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REVA Periodic Review Report

Marine Corps Air Ground Combat Center

Twentynine Palms, California

April

2016

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Range Environmental Vulnerability Assessment
Periodic Review Report

Marine Corps Air Ground Combat Center Twentynine Palms, California

April 2016

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Range Environmental Vulnerability Assessment Periodic Review

Marine Corps Air Ground Combat Center Twentynine Palms, California

April 2016

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Acronym	Definition
µg/kg	micrograms per kilogram
µg/L	micrograms per liter
CSM	conceptual site model
CVOT	Combat Vehicle Operator Training
CY	calendar year
DoD	Department of Defense
DoDIC	Department of Defense Identification Code
DoN	Department of the Navy
EOD	explosive ordnance disposal
GIS	geographic information system
HE	high explosive
HMX	cyclotetramethylene tetranitramine
HQMC	Headquarters Marine Corps
in/yr	inches per year
ITX	Integrated Training Exercise
lb	pounds
lb/yr	pounds per year
m	meters
m^2	square meters
MC	munitions constituents
MCAGCC	Marine Corps Air Ground Combat Center
MCCS	Marine Corps Community Service
MDL	method detection limit
MEB	Marine Expeditionary Brigade
MFTL	Mojave Fringe-Toed Lizard
mg/kg	millligrams per kilogram
MOUT	military operations in urban terrain
MTU	Marksmanship Training Unit
NEW	net explosive weight
ORC	Operational Range Clearance
RDX	cyclotrimethylene trinitramine
REVA	Range Environmental Vulnerability Assessment
RFMSS	Range Facility Management Support System
RTA	Range Training Area
SAR	small arms range
SARAP	Small Arms Range Assessment Protocol
SSC	Species of Special Concern
TECOM	Training and Education Command
TOC	total organic carbon
TNT	trinitrotoluene

Acronym	Definition
U.S.	United States
USFWS	United States Fish and Wildlife Service
UXO	unexploded ordnance

Executive Summary

The United States Marine Corps (Marine Corps) Range Environmental Vulnerability Assessment (REVA) program is a proactive and comprehensive program designed to support the Marine Corps' Range Sustainment Program. This REVA Periodic Review for Marine Corps Air Ground Combat Center (MCAGCC) Twentynine Palms documents the assessment of munitions loading from 2011 to 2014.

The REVA periodic review installation data collection and site visit was conducted in September 2014; at that time, 25 operational range training areas (RTAs) and 46 operational ranges were identified. A total of 31 munition constituent (MC) loading areas were identified. Of these MC loading areas, surface water and sediment screening-level fate and transport assessments were conducted for 24 MC loading areas, while groundwater screening-level fate and transport assessment was conducted for 7 MC loading areas. Indicator MC were assessed, which include cyclotetramethylene tetranitramine (HMX), cyclotrimethylene trinitramine (RDX), trinitrotoluene (TNT), and perchlorate. Annual lead deposition in the MC loading areas was also estimated, and a total of 11 fixed ranges were qualitatively evaluated using the Small Arms Range Assessment Protocol (SARAP).

The results of the screening-level analyses predicted MC concentrations in surface water significantly lower than the DoD screening values for applicable receptors. Assessment of sediment at Quackenbush Lake playa predicted HMX, RDX, and TNT at concentrations above the applicable lower bound Department of Defense (DoD) screening values. HMX was also predicted to be accumulating at Lavic Lake playa above the applicable lower bound DoD screening value, while TNT was predicted to be accumulating at Deadman Lake and Lavic Lake playas above the applicable lower bound DoD screening value. Perchlorate concentrations in sediment accumulating in all assessed playas were predicted to be above the median method detection limit (MDL); there is no applicable DoD sediment screening benchmark. No MC were predicted to reach groundwater at levels above median MDLs with the exception of perchlorate; regardless, perchlorate was not predicted to exceed the applicable California drinking water benchmark. Significant lead deposition associated with HE ranges was predicted to occur in the area draining to Deadman Lake playa. The SARAPs indicated a low-moderate probability for migration of lead from small arms ranges to off-range areas.

To address findings from the sediment screening-level assessment and lead deposition screening, limited field data collection was performed at MCAGCC Twentynine Palms in May 2015, involving composite sediment sampling at the Deadman Lake, Quackenbush Lake, and Mesquite Lake playas. No explosives were detected in the collected samples; perchlorate was only found at a reference location in Mesquite Lake playa. Lead was detected in samples collected from Deadman Lake playa; however, all concentrations were below the applicable DoD ecological freshwater sediment screening value.

The quantitative, qualitative, and field assessments of surface water, sediment, and groundwater did not indicate significant releases of MC from operational RTAs or ranges at MCAGCC Twentynine Palms. It is recommended that an evaluation of all operational range areas be conducted in the next periodic review cycle, or sooner if significant changes at the installation warrant reevaluation.

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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 being assessed 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 assessments of operational range areas and periodic five-year review assessments 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 assessment for Marine Corps Air Ground Combat Center (MCAGCC) Twentynine Palms, located in Southern California. For the purposes of this report, the name "MCAGCC Twentynine Palms" will be used to reference any and all training conducted at the installation. 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 assessments are provided in the *Final Range Environmental Vulnerability Assessment, Marine Corps Air Ground Combat Center Twentynine Palms* and the *Range Environmental Vulnerability Assessment Five Year Review, Marine Corps Air Ground Combat Center Twentynine Palms* (Malcolm Pirnie 2007; 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, fixed ranges, live-fire maneuver areas, small arms ranges (SARs), buffer areas, and training areas where military munitions are known or suspected currently to be or historically to have been used.

The indicator MC evaluated in the REVA program include cyclotetramethylene tetranitramine (HMX), cyclotrimethylene trinitramine (RDX), trinitrotoluene (TNT), perchlorate, and lead. Studies have shown that HMX, RDX, and TNT are detected in a high percentage of samples containing MC because they are common high explosives (HEs) used in a wide variety of military munitions and because of their chemical stability within the environment. Perchlorate is a component of the solid propellants used in some military munitions. Perchlorate also is considered an indicator MC because its high solubility, low sorption potential, and low natural degradation rate make the compound highly mobile in the environment. Lead is the most prevalent (by weight) 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* (Headquarters Marine Corps [HQMC] 2009).

1.3 Installation Overview

MCAGCC Twentynine Palms, located east of Los Angeles and northeast of Palm Springs, is the Marine Corps' largest live-fire training facility, encompassing several hundred thousand acres across the Mojave Desert in San Bernardino County, California. The installation is bounded by Interstate 40 on the north and Highway 62 on the south. MCAGCC Twentynine Palms conducts relevant live-fire combined arms training, urban operations, and Joint/Coalition level integration training that promotes operational forces readiness, as well as to provide the facilities, services, and support responsive to the needs of resident organizations, Marines, Sailors, and their families. The installation conducts a full spectrum of warfighter training, from multiweapon system, multiservice field maneuver exercises to individual small arms proficiency training by individual Marines. Current live-fire training at the installation is focused on the Integrated Training Exercise (ITX), which was initiated in 2013 and replaced the Enhanced Mojave Viper exercise. The ITX is a combined arms exercise involving ground, air, and support elements available to an infantry battalion in preparation for ground combat operations in the theatre of operations (MCAGCC Twentynine Palms 2012b).

An overview of the general location of the installation is provided on **Figure 1-1**. The installation is administratively subdivided into range training areas (RTAs), including a cantonment area (Mainside), that support fire and maneuver training. A summary of the operational RTAs and ranges at MCAGCC Twentynine Palms is provided in **Appendix A**.

The Department of the Navy (DoN), acting on behalf of the Marine Corps, is completing a land expansion at MCAGCC Twentynine Palms to enhance training capabilities. This expansion area will accommodate sustained, combined-arms, live-fire, and maneuver training for all elements of a Marine Expeditionary Brigade (MEB) (DoN 2013; MCAGCC Twentynine Palms 2012a). The expansion areas will include acquisitions to the west and south of the installation, totaling approximately 168,000 acres. These areas will be exclusive military-use areas (no public access), with the exception of a portion of the western expansion area that will be designated as a shared-use area which allows public access when training exercises are not being conducted. Each MEB exercise will involve off-road operations of wheeled and tracked vehicles and the use of munitions within MCAGCC and the western acquisition area. The southern acquisition area will primarily be used for unit marshalling and maneuvering. The land expansion was not evaluated as part of this periodic review. Once range and operations boundaries are defined along with projected ordnance usage, a baseline REVA evaluation may be conducted.

While no training activities are presently conducted in the proposed expansion areas, portions of the western acquisition area were historically used for training. Seven Formerly Used Defense Sites were used as bombing ranges during the World War II–era. All of these sites may undergo further investigation and remediation to render them non-hazardous; if they are not addressed through a separate program, then a baseline review of these historical training activities will be performed in the next REVA review.

