3 if pH < 4 or >10 2 if pH ≥ 4 < 6.5 or > 8.5 ≤ 10 1 if pH 6.5 ≤ pH ≤ 8.5	2
Soil Type/ Erosion	*Erosion potential is greatest for fine sands and silt. Clay has the lowest erosion potential. **The area where projectiles are deposited should be scored.***	2 if soil type is fine sand / silt 1 if soil type is clayey sand or silt / coarse sands 0 if soil type is clay	2
	Erosion observed at the projectile deposition area.	5 if there is visual evidence of eroded material being transported from the projectile deposition area 3 if bullet pockets or other indicators of erosion were observed 1 if no erosion was observed	1
Engineering Controls	*The presence of engineering controls or BMPs to modify or control **surface water run-on.*** *Controls may include barriers or diversions that reduce run-on to the range.*	0 if no engineering controls -1 if partial engineering controls -2 if effective engineering controls	0

K-509

MCIEAST - MCB Camp Lejeune

Table 2: Surface Water / Sediment Pathways Characteristics Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
	*The presence of engineering controls or BMPs to modify or control **surface water run-off or erosion.*** *Run-off controls may include silt fencing, rip-rap, sedimentation basins, or detention ponds that control run-off from the range. Erosion controls may include soil mix, irrigation, or netting.*	0 if no engineering controls -2 if partial engineering controls -4 if effective engineering controls	-4
Surface Water Pathway Score *Minimum: 4 Maximum: 29*			13

Notes:

Jacksonville, NC averages 56” of rainfall per year (MCB Camp Lejeune, 2006).

The entire range footprint of K-509 is vegetated with grass.

The deposition area of K-509 drains south towards the Whitehurst Creek with an approximate slope of 1.2%.

The primary soil types located at K-509 consist of Baymean, Foreston, and Stallings series soils. These are mostly composed of loamy fine sand and have a pH range of 3.6 to 6.5 (USDA, 1992).

K-509 contains several drainage channels that lead to a retention basin in the northern corner of the range which helps reduce surface water run-off.

K-509
MCIEAST - MCB Camp Lejeune

Table 3: Groundwater Pathways Characteristics Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
Precipitation	*Intensity and frequency of precipitation.*	3 if precipitation > 40 inches/year 2 if precipitation = 20-40 inches/year 1 if precipitation < 20 inches/year	3
Depth to Groundwater	*The potential for impact to the groundwater decreases with an increasing depth to the water table.*	6 if depth to groundwater < 3 feet 3 if depth to groundwater = 3-20 feet 1 if depth to groundwater = 20-100 feet 0 if in a groundwater discharge area or depth to groundwater > 100 feet	3
Soil Type / Infiltration Conditions	*Soil with a higher porosity (sands/gravels) has more infiltration and less runoff compared to soil with low porosity (silts/clays).* ***Most hydraulically restrictive infiltration horizon between the surface and groundwater is scored.***	6 if soil type is sand / gravel 3 if soil type is sand and silt 1 if soil type is clay / clayey sand/silt	3
	Vegetation impedes infiltration and groundwater recharge.	6 if vegetation cover < 10% 3 if vegetation cover = 10% to 90% 1 if vegetation cover > 90%	1
	Average slope from deposition area along the overland pathway to the first defined channel.	3 if slope < 2% (1.15°) 1 if slope = 2% to 20% 0 if slope > 20% (11.31°)	3
pH of Soil	*Lead tends to stay dissolved at pH conditions less than 6.5 and greater than 8.5 but tends to attach to soil particles at pH conditions between these levels.*	3 if pH < 4 or >10 2 if pH ≥ 4 < 6.5 or > 8.5 ≤ 10 1 if pH 6.5 ≤ pH ≤ 8.5	2
Groundwater Pathway Score *Minimum: 4 Maximum: 27*			15

Notes:

Jacksonville, NC averages 56” of rainfall per year (MCB Camp Lejeune, 2006).

Based on measurements collected in the vicinity of these ranges, the depth to groundwater in

K-509

MCIEAST - MCB Camp Lejeune

Table 3: Groundwater Pathways Characteristics Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
this area is approximately 2 to 5 feet below ground surface. The primary soil types located at K-509 consist of Baymean, Foreston, and Stallings series soils. These are mostly composed of loamy fine sand and have a pH range of 3.6 to 6.5 (USDA, 1992). The entire range footprint of K-509 is vegetated with grass. The deposition area of K-509 drains south towards the Whitehurst Creek with an approximate slope of 1.2%.			

K-509
MCIEAST - MCB Camp Lejeune

Table 4: Surface Water / Sediment Receptors Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
Surface Water Body	*Identify if a nearby surface water body is present down gradient, **as defined on the National Hydrography Dataset (NHD) map**.*	8 if surface water body is located downgradient of the range within 1,500 feet 4 if surface water body is located downgradient of the range 1,500-5,000 feet 0 if surface water body is located downgradient of the range over 5,000 feet	8
Drinking Water Use	*Identify if a down gradient surface water body is used as a drinking water source (drainage distance).*	4 if surface water body used as a drinking water source is located downgradient of the range within 1 mile 2 if surface water body used as a drinking water source is located downgradient of the range within 1 to 6 miles 0 if no known drinking water intakes are identified within 6 miles of the range	0
Drainage Distance to Installation Boundary	*Identify downgradient drainage distance to first potential ecological exposure off installation (i.e., installation boundary).*	4 if the installation boundary is located downgradient of the range within 0.5 miles 2 if the installation boundary is located downgradient of the range within 0.5 to 3 miles 0 if the installation boundary is located downgradient of the range greater than 3 miles, or if surface water runoff from the range does not discharge off the installation	4
Surface Water Receptor Score *Minimum: 0 Maximum: 16*			12

Notes:

According to the USGS National Hydrography Map, there is a downgradient marsh which boarders a tributary to the New River approximately 480 feet southwest of the bullet deposition area.

Drinking water is obtained from water supply wells throughout the installation. Surface water is not used as a drinking water source at the installation, nor are there any surface water bodies used as drinking water sources within 6 miles of this range.

The drainage pathway from K-509 proceeds southwest from the bullet deposition area to a marsh which drains southwest to a tributary of New River. This drainage pathway crosses the installation boundary upon reaching the tributary of the New River approximately 0.10 miles from the range.