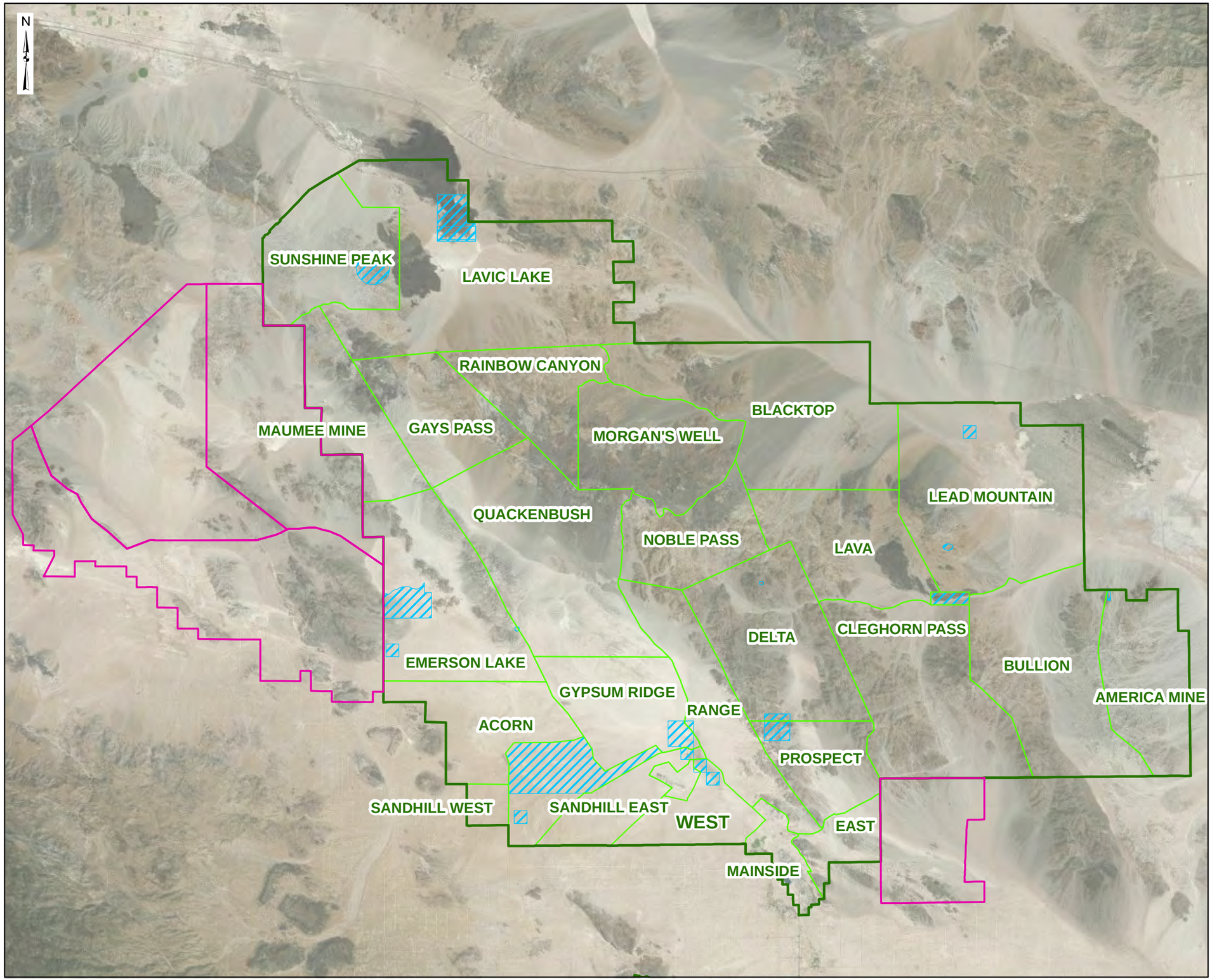


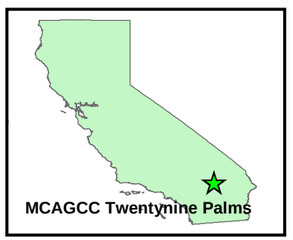
FIGURE 1-1
MCAGCC TWENTYNINE PALMS
OPERATIONAL RANGE
TRAINING AREAS

REVA
MCAGCC TWENTYNINE PALMS

Legend

- Installation Boundary
- Range Training Area
- Restricted Area
- Expansion Areas

Note:
Expansion areas may be evaluated upon initiation of training operations.



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Units: Meters

Date: August 2015

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GIS - MCAGCC Twentynine Palms, 2014b

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1.4 Summary of Areas Addressed in the Periodic Review

In September 2014, the REVA team conducted a periodic review site visit at MCAGCC Twentynine Palms and identified 25 operational RTAs and 46 operational ranges. The operational RTAs and ranges are shown on **Figure 1-1** and **Figure 1-2**, respectively. Eighteen RTAs at MCAGCC Twentynine Palms are authorized for live-fire training and use conventional air and ground munitions. These areas support large-scale combined arms operations, including the ITX. According to the Standard Operating Procedures for Range/RTA and Airspace (MCAGCC Twentynine Palms 2014a), all conventional munition expenditures within the RTAs must be at least 1,000 meters from other scheduled RTA boundaries, the installation boundary, and restricted area boundaries. In 2013, a new RTA (Morgan's Well) was established in the north-central portion of the installation, and the boundaries of five other RTAs were modified. Morgan's Well is a live-fire RTA that supports air-delivered ordnance as well as artillery training. Boundaries of Rainbow Canyon, Noble Pass, and Blacktop RTAs shifted due to the establishment of Morgan's Well RTA, and the shared boundary between the Lead Mountain and Bullion RTAs was moved approximately 2 miles north.

The remaining seven RTAs, all located in the southwest section of the installation, are designated as non-live-fire areas. Training activities in these RTAs consist mainly of non-live-fire maneuvering and may include the use of blank ammunition, smoke grenades, simulators, and illumination rounds. In 2013, the Sandhill RTA was split into two RTAs (Sandhill East and Sandhill West) due to an expansion of the adjacent restricted area toward the installation boundary (MCAGCC Twentynine Palms 2014a).

The 46 operational ranges at MCAGCC Twentynine Palms are generally unchanged since the REVA five-year review. Range 230, a military operations in urban terrain (MOUT) range, was identified during the site visit as a new range but was not evaluated in this periodic review because it remains under construction and has not yet been authorized for use. One new and currently active range (Range 705A) was identified during the periodic review site visit completed in September 2014. Range 705A is a combat vehicle operator training (CVOT) course established within the West and Mainside RTAs. Since no military munitions are authorized for use on this range, it was not evaluated as part of this periodic review.

Since the REVA five-year review, the installation has focused on adding or changing capabilities at existing ranges in order to address current training requirements, rather than constructing new ranges. In line with this approach, HESCO® barriers were added to the perimeter of the Range 051 demo pit to further enhance fragmentation containment, and a new net explosive weight (NEW) limit of 2,000 pounds was also established at this range. Similarly, new training capabilities and a higher NEW limit of 2,000 pounds (lb) were added to Range 112 to accommodate required explosive ordnance disposal (EOD) training. Lastly, sniper towers were constructed on Ranges 111 and 113 allowing snipers to engage targets at higher angles and from several different shooting positions within and on top of the towers.

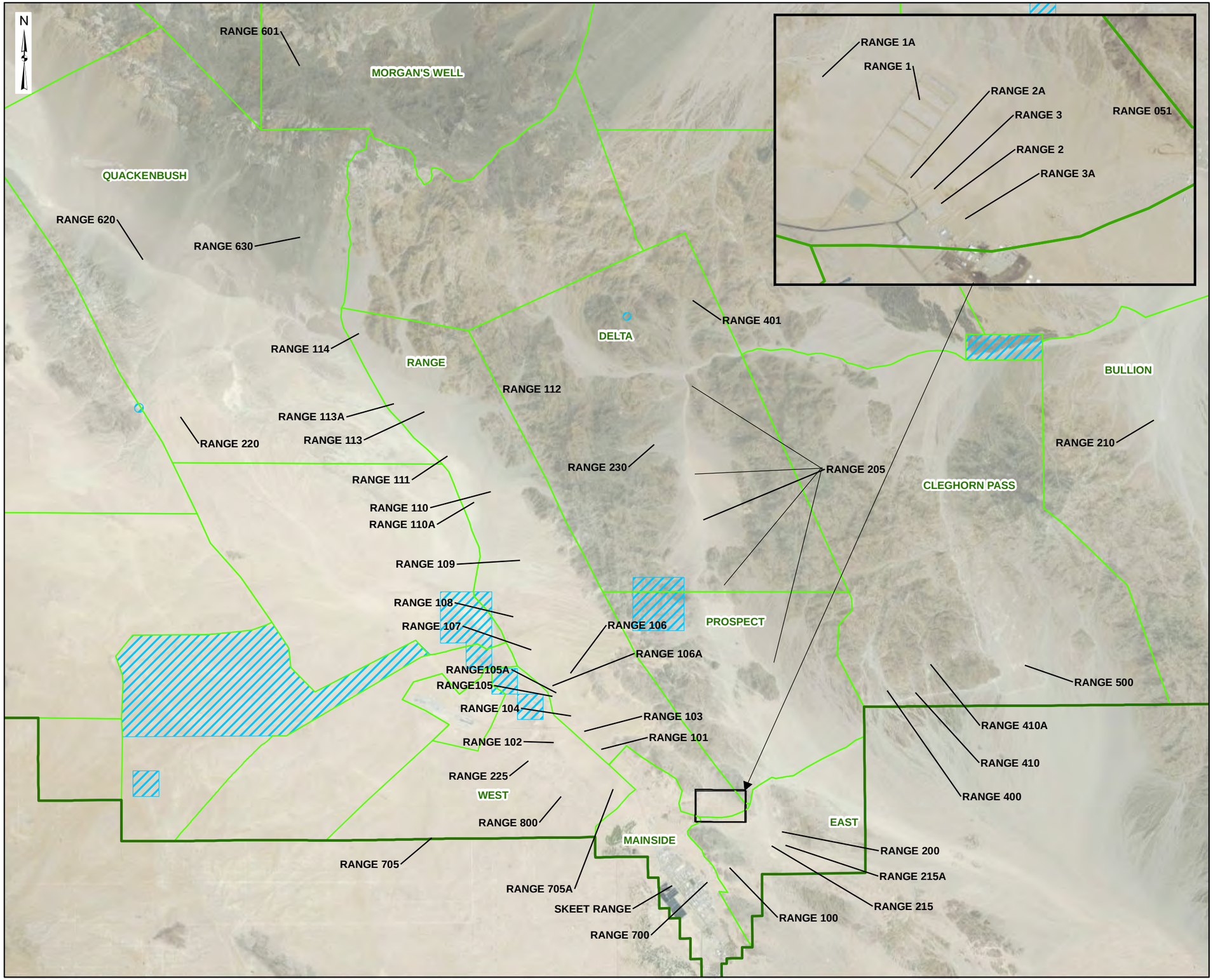
Eleven of the 46 operational ranges at MCAGCC Twentynine Palms are SARs. Six SARs are located within the marksmanship training unit (MTU) range complex located within the Range RTA. Four SARs are located outside of the MTU but still within the Range RTA. The skeet range, located within the Mainside RTA, is evaluated in this periodic review as a SAR. In 2013, bullet traps were removed from Ranges 2 and 3 at the MTU range complex and replaced with earthen impact berms. MTU personnel stated that a liquid

copolymer is regularly applied and maintained on the surface of all the earthen impact berms within the MTU to minimize erosion. Range 106A, which is located in the Range RTA and was formerly used as a grenade range, was converted to a machine gun certification range in 2012. As such, it was evaluated as a SAR during this periodic review.

MC loading areas are identified in REVA to describe where the majority of MC are deposited during training missions on a range or training area. These areas may encompass an entire range, target area, or a portion of the range area. During this periodic review period, 31 MC loading areas were identified at MCAGCC Twentynine Palms and are shown on **Figure 1-3**. The figure indicates whether the MC loading areas were identified based on RTA boundary or the location of a range, target area, or portion of range. The 11 SARs identified for qualitative evaluation are shown on **Figure 1-3**; further discussion of these range evaluations is found in **Section 2.4**.

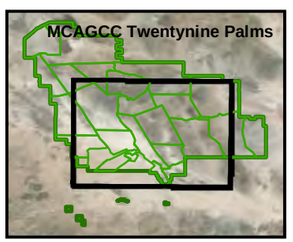
FIGURE 1-2
MCAGCC TWENTYNINE PALMS OPERATIONAL RANGES

REVA
MCAGCC TWENTYNINE PALMS



Legend

- Installation Boundary
- Range Training Area
- Restricted Area



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Zone: 11N
Datum: NAD83
Units: Meters

Date August 2015

Source: Aerial - ESRI
GIS - MCAGCC Twentynine Palms, 2014b

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FIGURE 1-3
MCAGCC TWENTYNINE PALMS
MC LOADING AREAS
AND SMALL ARMS RANGES

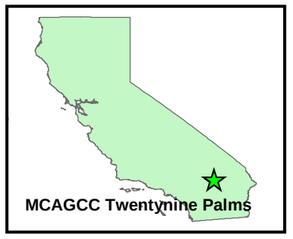
REVA
MCAGCC TWENTYNINE PALMS

Legend

- Installation Boundary
- Restricted Area

MC Loading Area

- Based on RTA Boundaries
- Based on Ranges and Target Locations



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Units: Meters

Date: August 2015

Source: Aerial - ESRI, not dated
GIS - MCAGCC Twentynine Palms, 2014b

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2. Assessment Methods and Results

MCAGCC Twentynine Palms was assessed qualitatively through the development of a site-specific conceptual site model (CSM) and quantitatively through screening-level transport assessments. This section contains discussions on the MC deposition estimates, the site-specific CSM, the screening-level modeling results, results of qualitative lead evaluations, and a summary of sampling results.

2.1 Estimated Munitions Constituents Loading

2.1.1 Munitions Constituents Loading Approach

The MC loading of HE and perchlorate was estimated based on mass-loading principles using military munitions expenditure data and 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 unexploded ordnance (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.

MC remaining from low order detonations are the most significant contributors to MC loading, but the REVA process accounts for MC contributed from all three of these potential sources. 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 act as source terms 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, and/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, surface danger zones, aerial imagery,

information from range personnel, visual notes from the site visit, and munitions data. Some MC loading areas account for expenditures from multiple ranges; a summary of MC loading areas and their contributing ranges is presented in **Table 2-1**. Training-specific information for some ranges and training areas indicated minimal use and/or use of munitions that result in negligible MC loading since the five-year review. Therefore, MC loading areas were not defined at these locations. MC loading is calculated using similar methods described in the REVA Five-Year Review Report and the REVA Five-Year Review Manual (ARCADIS/Malcolm Pirnie 2012; HQMC 2010).

Table 2-1: Summary of Ranges Contributing to MC Loading Areas

MC Loading Area	Contributing Ranges
Acorn	TA-ACORN
America Mine	TA-AMERICA MINE
Black Top I / Morgan's Well I	TA-BLACKTOP, TA-MORGANS WELL
Black Top II	TA-BLACKTOP
Bullion	TA-BULLION, 2013 EOD DATA FOR BULLION, R-210 (LIVE MOUT)
Cleghorn Pass I	R-400, R-410, R-410A
Cleghorn Pass II	TA-CLEGHORN PASS, TA-CLEGHORN PASS FARP, R-500
Delta	TA-DELTA, R-205 (CONVOY), R-205 (LIVE MOUT), R-401
East	TA-EAST, R-100, R-200 MOUT TOWN, R-215 (UWTC), R-215 (CLSA)
Emerson Lake	TA-EMERSON LAKE
Gays Pass I	TA-GAYS PASS
Gays Pass II	TA-GAYS PASS
Gypsum Ridge	TA-GYPSUM RIDGE
Lava	TA-LAVA
Lavic Lake	TA-LAVIC LAKE
Lead Mountain I	TA-LEAD MOUNTAIN
Maumee Mine	TA-MAUMEE MINE
Morgan's Well II	TA-MORGANS WELL, TA-RAINBOW CANYON, R-601
Noble Pass	TA-NOBLE PASS
Prospect	TA-PROSPECT
Quackenbush	TA-QUACKENBUSH (LAKE), R-220, R-220 A, R-220 C1, R-220 C2, R-220 C5, R-220 D, R-220 F1, R-220 F2, R-220 F4, R-220 H, R-220 I, R-220 O, R-220 S, R-220 U, R-220 W, R-620, R-630
Rainbow Canyon	TA-RAINBOW CANYON
Range 051	R-051, 2013 EOD DATA FOR R-051
Range I	R-104, R-105 A, R-106, R-106 A, R-107, 2013 EOD DATA FOR R-107
Range II	R-108, R-109
Range III	R-110, 2013 EOD DATA FOR R-110, R-110A
Range IV	R-111, R-112, 2013 EOD DATA FOR R-112, R-113, 2013 EOD DATA FOR R-113, R-113 A, R-114, 2013 EOD DATA FOR R-114
Sand Hill East	TA-SANDHILL
Sand Hill West	TA-SANDHILL
Sunshine Peak	TA-SUNSHINE PEAK
West	R-102, R-225, R-800 (TA WEST), R-800 IED TRAINING LANE, R-800 VILLAGE 1 (TVCS), R-800 VILLAGE 2 (TVCS), R-800 VILLAGE 3

NOTE:
TA = Training Area
R = Range

MC loading was estimated using the REVA MC Loading Rate Calculator (described in the REVA Reference Manual [HQMC 2009]) and modified to account for standard management practices involving removal of explosive hazards, such as implemented at demolition and EOD ranges at MCAGCC Twentynine Palms. These modifications are described in **Section 2.1.2**. 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 metals, lead deposition estimates assume no consumption from impact and that all of the lead contained within the munition is deposited in the loading area. Similarly, lead deposition estimates at SARs were also based on the total number of cartridges expended at a range and the amount of lead in each cartridge.