K-509
MCIEAST - MCB Camp Lejeune

Table 5: Groundwater Receptors Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
Wells Identified as Potable Water Sources	*Number and location of potable water or potable water supply wells relative to the location of the range.*	6 if a drinking water well is located within <50 feet of the range 3 if a drinking water well is located downgradient of the range within 50-1,500 feet 0 if there are no drinking water wells located within 1,500 feet downgradient of the range or if groundwater is not used as a drinking water source.	0
	Into what ***type of aquifer is the well set***	6 if unconfined 3 if semi-confined 0 if confined	0
Groundwater wells identified for purpose other than drinking water	*Groundwater wells used for purposes other than drinking water supply identified down gradient of the range.*	3 if a groundwater well is located within 50 feet of the range 1 if a groundwater well is located downgradient of the range within 50-1,500 feet 0 if groundwater well <1,500 feet downgradient of the range is not used for any purpose.	1
Groundwater Receptor Score *Minimum: 0 Maximum: 15*			1
Notes: The only well located within 1,500 feet of the range is a non-potable well that is approximately 590 feet from the range.			

K-509
MCIEAST - MCB Camp Lejeune

Table 6: Evaluation Score
(These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)

Element	Table	Score
Surface Water / Sediment		
Range Use and Range Management (Source)	1	9
Surface Water / Sediment Pathways	2	13
Surface Water / Sediment Receptors	4	12
Sum of Surface Water / Sediment Element Scores *Minimum: 0 Maximum: 65*		**34**
Groundwater		
Range Use and Range Management (Source)	1	9
Groundwater Pathways	3	15
Groundwater Receptors	5	1
Sum of Groundwater Element Scores *Minimum: 0 Maximum: 62*		**25**

Field Sampling and Observed Releases

Surface Water / Sediment	Surface water sampling conducted Yes ☒ No ☐ Sediment sampling conducted Yes ☐ No ☒ Results exceed DoD screening value Yes ☐ No ☒	**Surface Water / Sediment** ☒ No Modification ☐ High
Groundwater	Groundwater sampling conducted Yes ☒ No ☐ Results exceed DoD screening value Yes ☐ No ☒	**Groundwater** ☒ No Modification ☐ High

The relative evaluation ranking for each media is determined by selecting the appropriate score based on the data elements for that media:

Evaluation Ranking*	Score Range
High	45-65
Moderate	33-44
Minimal	0-32

Surface Water Evaluation Ranking	**Moderate**
Groundwater Evaluation Ranking	**Minimal**

Notes: One surface water sample (K2_SW-05) was collected at the confluence of Whitehurst Creek and Stones Bay. Total and dissolved lead were detected at concentrations of 2.1 µg/L and 0.79 µg/L, respectively. Results were below screening criteria.

Two groundwater samples (K2_MW-06 and K2_MW-07) were collected on the downgradient side of the K2 Impact Area. Total lead was detected at concentrations of 0.96 µg/L and 1.7 µg/L. Dissolved lead was detected at concentrations of 1.5 µg/L and 0.26 µg/L. All results were below screening criteria of 15 µg/L.

MAC 1, 2, 4, 5, and 6
MCIEAST - MCB Camp Lejeune
Jacksonville, North Carolina

Date of SARAP update: 11/19/2014

DESCRIPTION

Range Mission:	Assorted Urban Fire Team Ranges
Training Start Date:	1990
Direction of Fire:	Northwest
Firing Positions:	Variable
Target Range:	Variable
Impact Area(s):	☐ Open area ☐ Hillside ☐ Building ☒ Earthen berm ☐ Bullet trap
Existing BMPs:	☐ Basin/vault ☐ Control fabric ☐ Diversion ☐ Fencing ☐ Rip-rap ☐ Silt check ☐ Vegetation *Other:*
Reference(s):	

FINDINGS

Review Period		**Periodic Review**
Estimated Lead Deposition (lb/yr)		1,322
Surface Water / Sediment	***RANK***	Moderate
	Source	10
	Pathway	19
	Receptor	10
	TOTAL SCORE	39
Groundwater	***RANK***	Minimal
	Source	10
	Pathway	15
	Receptor	4
	TOTAL SCORE	29

RECOMMENDATIONS

☒ Periodically review operations for significant changes in training, management, and use.

☐ Gather additional data regarding ☐ range use, ☐ pathways, or ☐ receptors associated with the range: ____________________

☐ Collect site-specific field data to further assess potential off-range migration.

MAC 1, 2, 4, 5, and 6
MCIEAST - MCB Camp Lejeune

Table 1: Range Use and Range Management (*Source*) Element
(These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)

Criteria	Evaluation Characteristics	Score Criteria	Site Score
MC Loading Rates	*The amount of small arms ammunition expended on the range.* *Estimate the MC loading as average lead deposition rate.*	14 if MC loading > 8,000 pounds/year 11 if MC loading = 4,001-8,000 pounds/year 8 if MC loading = 2,001-4,000 pounds/year 5 if MC loading = 501-2,000 pounds/year 2 if MC loading < 501 pounds/year	5
Impact Area	*The bullet deposition scenario at the range.*	4 if projectiles are scattered in SDZ 3 if range has an impact berm 1 if range has a bullet trap	3
Lead Management	*Frequency of activities that result in the removal of lead from an EARTHERN BERM or SDZ.* *This includes MINOR removal (e.g. scraping and sifting of berm/area, soil amendments) as well as MAJOR removals (e.g. lead mining).*	0 if no notable mining -1 if a MINOR action completed once during either of the last two periodic reviews -2 if MINOR action completed during each of the two previous periodic reviews -3 if MAJOR action was completed once during either of the last two periodic reviews -4 if MAJOR action completed during each of the two previous periodic reviews	0
	Frequency of activities that result in the significant removal of lead from a BULLET TRAP.	-3 if bullet trap was not been serviced during last two periodic reviews -5 if bullet trap was serviced once during either of the last two periodic reviews -7 if bullet trap was serviced during each of the last two periodic reviews	
Duration of Range Use	*Length of time the range has been used.*	2 if > 5 years 0 if ≤ 5 years	2
Source Element Score *Minimum: -4 Maximum: 20*			10

Notes:

Annual lead deposition for all these ranges combined – 1,322 pounds/year.

These ranges have been in use since 1990.