2.1.2 Munitions Constituents Loading Assumptions

MC loading is based primarily on munitions expenditure data obtained from Training and Education Command (TECOM), which covers the period from calendar year (CY) 2011 through August 2014 (3 years and 8 months). The expenditure data were used to develop annual averages of expenditures for each identified MC loading area. These averages were then used in the REVA MC Loading Rate Calculator to generate estimated MC loading rates for each MC loading area. Based on a quality review of the provided data, a series of assumptions were made to accommodate the data in the Calculator:

- The primary expenditure data provided by the installation through TECOM were Range Facility Management Support System (RFMSS) data. According to range personnel, these data capture expenditures for all training operations and donor charges for EOD operations at MCAGCC Twentynine Palms. The RFMSS data provided for the period listed above were broken out by year and range area and represented expenditures over a period of 44 months. Annual average expenditure totals were calculated for each munition type.
- The expenditure summaries contain some DoD Identification Codes (DoDICs) for which information on MC content was not available. These entries were managed one of two ways:
  - In some 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 a similar description and known MC content was selected from available data sources for use in the MC loading calculations.
  - Where no descriptions for the munitions were provided, the associated expenditure counts for the unknown DoDICs were proportionally distributed among other known DoDICs associated with the given range, based on totals for the other DoDICs listed for the same range and year.

Additionally, key assumptions were developed with regard to EOD activities at MCAGCC Twentynine Palms. According to Range personnel, all explosive charges obtained from the ammunition supply point by EOD for training or demolition activities are tracked in RFMSS. However, items recovered and transported by EOD personnel to an alternate range for destruction are not necessarily captured in the RFMSS data.

EOD personnel provided a record of call sheets used to account for these items destroyed by EOD that may not be captured in the RFMSS data. The sheets cover the period of CY 2013 and contain detailed information about what items were involved, where they were found, and the remedy that was applied including a record of transport or use of demolition materials. These data were used to develop a single year

of averages which supplemented information developed from the RFMSS data, using the following assumptions:

- The call sheets represented 12 months of operations. These data were assumed to represent a typical year of operation, and the totals were added to the corresponding annual averages developed from the expenditure data.
- DoDICs where MC content data were not available in Munitions Items Disposition Action System (MIDAS) or other inventories were managed using assumptions similar to those described previously in this section.
- Only EOD call sheets documenting the destruction of ordnance items on ranges other than where they were originally expended were used to supplement the RFMSS data. EOD call sheets documenting items destroyed on the ranges where they were originally expended were not used to supplement the RFMSS data, as it is assumed that these ordnance items as well as the donor charges used to destroy them were already accounted for in RFMSS.
- 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 where munitions debris is routinely collected and removed following EOD operations.
- 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, and the data may not have been reported consistently. As such, the standard dud rate assumptions were used in order to maintain a higher level of conservatism in the loading estimate.

The MC loading rates generated by the REVA MC Loading Rate Calculator are listed in **Table 2-2**. Quantitative evaluations of potential MC migration are discussed in **Section 2**. The estimated deposition of lead in each MC loading area and SAR is presented in **Table 2-3**. Qualitative evaluations of potential lead migration are discussed in **Section 2.4**. Additional details regarding the MC loading methods are outlined in the REVA Reference Manual (HQMC 2009).

2.1.3 Operational Range Clearance

Operational range clearance (ORC) activities at MCAGCC Twentynine Palms have been modified since the REVA five-year review. Identification of areas that require ORC is based on regular analysis of range/RTA scheduling, munition expenditures, and areas where movement and live fire co-exist. Once identified, installation EOD personnel are tasked with completing surface and limited subsurface clearances of those areas. Since documentation containing specific details regarding the area, frequency, and scope of the ORC activities at MCAGCC Twentynine Palms was not available, ORC activities were not factored into the MC loading estimations for the Periodic Review.

Table 2-2: Estimated Annual MC Loading Rates

MC Loading Area	Assumed Loading Area (m^2)	Estimated Annual Loading Rate ($kg/m^2/yr$)			
		HMX	RDX	TNT	Perchlorate
Acorn	7,029,113	6.60E-14	2.96E-11	2.60E-13	5.17E-10
America Mine	8,421,062	1.77E-08	5.79E-08	1.32E-06	2.80E-09
Black Top I / Morgan's Well I	11,187,566	6.30E-08	5.06E-07	7.67E-06	9.12E-08
Black Top II	9,810,336	4.62E-08	3.22E-07	5.38E-06	5.79E-08
Bullion	10,046,505	1.44E-08	3.23E-07	3.46E-06	8.82E-08
Cleghorn Pass I	5,127,190	1.32E-08	1.43E-06	1.90E-06	1.95E-08
Gleghorn Pass II	7,742,468	5.59E-09	4.81E-08	7.50E-07	4.93E-10
Delta	25,265,778	1.23E-08	6.11E-07	1.30E-06	5.71E-09
East	2,631,300	1.27E-13	5.69E-11	1.21E-12	1.40E-09
Emerson Lake	12,966,333	9.86E-08	2.66E-07	3.05E-06	7.19E-08
Gays Pass I	9,567,943	7.81E-08	1.93E-07	1.40E-06	1.27E-08
Gays Pass II	8,770,745	8.52E-08	2.11E-07	1.53E-06	1.38E-08
Gypsum Ridge	7,391,528	6.28E-14	1.68E-10	9.24E-09	2.84E-10
Lava	3,423,075	1.77E-07	9.86E-07	2.76E-05	1.02E-07
Lavic Lake	22,753,477	2.91E-08	1.33E-07	4.54E-06	1.91E-07
Lead Mountain	18,144,381	1.37E-07	7.74E-07	1.42E-05	1.15E-07
Maumee Mine	6,532,045	1.41E-07	3.50E-07	6.01E-06	8.81E-08
Morgan's Well II	8,765,203	9.28E-08	4.38E-07	2.35E-06	3.94E-08
Noble Pass	6,812,648	6.80E-09	1.40E-07	3.43E-06	3.48E-08
Prospect	17,473,260	3.05E-09	5.67E-08	4.16E-07	7.26E-09
Quackenbush	31,340,709	5.49E-08	6.77E-07	1.31E-05	1.98E-08
Rainbow Canyon	2,886,780	2.65E-07	9.05E-07	4.05E-06	8.04E-08
Range I	10,069,913	5.09E-09	5.62E-07	3.20E-07	1.76E-09
Range II	6,891,398	9.26E-13	1.14E-09	3.77E-10	1.69E-09
Range III	2,975,705	1.01E-08	2.56E-06	3.08E-08	7.14E-09
Range IV	19,202,818	2.60E-11	2.34E-07	1.66E-07	2.86E-08
Sand Hill East	3,775,039	1.23E-13	5.50E-11	2.46E-13	7.52E-11
Sand Hill West	1,043,216	4.45E-13	1.99E-10	8.90E-13	2.72E-10
Sunshine Peak	9,250,547	3.14E-13	2.04E-08	2.69E-08	1.04E-12
West	4,032,738	0.00E+00	4.99E-09	1.10E-09	3.02E-09
Range 051	149,299	9.40E-08	1.99E-06	9.84E-08	4.40E-09

Acronyms and Abbreviations:
$kg/m^2/yr$ = kilograms per square meter per year
m^2 = square meters

Table 2-3: Estimated Annual Lead Deposition

Source	Assumed Deposition Area (m^2)	Lead Deposition Rate (Total lb/yr)
MC Loading Area		
Acorn	7,029,113	8.42E-01
America Mine	8,421,062	8.95E+02
Black Top I / Morgan's Well I	11,187,566	1.67E+03
Black Top II	9,810,336	8.62E+02
Bullion	10,046,505	2.45E+03
Cleghorn Pass I	5,127,190	1.49E+04
Gleghorn Pass II	7,742,468	4.35E+03
Delta	25,265,778	8.22E+03
East	2,631,300	2.25E+00
Emerson Lake	12,966,333	1.37E+03
Gays Pass I	9,567,943	3.85E+02
Gays Pass II	8,770,745	3.85E+02
Gypsum Ridge	7,391,528	8.42E-01
Lava	3,423,075	1.80E+03
Lavic Lake	22,753,477	3.74E+03
Lead Mountain	18,144,381	3.26E+03
Maumee Mine	6,532,045	7.94E+01
Morgan's Well II	8,765,203	2.94E+03
Noble Pass	6,812,648	1.15E+03
Prospect	17,473,260	1.28E+03
Quackenbush	31,340,709	3.70E+03
Rainbow Canyon	2,886,780	2.48E+03
Range I	10,069,913	8.98E+03
Range II	6,891,398	1.47E+03
Range III	2,975,705	4.47E+03
Range IV	19,202,818	4.41E+04
Sand Hill East	3,775,039	2.88E-04
Sand Hill West	1,043,216	2.88E-04
Sunshine Peak	9,250,547	8.55E-03
West	4,032,738	1.78E+00
Range 051	149,299	4.53E-01

Source	Assumed Deposition Area (m^2)	Lead Deposition Rate (Total lb/yr)
Small Arms Range		
Range 1	NA	9.51E+03
Range 1A	NA	2.69E+03
Range 2	NA	6.96E+03
Range 2A	NA	8.84E+01
Range 3	NA	5.09E+02
Range 3A	NA	2.88E+03
Range 101	NA	1.41E+03
Range 103	NA	1.57E+03
Range 106A	NA	3.99E+03
Range 113A	NA	4.23E+03
MCCS Skeet Range	NA	N/A

Acronyms and Abbreviations:
lb/yr = pounds per year
m^2 = square meters
MCCS = Marine Corps Community Services
N/A = Not Applicable - Only lead-free ammunition was used at the Skeet Range during the periodic review period.

2.2 Conceptual Site Model

A CSM is used to characterize the dynamics that may affect off-range migration of MC, including potential exposure pathways and possible receptors. The site-specific CSM for MCAGCC Twentynine Palms builds on and updates the CSM developed as part of the installation baseline and five-year REVA assessments (Malcolm Pirnie 2007; ARCADIS/Malcolm Pirnie 2012; ARCADIS 2014).

2.2.1 Potential Pathways

Exposure pathways identified at MCAGCC Twentynine Palms for off-range human and ecological receptors are surface water, sediment, and groundwater. The off-range points of exposure to MC at MCAGCC Twentynine Palms include the following:

- Playas downgradient of MC loading areas (sediment, surface water)
- Streams downgradient of MC loading areas draining off the installation boundary (sediment, surface water)
- Active and planned groundwater production wells located in Surprise Spring and Deadman Lake sub-basins, which serve as potable water sources (groundwater)

Potential pathways and receptors currently associated with the land expansion to the west and south are discussed in the *Final Environmental Impact Statement, Land Acquisition and Airspace Establishment to*

Support Large-Scale Marine Air Ground Task Force Live Fire and Maneuver Training, Marine Corps Air Ground Combat Center Twentynine Palms, CA (DoN 2012). The potential pathways anticipated in the expansion areas are similar to existing pathways associated with current operational training area.

A graphical depiction of the potential transport pathways at MCAGCC Twentynine Palms is shown on **Figure 2-1**.

2.2.1.1 Surface Water and Sediments

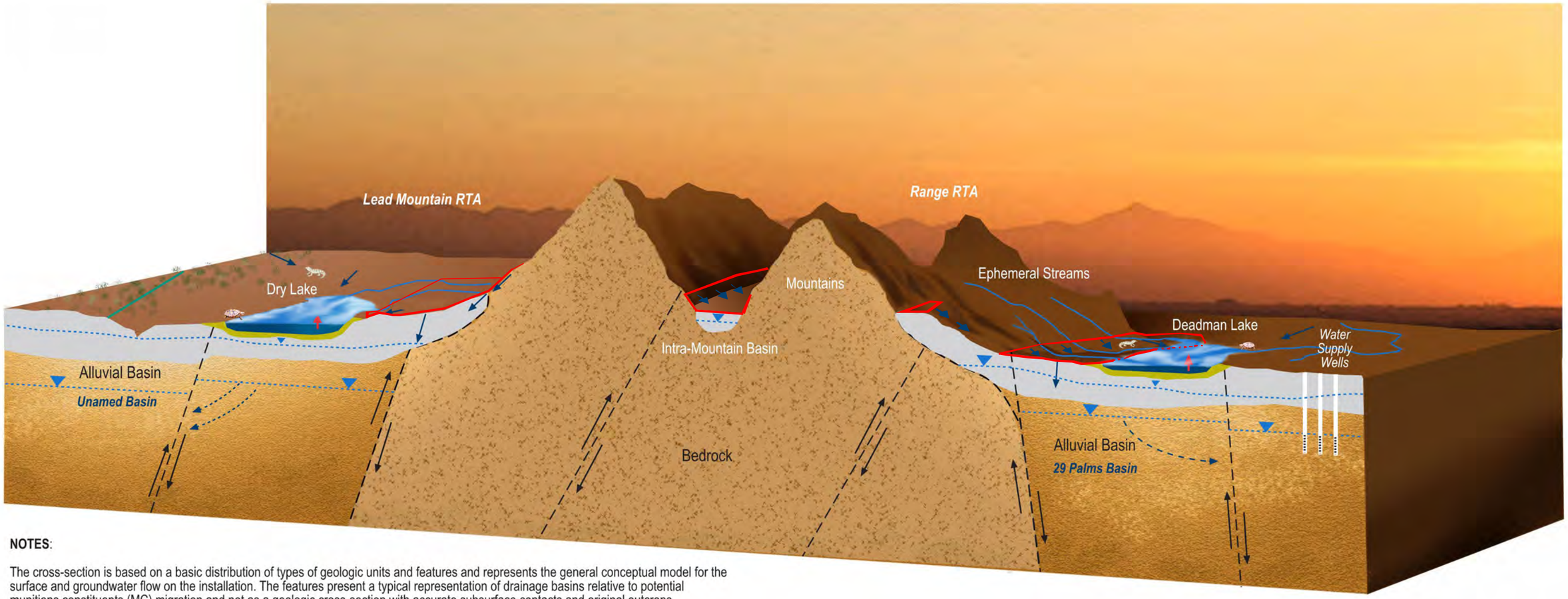
The MC loading areas assessed in this periodic review drain to nine playas located within and just outside the installation boundary and to streams that drain off the installation boundary. MC can accumulate in the soil of MC loading areas and may be transported off range via surface water or sediment (ARCADIS/Malcolm Pirnie 2012). The average yearly precipitation at the installation is approximately 4.8 inches (Malcolm Pirnie 2007); strong summer storms often drop the majority of this total, resulting in flash floods. The occurrence of these infrequent flash floods can mobilize and transport accumulated MC in soil through dissolution or erosion of soil and sediments.

The majority of the overland flow from the MC loading areas drains in dry washes and streambeds to the interior of the installation where drainage accumulates in playas within and adjacent to the installation (**Figure 2-2**). The fate of surface water in the playas is typically evaporation, although limited infiltration may occur. The playas can be filled with water for up to 2 months per year, providing habitat for wildlife during that time. When the water evaporates, the MC in the water will likely volatilize, degrade, and deposit into the sediment of the playa bed. Stream drainages originating from MC loading areas within the Cleghorn Pass watershed in the southeastern part of the installation, and stream drainages originating from within the East and West watershed in the northwestern part of the installation, flow off the installation boundary, potentially impacting receptors outside the installation boundary.

Based on the estimated annual average surface water runoff rate at the identified MC loading areas, there is a low potential for MC to migrate via runoff from the MC loading areas. The low estimated annual average surface water runoff rate at all MC loading areas is attributed to the low annual average precipitation at the installation. While the precipitation events can be intense and potentially cause flash flooding, the average annual precipitation is low leading to low annual average surface water runoff rates.

Erosion characteristics of the MC loading areas, as quantified in the Revised Universal Soil Loss Equation, indicate moderate potential for soil erosion at 16 of the 24 MC loading areas assessed. Low soil erosion potential was estimated for eight MC loading areas. The moderate soil erosion potential at a majority of the MC loading areas assessed is attributable to steeper topographic slopes (generally ranging from 6% to 14%) or higher inherent soil erodibility factors. This moderate soil erosion potential is more conducive for potential sediment transport of MC to surface water.

East West



NOTES:

The cross-section is based on a basic distribution of types of geologic units and features and represents the general conceptual model for the surface and groundwater flow on the installation. The features present a typical representation of drainage basins relative to potential munitions constituents (MC) migration and not as a geologic cross-section with accurate subsurface contacts and original outcrops.