MAC 1, 2, 4, 5, and 6
MCIEAST - MCB Camp Lejeune

Table 2: Surface Water / Sediment Pathways Characteristics Element
(These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)

Criteria	Evaluation Characteristics	Score Criteria	Site Score
Precipitation	*Rate of precipitation.*	8 if precipitation > 40 inches/year 6 if precipitation = 20-40 inches/year 4 if precipitation < 20 inches/year	8
Vegetation	*Approximate vegetation cover **within and directly downslope of the projectile deposition area.***	6 if vegetation cover < 10% 4 if vegetation cover = 10% to 90% 2 if vegetation cover > 90%	4
Slope of Range	*Average slope **from deposition area along the overland pathway to the first defined channel.***	5 if slope > 10% (5.71°) 3 if slope = 5% to 10% 2 if slope < 5% (2.86°)	3
pH of Soil	*pH below 6.5 and above 8.5 increases the rate of lead dissolution.*	3 if pH < 4 or >10 2 if pH ≥ 4 < 6.5 or > 8.5 ≤ 10 1 if pH 6.5 ≤ pH ≤ 8.5	2
Soil Type/ Erosion	*Erosion potential is greatest for fine sands and silt. Clay has the lowest erosion potential. **The area where projectiles are deposited should be scored.***	2 if soil type is fine sand / silt 1 if soil type is clayey sand or silt / coarse sands 0 if soil type is clay	2
	Erosion observed at the projectile deposition area.	5 if there is visual evidence of eroded material being transported from the projectile deposition area 3 if bullet pockets or other indicators of erosion were observed 1 if no erosion was observed	3
Engineering Controls	*The presence of engineering controls or BMPs to modify or control **surface water run-on.*** *Controls may include barriers or diversions that reduce run-on to the range.*	0 if no engineering controls -1 if partial engineering controls -2 if effective engineering controls	-1

MAC 1, 2, 4, 5, and 6
MCIEAST - MCB Camp Lejeune

Table 2: Surface Water / Sediment Pathways Characteristics Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
	*The presence of engineering controls or BMPs to modify or control **surface water run-off or erosion.*** *Run-off controls may include silt fencing, rip-rap, sedimentation basins, or detention ponds that control run-off from the range. Erosion controls may include soil mix, irrigation, or netting.*	0 if no engineering controls -2 if partial engineering controls -4 if effective engineering controls	-2
Surface Water Pathway Score *Minimum: 4 Maximum: 29*			19

Notes:

Jacksonville, NC averages 56" of rainfall per year (MCB Camp Lejeune, 2006).

The majority of the MAC ranges are vegetated with grass. Only small bare areas present in impact berms were observed.

The deposition areas of the MAC ranges drain southeast towards the most upstream segment of Bear Creek with an approximate slope of 6%.

A large portion of the soil located at the MAC ranges is made up of Pit (excavated) soils which tend to be poorly drained. Additionally, there is Norfolk, Baymead, Foreston, and Stallings series soils. These are mostly composed of loamy fine sand. Pit soils in the area have a pH range of approximately 4.5 to 6.

An impact berm stretches the length of the entire MAC range complex which diverts surface water flow around the complex thus reducing run-on. Additionally, the MAC ranges contain vegetated drainage features which slow surface water run-off.

MAC 1, 2, 4, 5, and 6
MCIEAST - MCB Camp Lejeune

Table 3: Groundwater Pathways Characteristics Element
(These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)

Criteria	Evaluation Characteristics	Score Criteria	Site Score
Precipitation	*Intensity and frequency of precipitation.*	3 if precipitation > 40 inches/year 2 if precipitation = 20-40 inches/year 1 if precipitation < 20 inches/year	3
Depth to Groundwater	*The potential for impact to the groundwater decreases with an increasing depth to the water table.*	6 if depth to groundwater < 3 feet 3 if depth to groundwater = 3-20 feet 1 if depth to groundwater = 20-100 feet 0 if in a groundwater discharge area or depth to groundwater > 100 feet	3
Soil Type / Infiltration Conditions	*Soil with a higher porosity (sands/gravels) has more infiltration and less runoff compared to soil with low porosity (silts/clays).* ***Most hydraulically restrictive infiltration horizon between the surface and groundwater is scored.***	6 if soil type is sand / gravel 3 if soil type is sand and silt 1 if soil type is clay / clayey sand/silt	3
	Vegetation impedes infiltration and groundwater recharge.	6 if vegetation cover < 10% 3 if vegetation cover = 10% to 90% 1 if vegetation cover > 90%	3
	Average slope from deposition area along the overland pathway to the first defined channel.	3 if slope < 2% (1.15°) 1 if slope = 2% to 20% 0 if slope > 20% (11.31°)	1
pH of Soil	*Lead tends to stay dissolved at pH conditions less than 6.5 and greater than 8.5 but tends to attach to soil particles at pH conditions between these levels.*	3 if pH < 4 or >10 2 if pH ≥ 4 < 6.5 or > 8.5 ≤ 10 1 if pH 6.5 ≤ pH ≤ 8.5	2
Groundwater Pathway Score *Minimum: 4 Maximum: 27*			15

Notes:

Jacksonville, NC averages 56” of rainfall per year (MCB Camp Lejeune, 2006).

Based on measurements collected in the vicinity of these ranges, the depth to groundwater in this area is approximately 8 to 13 feet below ground surface.

MAC 1, 2, 4, 5, and 6
MCIEAST - MCB Camp Lejeune

Table 3: Groundwater Pathways Characteristics Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	Evaluation Characteristics	Score Criteria	Site Score
A large portion of the soil located at the MAC ranges is made up of Pit (excavated) soils which tend to be poorly drained. Additionally, there is Norfolk, Baymead, Foreston, and Stallings series soils. These are mostly composed of loamy fine sand. Pit soils in the area have a pH range of approximately 4.5 to 6. The majority of the MAC ranges are vegetated with grass. Only small bare areas present in impact berms were observed. The deposition areas of the MAC ranges drain southeast towards the most upstream segment of Bear Creek with an approximate slope of 6%.			