Three major processes control MC migration:

1. Potential surface water transport from MC loading areas to dry lakes (playas) via ephemeral/intermittent stream.
2. Potential direct groundwater recharge due to washoff into quaternary deposits
3. Potential migration ot MC from shallow groundwater to deeper groundwater

Ecological Receptors:

- Desert Tortoise
- Fringe-Toed Lizard

Legend

- Alluvial Basin - Quaternary Deposits
- Alluvial Basin - Tertiary Deposits
- Groundwater Flow Direction
- Potential MC Migration
- Potential MC Interaction
- MC Loading Area
- Ephemeral/Intermittent Streams
- Water Table
- Playa Soil
- Bedrock
- Strike-Slip Faults
- Playa Lakes
- Installation Boundary

Bedrock: comprise of precambrain igneous and metamorphic complex, Jurassic grantic rocks and quaternary basalts and related volcanic deposits

Alluvial Basin-Tertiary Deposits: comprised of poorly sorted medium to course arkosic sand, silt, and gravel

Alluvial Basin- Quaternary Deposits: comprised of material derived from uplifted bedrock highs and may also contain reworked sediment from Tertiary deposits

Playa Soils: comprised of thin veneer of very poorly drained clayey loam

Strike-Slip Faults: potentially act as hydraulic barriers

Ecological Receptors: includes the Desert Tortoise and the Mojave Fringe-Toed Lizard

Figure 2-1
Graphical Conceptual Site Model
MCAGCC Twentynine Palms

MCAGCC Twentynine Palms
Twentynine Palms, CA

ARCADIS

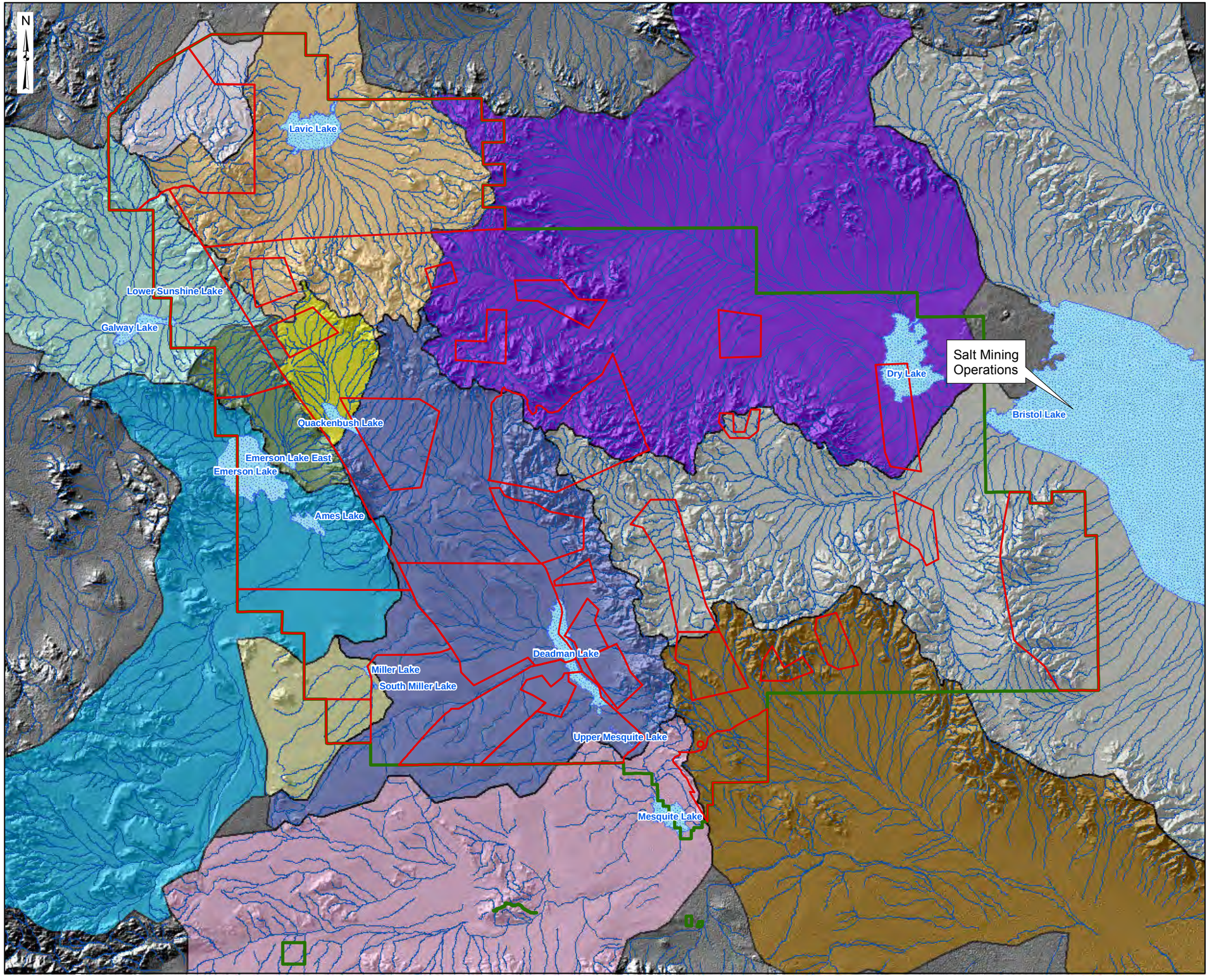


FIGURE 2-2
MCAGCC TWENTYNINE PALMS SURFACE WATER FEATURES

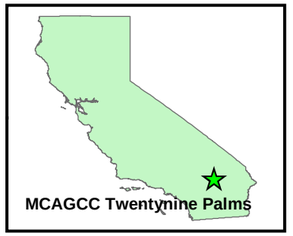
REVA
MCAGCC TWENTYNINE PALMS

Legend

- MC Loading Area
- Installation Boundary
- Playa Lake (Ephermal/Intermittent)
- Stream/Wash (Ephermal/Intermittent)

Watershed

- Bristol Lake
- Cleghorn Pass/Dale Lake
- Deadman Lake
- Dry Lake
- East and West Sunshine
- Emerson Lake
- Galway Lake
- Goat Mountain
- Lavic Lake
- Mesquite Lake
- Quakenbush
- Upper Emerson



0 1 2 4 6
Miles

Coordinate System: UTM
Zone: 11N
Datum: NAD83
Units: Meters

Date: August 2015

Source: MCAGCC Twentynine Palms, 2014b

ARCADIS

Water that accumulates in the playas may present a potential, limited exposure pathway for ecological species, including the federally threatened Agassiz's desert tortoise and the Mojave fringe-toed lizard (MFTL), a California Species of Special Concern (SSC) (Malcolm Pirnie 2007). Sediment accumulated along drainages and in the playas may also present a potential exposure pathway to ecological species. Although there is no documented extensive use of drainages and playas for recreation, surface water is considered a potential exposure pathway for human health through incidental contact. However, installation personnel are prohibited from entering playas within the installation boundary when they are wet, and there is no extensive recreational use of the playas anticipated outside of the installation.

Salt mining operations are located outside the installation at Bristol Lake Playa, downgradient of several MC loading areas, including Delta, Lava, Lead Mountain, Bullion, Prospect, Noble Pass and America Mine MC loading areas. Salt produced by the existing operations may be used in a variety of products, including those destined for human consumption. However, exposure of produced salt to oncoming drainage is anticipated to be negligible since the production involves the extraction of local, briny groundwater (mostly pumped from deep groundwater zones), which is placed in constructed ponds and trenches for evaporation. Although there is a possibility of a potential human exposure to MC in surface water and sediment through incidental contact by salt mine workers, there is no known human consumption of surface water for drinking water. Therefore, the playas do not represent a significant human exposure pathway.

There are several playas that exist in the western expansion area, including Galway Lake and Emerson Lake, which were identified as potential off-range receptor locations in this REVA periodic review. Other playas that exist in the western expansion area include Melville Lake, Soggy Lake, and Means Dray Lake. The southern expansion area falls in the Cleghorn Pass watershed, where Dale Lake Playa exists several miles downgradient of the expansion area. Based on U.S. Geological Survey maps, no seeps or springs are known to exist in the western or southern expansion areas.

2.2.1.2 Groundwater

Groundwater at MCAGCC Twentynine Palms is found in the alluvium-filled basins that flank the bedrock uplands. Primary groundwater basins include the Twentynine Palms basin on the southwestern margin of the Bullion Mountains (composed of five groundwater sub-basins covering parts of MCAGCC Twentynine Palms), the Bristol Valley basin on the northeastern side of the Bullion Mountains, and several smaller intramountain sub-basins (portions of the Dale Valley and Lavic Valley) that are located in the Bullion and Lava Bed mountains (**Figure 2-3**).

Shallow perched groundwater exists beneath playa lakes throughout the installation (ARCADIS/Malcolm Pirnie, 2012). The source of the perched groundwater is likely from limited infiltration through playa soils and/or from infiltration through the permeable alluvial soils surrounding the playas during flood events. Recharge directly through the playa soils is minimal due to the low permeability of these soils which can have a thickness of up to 50 feet (Li and Martin 2008). As a result, potential MC migration from the playa lakes down to the shallow perched groundwater is limited.