MAC 1, 2, 4, 5, and 6
MCIEAST - MCB Camp Lejeune

Table 4: Surface Water / Sediment Receptors Element
(These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)

Criteria	Evaluation Characteristics	Score Criteria	Site Score
Surface Water Body	*Identify if a nearby surface water body is present down gradient, **as defined on the National Hydrography Dataset (NHD) map**.*	8 if surface water body is located downgradient of the range within 1,500 feet 4 if surface water body is located downgradient of the range 1,500-5,000 feet 0 if surface water body is located downgradient of the range over 5,000 feet	8
Drinking Water Use	*Identify if a down gradient surface water body is used as a drinking water source (drainage distance).*	4 if surface water body used as a drinking water source is located downgradient of the range within 1 mile 2 if surface water body used as a drinking water source is located downgradient of the range within 1 to 6 miles 0 if no known drinking water intakes are identified within 6 miles of the range	0
Drainage Distance to Installation Boundary	*Identify downgradient drainage distance to first potential ecological exposure off installation (i.e., installation boundary).*	4 if the installation boundary is located downgradient of the range within 0.5 miles 2 if the installation boundary is located downgradient of the range within 0.5 to 3 miles 0 if the installation boundary is located downgradient of the range greater than 3 miles, or if surface water runoff from the range does not discharge off the installation	2
Surface Water Receptor Score *Minimum: 0 Maximum: 16*			10

Notes:

According to the USGS National Hydrography Map, there is a downgradient marsh which boarders Bear Creek approximately 480 feet southeast of the bullet deposition area.

Drinking water is obtained from water supply wells throughout the installation. Surface water is not used as a drinking water source at the installation, nor are there any surface water bodies used as drinking water sources within 6 miles of these ranges.

The drainage pathway from the MAC ranges proceeds southeast from the bullet deposition area to a marsh which drains southeast to Bear Creek. Bear Creek flows east and crosses the installation boundary approximately 1.2 miles from the ranges.

MAC 1, 2, 4, 5, and 6
MCIEAST - MCB Camp Lejeune

Table 5: Groundwater Receptors Element
(These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)

Criteria	Evaluation Characteristics	Score Criteria	Site Score
Wells Identified as Potable Water Sources	*Number and location of potable water or potable water supply wells relative to the location of the range.*	6 if a drinking water well is located within <50 feet of the range 3 if a drinking water well is located downgradient of the range within 50-1,500 feet 0 if there are no drinking water wells located within 1,500 feet downgradient of the range or if groundwater is not used as a drinking water source.	0
	Into what ***type of aquifer is the well set***	6 if unconfined 3 if semi-confined 0 if confined	3
Groundwater wells identified for purpose other than drinking water	*Groundwater wells used for purposes other than drinking water supply identified down gradient of the range.*	3 if a groundwater well is located within 50 feet of the range 1 if a groundwater well is located downgradient of the range within 50-1,500 feet 0 if groundwater well <1,500 feet downgradient of the range is not used for any purpose.	1
Groundwater Receptor Score *Minimum: 0 Maximum: 15*			4

Notes:

The only well located within 1,500 feet of the MAC range complex is a non-potable well that is approximately 80 feet to northeast.

MAC 1, 2, 4, 5, and 6
MCIEAST - MCB Camp Lejeune

Table 6: Evaluation Score
(These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)

Surface Water / Sediment		
Element	**Table**	**Score**
Range Use and Range Management (Source)	1	10
Surface Water / Sediment Pathways	2	19
Surface Water / Sediment Receptors	4	10
Sum of Surface Water / Sediment Element Scores *Minimum: 0 Maximum: 65*		**39**
Groundwater		
Element	**Table**	**Score**
Range Use and Range Management (Source)	1	10
Groundwater Pathways	3	15
Groundwater Receptors	5	4
Sum of Groundwater Element Scores *Minimum: 0 Maximum: 62*		**29**

Field Sampling and Observed Releases

Surface Water / Sediment	Surface water sampling conducted Yes ☐ No ☒ Sediment sampling conducted Yes ☐ No ☐ Results exceed DoD screening value Yes ☐ No ☐	**Surface Water / Sediment** ☒ No Modification ☐ High **Groundwater** ☒ No Modification ☐ High
Groundwater	Groundwater sampling conducted Yes ☐ No ☒ Results exceed DoD screening value Yes ☐ No ☐	

The relative evaluation ranking for each media is determined by selecting the appropriate score based on the data elements for that media:

Evaluation Ranking*	Score Range
High	45-65
Moderate	33-44
Minimal	0-32

Surface Water Evaluation Ranking	**Moderate**
Groundwater Evaluation Ranking	**Minimal**

Notes:

R-100
MCIEAST - MCB Camp Lejeune
Jacksonville, North Carolina

Date of SARAP update: 11/20/2014

DESCRIPTION

Range Mission:	Skeet Range/Recreation/Archery
Training Start Date:	2013
Direction of Fire:	Northeast
Firing Positions:	40
Target Range:	Variable (Skeet Targets)
Impact Area(s):	☒ Open area ☐ Hillside ☐ Building ☐ Earthen berm ☐ Bullet trap
Existing BMPs:	☐ Basin/vault ☐ Control fabric ☐ Diversion ☐ Fencing ☐ Rip-rap ☐ Silt check ☐ Vegetation
	Other:
Reference(s):	

FINDINGS

Review Period		**Periodic Review**
Estimated Lead Deposition (lb/yr)		24,475
Surface Water / Sediment	***RANK***	High[a]
	Source	18
	Pathway	15
	Receptor	6
	TOTAL SCORE	39
Groundwater	***RANK***	Moderate
	Source	18
	Pathway	16
	Receptor	6
	TOTAL SCORE	40

Note:
a. Score modified from Moderate to High based on sample results.

RECOMMENDATIONS

☒ Periodically review operations for significant changes in training, management, and use.

☐ Gather additional data regarding ☐ range use, ☐ pathways, or ☐ receptors associated with the range: ____________________

☒ Collect site-specific field data to further assess potential off-range migration.

R-100
MCIEAST - MCB Camp Lejeune

Table 1: Range Use and Range Management (*Source)* Element
(These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)

Criteria	Evaluation Characteristics	Score Criteria	Site Score
MC Loading Rates	*The amount of small arms ammunition expended on the range.* *Estimate the MC loading as average lead deposition rate.*	14 if MC loading > 8,000 pounds/year 11 if MC loading = 4,001-8,000 pounds/year 8 if MC loading = 2,001-4,000 pounds/year 5 if MC loading = 501-2,000 pounds/year 2 if MC loading < 501 pounds/year	14
Impact Area	*The bullet deposition scenario at the range.*	4 if projectiles are scattered in SDZ 3 if range has an impact berm 1 if range has a bullet trap	4
Lead Management	*Frequency of activities that result in the removal of lead from an EARTHERN BERM or SDZ.* *This includes MINOR removal (e.g. scraping and sifting of berm/area, soil amendments) as well as MAJOR removals (e.g. lead mining).*	0 if no notable mining -1 if a MINOR action completed once during either of the last two periodic reviews -2 if MINOR action completed during each of the two previous periodic reviews -3 if MAJOR action was completed once during either of the last two periodic reviews -4 if MAJOR action completed during each of the two previous periodic reviews	0
	Frequency of activities that result in the significant removal of lead from a BULLET TRAP.	-3 if bullet trap was not been serviced during last two periodic reviews -5 if bullet trap was serviced once during either of the last two periodic reviews -7 if bullet trap was serviced during each of the last two periodic reviews	
Duration of Range Use	*Length of time the range has been used.*	2 if > 5 years 0 if ≤ 5 years	0
Source Element Score *Minimum: -4 Maximum: 20*			18

Notes:

Annual lead deposition – 24,475 pounds/year.

This range has been in use since 2013.

R-100
MCIEAST - MCB Camp Lejeune

Table 2: Surface Water / Sediment Pathways Characteristics Element
(These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)

Criteria	Evaluation Characteristics	Score Criteria	Site Score
Precipitation	*Rate of precipitation.*	8 if precipitation > 40 inches/year 6 if precipitation = 20-40 inches/year 4 if precipitation < 20 inches/year	8
Vegetation	*Approximate vegetation cover* ***within and directly downslope of the projectile deposition area.***	6 if vegetation cover < 10% 4 if vegetation cover = 10% to 90% 2 if vegetation cover > 90%	2
Slope of Range	*Average slope* ***from deposition area along the overland pathway to the first defined channel.***	5 if slope > 10% (5.71°) 3 if slope = 5% to 10% 2 if slope < 5% (2.86°)	2
pH of Soil	*pH below 6.5 and above 8.5 increases the rate of lead dissolution.*	3 if pH < 4 or >10 2 if pH ≥ 4 < 6.5 or > 8.5 ≤ 10 1 if pH 6.5 ≤ pH ≤ 8.5	2
Soil Type/ Erosion	*Erosion potential is greatest for fine sands and silt. Clay has the lowest erosion potential.* ***The area where projectiles are deposited should be scored.***	2 if soil type is fine sand / silt 1 if soil type is clayey sand or silt / coarse sands 0 if soil type is clay	2
	Erosion observed at the projectile deposition area.	5 if there is visual evidence of eroded material being transported from the projectile deposition area 3 if bullet pockets or other indicators of erosion were observed 1 if no erosion was observed	1
Engineering Controls	*The presence of engineering controls or BMPs to modify or control* ***surface water run-on.*** *Controls may include barriers or diversions that reduce run-on to the range.*	0 if no engineering controls -1 if partial engineering controls -2 if effective engineering controls	0

R-100

MCIEAST - MCB Camp Lejeune

Table 2: Surface Water / Sediment Pathways Characteristics Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
	The presence of engineering controls or BMPs to modify or control ***surface water run-off or erosion.*** *Run-off controls may include silt fencing, rip-rap, sedimentation basins, or detention ponds that control run-off from the range. Erosion controls may include soil mix, irrigation, or netting.*	0 if no engineering controls -2 if partial engineering controls -4 if effective engineering controls	-2
Surface Water Pathway Score *Minimum: 4 Maximum: 29*			15

Notes:

Jacksonville, NC averages 56” of rainfall per year (MCB Camp Lejeune, 2006).

The entire range footprint is covered with vegetation.

The range slopes slightly towards the firing line which contains a drainage channel that flows southeast. The slope to this channel from the shot fall area is approximately 2.5%.

According to the USDA, soils at R-100 are comprised of Foreston loamy fine sand and Woodington loamy fine sand which both range from extremely acidic through strongly acidic.

R-100 contains no engineering controls to prevent surface water run-on. Partial engineering controls addressing run-off include the presence of vegetation throughout the range area and a vegetated drainage feature.

R-100
MCIEAST - MCB Camp Lejeune

Table 3: Groundwater Pathways Characteristics Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
Precipitation	*Intensity and frequency of precipitation.*	3 if precipitation > 40 inches/year 2 if precipitation = 20-40 inches/year 1 if precipitation < 20 inches/year	3
Depth to Groundwater	*The potential for impact to the groundwater decreases with an increasing depth to the water table.*	6 if depth to groundwater < 3 feet 3 if depth to groundwater = 3-20 feet 1 if depth to groundwater = 20-100 feet 0 if in a groundwater discharge area or depth to groundwater > 100 feet	3
Soil Type / Infiltration Conditions	*Soil with a higher porosity (sands/gravels) has more infiltration and less runoff compared to soil with low porosity (silts/clays).* ***Most hydraulically restrictive infiltration horizon between the surface and groundwater is scored.***	6 if soil type is sand / gravel 3 if soil type is sand and silt 1 if soil type is clay / clayey sand/silt	6
	Vegetation impedes infiltration and groundwater recharge.	6 if vegetation cover < 10% 3 if vegetation cover = 10% to 90% 1 if vegetation cover > 90%	1
	Average slope from deposition area along the overland pathway to the first defined channel.	3 if slope < 2% (1.15°) 1 if slope = 2% to 20% 0 if slope > 20% (11.31°)	1
pH of Soil	*Lead tends to stay dissolved at pH conditions less than 6.5 and greater than 8.5 but tends to attach to soil particles at pH conditions between these levels.*	3 if pH < 4 or >10 2 if pH ≥ 4 < 6.5 or > 8.5 ≤ 10 1 if pH 6.5 ≤ pH ≤ 8.5	2
Groundwater Pathway Score *Minimum: 4 Maximum: 27*			16

Notes:

Jacksonville, NC averages 56" of rainfall per year (MCB Camp Lejeune, 2006).

Groundwater is relatively shallow as evidenced by the low elevation and proximity to the New

R-100

MCIEAST - MCB Camp Lejeune

Table 3: Groundwater Pathways Characteristics Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
River and the coast. According to the USDA, soils at R-100 are comprised of Foreston loamy fine sand and Woodington loamy fine sand which both range from extremely acidic through strongly acidic. The entire range footprint is covered with vegetation. The range slopes slightly towards the firing line which contains a drainage channel that flows southeast. The slope to this channel from the shot fall area is approximately 2.5%.			