MC deposited on MC loading areas at MCAGCC Twentynine Palms have the potential to migrate to groundwater by dissolution into precipitation and subsequent infiltration into the subsurface. However, vertical migration of MC to groundwater is very slow and limited due to the following factors:

- Infrequent nature of rainfall in the area (less than 5 inches per year [in/yr])
- High evapotranspiration rate (approximately 66.5 in/yr [Li and Martin, 2008])
- Deep depth to groundwater (largely above 100 feet below ground surface)

MC at MCAGCC Twentynine Palms can also potentially be transported to groundwater through preferential recharge from the infrequent stream flow along the ephemeral streambeds and dry washes and in local depressions, where runoff and standing water are concentrated. Groundwater flow direction is variable within the different groundwater basins and sub-basins found at the installation, though generally it flows south, southeast, and east (**Figure 2-3**).

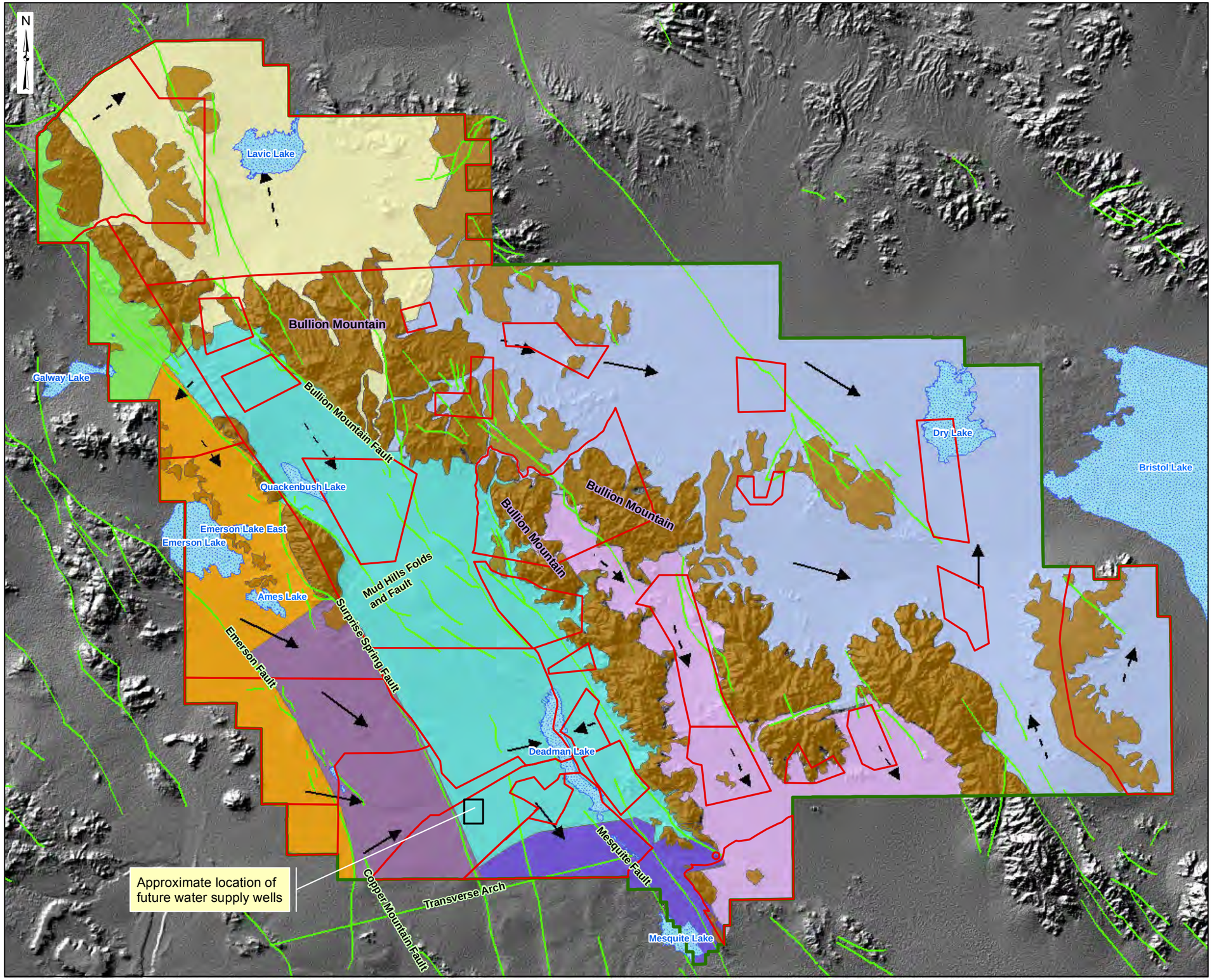
Groundwater does not discharge to surface water and, therefore, is not expected to impact ecological receptors. Three inactive non-potable wells are located in the Giant Rock and Deadman Lake sub-basins (**Figure 2-3**). One of these non-potable wells is located on the southwest edge of Deadman Lake Playa and is used by Marines for washing vehicles and field equipment (ARCADIS/Malcolm Pirnie 2012). The installation currently uses 11 production wells to draw water for potable purposes. All active potable wells (i.e., the 11 production wells) are located within the Surprise Spring sub-basin. The Emerson Lake MC loading area, which is estimated to have significant MC loading, is located within Surprise Spring sub-basin and a potential pathway exists to impact to the groundwater in this sub-basin. MC migration to the Surprise Spring sub-basin from adjacent sub-basins is restricted by the presence of bounding faults, such as the Surprise Spring and Emerson faults, which hydraulically separate the sub-basin from adjacent ones (ARCADIS/Malcolm Pirnie 2012).

In the near future, the installation is planning to install two or three production wells within the Deadman Lake sub-basin (**Figure 2-3**). Based on information obtained from MCAGCC Twentynine Palms, the wells will be located southwest of potable water equalization tanks just outside of Camp Wilson. Water obtained from these wells will be combined with water from the wells in the Surprise Spring sub-basin and used for potable purposes. A potential pathway exists from the MC loading areas within the Deadman Lake sub-basin to the groundwater wells within this sub-basin, and these wells were evaluated as receptor endpoints in the groundwater screening assessment discussed in **Section 2.3.3**.

The western expansion area lies within the Bessemer Valley and the Giant Rock sub-basins of the Twentynine Palms groundwater basin, the Johnson Valley basin, the Means Valley Basin, and the Este Subarea of the Adjudicated Mojave Basin Area (MCAGCC Twentynine Palms 2012a). The Johnson Valley, Means Valley, and Este Subarea of the Adjudicated Mojave groundwater basins are northwest of the existing MCAGCC Twentynine Palms boundary. The main water-bearing materials in the area are alluvial deposits. The principal source of recharge to these basins is infiltration of runoff from the surrounding mountains in the washes and alluvial fans. The southern expansion area is part of the Dale Valley groundwater basin, where groundwater conditions are expected to be similar to those in the Twentynine Palms basin.

FIGURE 2-3
MCAGCC TWENTYNINE PALMS GROUNDWATER FEATURES

REVA
MCAGCC TWENTYNINE PALMS



Legend

- Installation Boundary
- MC Loading Area
- Playa Lake (Ephermal/Intermittent)
- Groundwater Flow (Known)
- Groundwater Flow (Inferred)
- Geologic Fault
- Exposed Bedrock

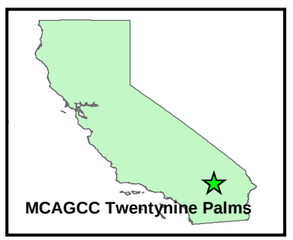
Twentynine Palms Basin

- Bessemer Valley Subbasin
- Deadman Lake Subbasin
- Giant Rock Subbasin
- Surprise Spring Subbasin
- Twentynine Pams Valley Subbasin

Intramountain Basin

- Dale Valley Subbasin
- Lavic Valley Subbasin

Bristol Valley Basin



0 0.75 1.5 3 4.5
Miles

Coordinate System: UTM
Zone: 11N
Datum: NAD83
Units: Meters

Date: August 2015

Source: MCAGCC Twentynine Palms, 2014b

ARCADIS

Groundwater recharge is principally from groundwater subsurface flow originating as surface runoff from the surrounding mountains, recharging along the bedrock-alluvial deposit interface, and migrating through adjacent basins.

2.2.2 Potential Receptors

The potential receptors identified at MCAGCC Twentynine Palms include:

1) Humans
   - Potable water use from groundwater supply wells
   - Incidental contact of surface water and sediment at the salt mining operations at Bristol Lake playa
   - Incidental contact of surface water outside the installation boundary
2) Ecological species

As discussed in **Section 2.2.1.2**, potential MC exposure to humans from groundwater use is limited. This is because the vertical migration of MC to groundwater at MCAGCC Twentynine Palms is very slow due to the low rainfall, high evapotranspiration and deep depth to groundwater. Although there is a possibility for human exposure through incidental contact of surface water/ or sediment, the potential of MC exposure through this pathway is highly limited.