R-100
MCIEAST - MCB Camp Lejeune

Table 4: Surface Water / Sediment Receptors Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
Surface Water Body	*Identify if a nearby surface water body is present down gradient,* ***as defined on the National Hydrography Dataset (NHD) map****.*	8 if surface water body is located downgradient of the range within 1,500 feet 4 if surface water body is located downgradient of the range 1,500-5,000 feet 0 if surface water body is located downgradient of the range over 5,000 feet	4
Drinking Water Use	*Identify if a down gradient surface water body is used as a drinking water source (drainage distance).*	4 if surface water body used as a drinking water source is located downgradient of the range within 1 mile 2 if surface water body used as a drinking water source is located downgradient of the range within 1 to 6 miles 0 if no known drinking water intakes are identified within 6 miles of the range	0
Drainage Distance to Installation Boundary	*Identify downgradient drainage distance to first potential ecological exposure off installation (i.e., installation boundary).*	4 if the installation boundary is located downgradient of the range within 0.5 miles 2 if the installation boundary is located downgradient of the range within 0.5 to 3 miles 0 if the installation boundary is located downgradient of the range greater than 3 miles, or if surface water runoff from the range does not discharge off the installation	2
Surface Water Receptor Score *Minimum: 0 Maximum: 16*			6

Notes:

According to the USGS National Hydrography Map, there is a downgradient tributary of the New River approximately 2,100 feet southeast of the shot fall area.

Drinking water is obtained from water supply wells throughout the installation. Surface water is not used as a drinking water source at the installation, nor are there any surface water bodies used as drinking water sources within 6 miles of this range.

The drainage pathway from R-100 proceeds southeast from the shot fall area to a tributary of the New River. This tributary flows south and crosses the installation boundary approximately 1.5 miles from the range.

R-100
MCIEAST - MCB Camp Lejeune

Table 5: Groundwater Receptors Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
Wells Identified as Potable Water Sources	*Number and location of potable water or potable water supply wells relative to the location of the range.*	6 if a drinking water well is located within <50 feet of the range 3 if a drinking water well is located downgradient of the range within 50-1,500 feet 0 if there are no drinking water wells located within 1,500 feet downgradient of the range or if groundwater is not used as a drinking water source.	3
	Into what ***type of aquifer is the well set***	6 if unconfined 3 if semi-confined 0 if confined	3
Groundwater wells identified for purpose other than drinking water	*Groundwater wells used for purposes other than drinking water supply identified down gradient of the range.*	3 if a groundwater well is located within 50 feet of the range 1 if a groundwater well is located downgradient of the range within 50-1,500 feet 0 if groundwater well <1,500 feet downgradient of the range is not used for any purpose.	0
Groundwater Receptor Score *Minimum: 0 Maximum: 15*			6
Notes: A potable supply well is located approximately 740 feet downgradient from the range.			

Table 6: Evaluation Score (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)		
Surface Water / Sediment		
Element	**Table**	**Score**
Range Use and Range Management (Source)	1	18
Surface Water / Sediment Pathways	2	15
Surface Water / Sediment Receptors	4	6
Sum of Surface Water / Sediment Element Scores *Minimum: 0 Maximum: 65*		**39**
Groundwater		
Element	**Table**	**Score**
Range Use and Range Management (Source)	1	18
Groundwater Pathways	3	16
Groundwater Receptors	5	6
Sum of Groundwater Element Scores *Minimum: 0 Maximum: 62*		**40**

Field Sampling and Observed Releases

Surface Water / Sediment	Surface water sampling conducted Yes ☒ No ☐ Sediment sampling conducted Yes ☒ No ☐ Results exceed DoD screening value Yes ☒ No ☐	**Surface Water / Sediment** ☐ No Modification ☒ High
Groundwater	Groundwater sampling conducted Yes ☐ No ☒ Results exceed DoD screening value Yes ☐ No ☐	**Groundwater** ☒ No Modification ☐ High

The relative evaluation ranking for each media is determined by selecting the appropriate score based on the data elements for that media:

Evaluation Ranking*	Score Range
High	45-65
Moderate	33-44
Minimal	0-32

Surface Water Evaluation Ranking	**High[1]**
Groundwater Evaluation Ranking	**Moderate**

Notes: 1. Surface water scoring resulted in a Moderate ranking; however, this was modified to High based on surface water and sediment sample results.

Two surface water, four sediment, and six soil samples were collected and analyzed for total and dissolved lead at R-100. Total lead exceeded screening criteria (25 µg/L) in one sample with a concentration of 26 µg/L (duplicate result 31 µg/L). Dissolved lead exceeded screening criteria (0.86 and 1.36 µg/L) in both surface water samples with concentrations of 2.2 µg/L and 22 µg/L (duplicate result of 23 µg/L). Lead in sediment exceeded screening criteria of 30.2 and 47 in one sample with a concentration of 73 mg/kg. All lead detections in soil were below screening criteria.

The highest surface water and sediment lead concentrations were on the downgradient side of the skeet range downgradient of a debris pile that accumulated at least partially from surface water runoff. Soil characteristics measured are not conducive to immobilizing lead. Removing this debris pile and incorporating soil amendments, such as lime, may help in reducing lead concentrations at this downgradient side of the range.

SR-8
MCIEAST - MCB Camp Lejeune
Jacksonville, North Carolina

Date of SARAP update: 11/19/2014

DESCRIPTION

Range Mission:	Multi-purpose Machinegun Qualification Firing Range
Training Start Date:	2009
Direction of Fire:	Northwest
Firing Positions:	10
Target Range:	300, 450, and 650 meters
Impact Area(s):	☐ Open area ☐ Hillside ☐ Building ☒ Earthen berm ☐ Bullet trap
Existing BMPs:	☒ Basin/vault ☐ Control fabric ☒ Diversion ☐ Fencing ☐ Rip-rap ☐ Silt check ☒ Vegetation *Other:*
Reference(s):	

FINDINGS

Review Period		**Periodic Review**
Estimated Lead Deposition (lb/yr)		32,214
Surface Water / Sediment	***RANK***	Moderate
	Source	19
	Pathway	14
	Receptor	8
	TOTAL SCORE	41
Groundwater	***RANK***	Moderate
	Source	19
	Pathway	17
	Receptor	3
	TOTAL SCORE	39

RECOMMENDATIONS

☒ Periodically review operations for significant changes in training, management, and use.

☐ Gather additional data regarding ☐ range use, ☐ pathways, or ☐ receptors associated with the range: ______________________________

☒ Collect site-specific field data to further assess potential off-range migration.

SR-8
MCIEAST - MCB Camp Lejeune

Table 1: Range Use and Range Management (*Source)* Element
(These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)

Criteria	Evaluation Characteristics	Score Criteria	Site Score
MC Loading Rates	*The amount of small arms ammunition expended on the range.* *Estimate the MC loading as average lead deposition rate.*	14 if MC loading > 8,000 pounds/year 11 if MC loading = 4,001-8,000 pounds/year 8 if MC loading = 2,001-4,000 pounds/year 5 if MC loading = 501-2,000 pounds/year 2 if MC loading < 501 pounds/year	14
Impact Area	*The bullet deposition scenario at the range.*	4 if projectiles are scattered in SDZ 3 if range has an impact berm 1 if range has a bullet trap	3
Lead Management	*Frequency of activities that result in the removal of lead from an EARTHERN BERM or SDZ.* *This includes MINOR removal (e.g. scraping and sifting of berm/area, soil amendments) as well as MAJOR removals (e.g. lead mining).*	0 if no notable mining -1 if a MINOR action completed once during either of the last two periodic reviews -2 if MINOR action completed during each of the two previous periodic reviews -3 if MAJOR action was completed once during either of the last two periodic reviews -4 if MAJOR action completed during each of the two previous periodic reviews	0
	Frequency of activities that result in the significant removal of lead from a BULLET TRAP.	-3 if bullet trap was not been serviced during last two periodic reviews -5 if bullet trap was serviced once during either of the last two periodic reviews -7 if bullet trap was serviced during each of the last two periodic reviews	
Duration of Range Use	*Length of time the range has been used.*	2 if > 5 years 0 if ≤ 5 years	2
Source Element Score *Minimum: -4 Maximum: 20*			19

Notes:

Annual lead deposition – 32,214 pounds/year.

Impact berms are positioned behind the targets. There are no bullet traps present.

This range has been in use since 2009.

SR-8
MCIEAST - MCB Camp Lejeune

Table 2: Surface Water / Sediment Pathways Characteristics Element
(These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)

Criteria	Evaluation Characteristics	Score Criteria	Site Score
Precipitation	*Rate of precipitation.*	8 if precipitation > 40 inches/year 6 if precipitation = 20-40 inches/year 4 if precipitation < 20 inches/year	8
Vegetation	*Approximate vegetation cover **within and directly downslope of the projectile deposition area.***	6 if vegetation cover < 10% 4 if vegetation cover = 10% to 90% 2 if vegetation cover > 90%	4
Slope of Range	*Average slope **from deposition area along the overland pathway to the first defined channel.***	5 if slope > 10% (5.71°) 3 if slope = 5% to 10% 2 if slope < 5% (2.86°)	2
pH of Soil	*pH below 6.5 and above 8.5 increases the rate of lead dissolution.*	3 if pH < 4 or >10 2 if pH ≥ 4 < 6.5 or > 8.5 ≤ 10 1 if pH 6.5 ≤ pH ≤ 8.5	2
Soil Type/ Erosion	*Erosion potential is greatest for fine sands and silt. Clay has the lowest erosion potential. **The area where projectiles are deposited should be scored.***	2 if soil type is fine sand / silt 1 if soil type is clayey sand or silt / coarse sands 0 if soil type is clay	2
	Erosion observed at the projectile deposition area.	5 if there is visual evidence of eroded material being transported from the projectile deposition area 3 if bullet pockets or other indicators of erosion were observed 1 if no erosion was observed	1
Engineering Controls	*The presence of engineering controls or BMPs to modify or control **surface water run-on.*** *Controls may include barriers or diversions that reduce run-on to the range.*	0 if no engineering controls -1 if partial engineering controls -2 if effective engineering controls	-1

SR-8
MCIEAST - MCB Camp Lejeune

Table 2: Surface Water / Sediment Pathways Characteristics Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
	The presence of engineering controls or BMPs to modify or control ***surface water run-off or erosion.*** *Run-off controls may include silt fencing, rip-rap, sedimentation basins, or detention ponds that control run-off from the range. Erosion controls may include soil mix, irrigation, or netting.*	0 if no engineering controls -2 if partial engineering controls -4 if effective engineering controls	-4
Surface Water Pathway Score *Minimum: 4 Maximum: 29*			14

Notes:

Jacksonville, NC averages 56" of rainfall per year (MCB Camp Lejeune, 2006).

The range floor of SR-8 is well vegetated with grass with only minor bare areas. The impact berm and drainage ditches are also well vegetated with grass.

The deposition area of SR-8 drains north towards the Shelter Swamp Creek adjacent to the range with an approximate slope of 1.6%.

The primary soil types located at SR-8 consist of Leon-Murnville-Kureb, Baymeade-Foreston-Stallings, and Rains-Woodington-Torhunta series soils. These are mostly composed of fine sand and have a pH range of 3.6 to 5.5 (USDA, 1992).

SR-8 is equipped with vegetated drainage ditches located within the range footprint and also around the perimeter of the range. These ditches divert and channel water to the north/northwest and thus help to control both surface water run-on and run-off. Additionally, a vegetated impact berm is in place behind the target locations which also helps reduce surface water run-off.

SR-8

MCIEAST - MCB Camp Lejeune

Table 3: Groundwater Pathways Characteristics Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
Precipitation	*Intensity and frequency of precipitation.*	3 if precipitation > 40 inches/year 2 if precipitation = 20-40 inches/year 1 if precipitation < 20 inches/year	3
Depth to Groundwater	*The potential for impact to the groundwater decreases with an increasing depth to the water table.*	6 if depth to groundwater < 3 feet 3 if depth to groundwater = 3-20 feet 1 if depth to groundwater = 20-100 feet 0 if in a groundwater discharge area or depth to groundwater > 100 feet	3
Soil Type / Infiltration Conditions	*Soil with a higher porosity (sands/gravels) has more infiltration and less runoff compared to soil with low porosity (silts/clays).* ***Most hydraulically restrictive infiltration horizon between the surface and groundwater is scored.***	6 if soil type is sand / gravel 3 if soil type is sand and silt 1 if soil type is clay / clayey sand/silt	3
	Vegetation impedes infiltration and groundwater recharge.	6 if vegetation cover < 10% 3 if vegetation cover = 10% to 90% 1 if vegetation cover > 90%	3
	Average slope from deposition area along the overland pathway to the first defined channel.	3 if slope < 2% (1.15°) 1 if slope = 2% to 20% 0 if slope > 20% (11.31°)	3
pH of Soil	*Lead tends to stay dissolved at pH conditions less than 6.5 and greater than 8.5 but tends to attach to soil particles at pH conditions between these levels.*	3 if pH < 4 or >10 2 if pH ≥ 4 < 6.5 or > 8.5 ≤ 10 1 if pH 6.5 ≤ pH ≤ 8.5	2
Groundwater Pathway Score *Minimum: 4* *Maximum: 27*			17

Notes:

Jacksonville, NC averages 56” of rainfall per year (MCB Camp Lejeune, 2006).

Based on measurements collected in the vicinity of these ranges, the depth to groundwater in this area is approximately 10 to 14 feet below ground surface.

SR-8
MCIEAST - MCB Camp Lejeune

Table 3: Groundwater Pathways Characteristics Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	Evaluation Characteristics	Score Criteria	Site Score
The primary soil types located at SR-8 consist of Leon-Murnville-Kureb, Baymeade-Foreston-Stallings, and Rains-Woodington-Torhunta series soils. These are mostly composed of fine sand and have a pH range of 3.6 to 5.5 (USDA, 1992). The range floor of SR-8 is well vegetated with grass with only minor bare areas. The impact berm and drainage ditches are also well vegetated with grass. The deposition area of SR-8 drains north towards the Shelter Swamp Creek adjacent to the range with an approximate slope of 1.6%.			

SR-8
MCIEAST - MCB Camp Lejeune

Table 4: Surface Water / Sediment Receptors Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
Surface Water Body	*Identify if a nearby surface water body is present down gradient, **as defined on the National Hydrography Dataset (NHD) map**.*	8 if surface water body is located downgradient of the range within 1,500 feet 4 if surface water body is located downgradient of the range 1,500-5,000 feet 0 if surface water body is located downgradient of the range over 5,000 feet	8
Drinking Water Use	*Identify if a down gradient surface water body is used as a drinking water source (drainage distance).*	4 if surface water body used as a drinking water source is located downgradient of the range within 1 mile 2 if surface water body used as a drinking water source is located downgradient of the range within 1 to 6 miles 0 if no known drinking water intakes are identified within 6 miles of the range	0
Drainage Distance to Installation Boundary	*Identify downgradient drainage distance to first potential ecological exposure off installation (i.e., installation boundary).*	4 if the installation boundary is located downgradient of the range within 0.5 miles 2 if the installation boundary is located downgradient of the range within 0.5 to 3 miles 0 if the installation boundary is located downgradient of the range greater than 3 miles, or if surface water runoff from the range does not discharge off the installation	0
Surface Water Receptor Score *Minimum: 0 Maximum: 16*			8

Notes:

According to the USGS National Hydrography Map, there is a downgradient marsh approximately 1,300 feet northwest of the bullet deposition area.

Drinking water is obtained from water supply wells throughout the installation. Surface water is not used as a drinking water source at the installation, nor are there any surface water bodies used as drinking water sources within 6 miles of this range.

The shortest drainage pathway from SR-8 to the installation boundary proceeds northwest from the bullet deposition area to a marsh which drains west towards an intermittent stream. This intermittent stream flows southwest and crosses the installation boundary approximately 4.5 miles from the range.

SR-8
MCIEAST - MCB Camp Lejeune

Table 5: Groundwater Receptors Element
(These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)

Criteria	Evaluation Characteristics	Score Criteria	Site Score
Wells Identified as Potable Water Sources	*Number and location of potable water or potable water supply wells relative to the location of the range.*	6 if a drinking water well is located within <50 feet of the range 3 if a drinking water well is located downgradient of the range within 50-1,500 feet 0 if there are no drinking water wells located within 1,500 feet downgradient of the range or if groundwater is not used as a drinking water source.	0
	Into what ***type of aquifer is the well set***	6 if unconfined 3 if semi-confined 0 if confined	3
Groundwater wells identified for purpose other than drinking water	*Groundwater wells used for purposes other than drinking water supply identified down gradient of the range.*	3 if a groundwater well is located within 50 feet of the range 1 if a groundwater well is located downgradient of the range within 50-1,500 feet 0 if groundwater well <1,500 feet downgradient of the range is not used for any purpose.	0
Groundwater Receptor Score *Minimum: 0 Maximum: 15*			3

Notes:

The closest well is a potable off-installation county well that is located approximately 13,000 feet from the range.

SR-8
MCIEAST - MCB Camp Lejeune

Table 6: Evaluation Score
(These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)

Surface Water / Sediment		
Element	**Table**	**Score**
Range Use and Range Management (Source)	1	19
Surface Water / Sediment Pathways	2	14
Surface Water / Sediment Receptors	4	8
Sum of Surface Water / Sediment Element Scores *Minimum: 0 Maximum: 65*		**41**
Groundwater		
Element	**Table**	**Score**
Range Use and Range Management (Source)	1	19
Groundwater Pathways	3	17
Groundwater Receptors	5	3
Sum of Groundwater Element Scores *Minimum: 0 Maximum: 62*		**39**

Field Sampling and Observed Releases

Surface Water / Sediment	Surface water sampling conducted Yes ☒ No ☐ Sediment sampling conducted Yes ☐ No ☒ Results exceed DoD screening value Yes ☐ No ☒	**Surface Water / Sediment** ☒ No Modification ☐ High
Groundwater	Groundwater sampling conducted Yes ☐ No ☒ Results exceed DoD screening value Yes ☐ No ☐	**Groundwater** ☒ No Modification ☐ High

The relative evaluation ranking for each media is determined by selecting the appropriate score based on the data elements for that media:

Evaluation Ranking*	Score Range
High	45-65
Moderate	33-44
Minimal	0-32

Surface Water Evaluation Ranking	**Moderate**
Groundwater Evaluation Ranking	**Moderate**

Notes: One surface water sample was collected in the northern tributary of Shelter Swamp Creek near the installation boundary and analyzed for total and dissolved lead. Total and dissolved lead were detected at concentrations of 7.7 μg/L and 0.26 μg/L, respectively. All results were below screening criteria.