Ecological receptors have been identified as the primary potential receptors of concern for MC transport at MCAGCC Twentynine Palms. Ecological receptors, including special status species, may be exposed to MC in storm water runoff and deposited sediment that accumulates in drainages and playa lakes. Ten ecosystems have been described at MCAGCC Twentynine Palms; the dominant ecosystem is creosote/bursage scrub, covering approximately 90% of the installation (ARCADIS/Malcolm Pirnie 2012). Wildlife species present across much of the installation are typical of Mojave Desert fauna, whose distribution is generally limited by the availability of water. There are no ecological receptors associated with groundwater. Based on information obtained from MCAGCC Twentynine Palms, there have been no new protected species identified at the installation since the completion of the REVA five-year review. Only the federally threatened species, Agassiz's desert tortoises (*Gopherus agassizii*), was identified in the REVA Five-Year Review Report as a special status species (ARCADIS/Malcolm Pirnie 2012). The desert tortoise is found throughout the Mojave Desert, and critical habitat is located near the installation, though not within its boundaries. Critical habitat is a specific geographic area that contains the biological and physical features essential to the species' conservation and that may require special management considerations or protection. The U.S. Fish and Wildlife Service (USFWS) designated critical habitat for the desert tortoise in portions of California, Nevada, Arizona, and Utah in a final rule, published 8 February 1994 (USFWS 1994). The installation's Integrated Natural Resources Management Plan (MCAGCC Twentynine Palms 2012) designates approximately 7,900 acres within the installation as Special Use or Restricted Areas, which is separate from critical habitat outside the installation. Within the Special Use Areas, off-road vehicle travel is not authorized, and other types of military operations are limited in order to minimize impacts to the tortoise populations. Since the REVA five-year review was completed, one of the existing Restricted Areas was expanded to further safeguard the desert tortoise population in that area.

Playas on the installation provide habitats for a variety of avian, reptilian, and mammalian populations, including the MFTL (*Uma scoparia*), a California SSC. The installation also provides habitat for the Emory's crucifixion thorn (*Castela emoryi*), another California SSC. Small crucifixion thorn populations in Blacktop, Emerson Lake, and southern Lavic Lake RTAs are protected from destruction during training by warning posts placed around the growth areas (DoN 2013).

As previously noted, an expansion of MCAGCC Twentynine Palms is underway. The shared-use area of the western acquisition area (described in **Section 1.3**) is already heavily used by off-highway vehicles and contains low numbers of desert tortoises. No other federal special status species are present, and no special requirements will be placed on this area (DoN 2013). However, three new Restricted Areas will be established in the military use–only areas to protect habitats supporting moderate densities of desert tortoises: two Restricted Areas (12,015 acres combined) in the western acquisition area and one Restricted Area (2,935 acres) in the southern acquisition area. Two of these areas are adjacent to existing protected areas; Ord-Rodman Desert Wildlife Management Area is adjacent to the western acquisition area and is Cleghorn Lakes Wilderness adjacent to the southern acquisition area. The third is located in the western portion of the western acquisition area and is not contiguous with existing or proposed conservation areas. A new Restricted Area will also be created on the existing installation, encompassing a new area within the Sunshine Peak Training Area (I,987 acres) and an existing Restricted Area within the Sunshine Peak and Lavic Lake Training Areas (8,901 acres). This new Restricted Area is being created to increase the protection of desert tortoises within the boundaries of the existing installation.

2.3 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 to 2014. In order to determine conservative estimates of MC concentrations in surface water, sediment, and groundwater at identified potential off-range receptor locations downgradient of MC loading areas, surface water and sediment screening-level fate and transport assessments were conducted for 24 of the 31 identified MC loading areas. Groundwater screening-level fate and transport assessment was conducted for 7 of the 31 identified MC loading areas. The procedures used are presented in the REVA Five-Year Review Manual (HQMC 2010). The following MC loading areas were selected for quantitative screening-level assessments based on range use and their potential for MC migration to off-range receptor locations. All REVA MC were modeled for each MC loading area assessed.

The following MC loading areas were assessed for surface water and sediment:

- America Mine
- Black Top I/ Morgan's
- Black Top II
- Bullion
- Cleghorn Pass I
- Cleghorn Pass II
- Delta
- Emerson Lake
- Gays Pass I
- Gays Pass II
- Lava
- Lavic Lake
- Lead Mountain
- Maumee Mine
- Morgan's Well II
- Noble Pass
- Prospect
- Quackenbush
- Rainbow
- Range 051
- Range I
- Range III
- Range IV
- Sunshine Peak

The following MC loading areas were assessed for groundwater:

- Emerson Lake
- Gays Pass I
- Gays Pass II
- Quackenbush
- Range I
- Range III
- Range IV

The surface water and sediment screening assessment was not conducted for seven identified MC loading areas (Acorn, East, Gypsum Ridge, Range II, Sand Hill East, Sand Hill West and West) because these areas were estimated to have low MC loading and are expected to contribute very little MC mass in surface water and sediment to downstream off-range receptor locations. The groundwater screening assessment was not conducted for 24 identified MC loading areas, because these areas were either estimated to have low MC loading or are located outside a drinking water source groundwater sub-basin; therefore, the MC loading areas are not expected to impact potential groundwater receptors.

Brief discussions of the results of surface water, sediment, and groundwater screening-level assessments are presented in the following sections. Results were compared to REVA median method detection limits (MDLs). 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 within REVA to determine if the predicted concentrations of REVA MC generated from the fate and transport models are detectable. Predicted concentrations exceeding MDLs are recommended for additional review. Parameter values used in the screening assessment are presented in **Appendix B**. Technical memoranda describing the surface water, sediment, and groundwater screening-level assessments are also provided in **Appendix B**.

2.3.1 Surface Water Screening-Level Results

The 24 MC loading areas assessed at MCAGCC Twentynine Palms drain to 18 off-range receptor locations, which include nine playas located within and just outside the installation boundary and nine streams draining off the installation boundary (**Figure 2-4**). Eight of the nine playas (Ames Dry Lake, Deadman Lake, Dry Lake, Emerson Lake, Galway Lake, Lavic Lake, Quackenbush Lake, and Upper Emerson Lake) are located within the installation boundary, and one (Bristol Lake) is located just outside the installation boundary.

The primary receptors identified for surface water at MCAGCC Twentynine Palms are potential ecological receptors. Although the ephemeral streams and washes that contain water following storm events may represent the closest potential ecological receptor locations, the downgradient off-range locations at the playas (the ultimate drainage end points) and the installation boundary were selected as the modeled receptor locations in order to predict potential off-range releases.

Figure 2-4 shows the MC loading areas in relation to the drainage areas of the 18 off-range receptor locations. A summary of the 18 off-range receptor locations, associated MC loading areas, and the approximate percentage of the MC loading area draining to the off-range receptor locations is provided in **Appendix B**.

The REVA screening-level surface water assessment at MCAGCC Twentynine Palms involved 1) estimating the average annual MC concentrations in surface water runoff at the edge of each MC loading area using a multimedia partitioning model to estimate the MC mass partitioned to surface water runoff 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. This was done by combining MC mass contributed from individual MC loading areas draining to the same downstream off-range receptor location and dividing the total mass by the surface water runoff volume of the receptor location drainage area. A technical memorandum in **Appendix B** provides further details of this assessment.

Table 2-4 presents the estimated annual average MC concentrations in surface water at the 18 downstream off-range receptor locations. The off-range receptor locations with a predicted detectable concentration are bolded in **Table 2-4** and identified with an orange symbol on **Figure 2-5**. Results are summarized as follows:

- HMX concentrations were predicted to exceed the median MDL in streams draining within Cleghorn Pass watersheds 3 and 4 at the installation boundary, in Quackenbush Lake, and in Upper Emerson Lake.
- RDX concentrations were predicted to exceed the median MDL in streams draining within Cleghorn Pass watersheds 3, 4, 5, and 6 at the installation boundary, in Deadman Lake, and in Quackenbush Lake. Cleghorn Pass I MC loading area contributes 100% of the RDX mass to streams within Cleghorn Pass watersheds 3, 4, and 5 at the installation boundary.
- TNT concentrations were predicted to exceed the median MDL in streams draining within Cleghorn Pass watersheds 1, 2, 3, 4, 5, 6, 7, and East and West Sunshine watershed at the installation boundary, as well as entering Bristol Lake, Deadman Lake, Dry Lake, Emerson Lake, Galway Lake, Lavic Lake, Quackenbush Lake, and Upper Emerson Lake playas.
- Perchlorate concentrations were predicted to exceed the median MDL in streams draining within Cleghorn Pass watersheds 3, 4, 5, 6, and East and West Sunshine watershed at the installation boundary, in Dry Lake, in Lavic Lake, and in Upper Emerson Lake.

All MC concentrations predicted at the downstream off-range receptor locations were significantly lower than the DoD freshwater screening values used as comparison values. HMX and RDX concentrations are at least two orders of magnitude lower than their respective DoD screening values; TNT concentrations are at least one order of magnitude lower than its DoD screening value; and perchlorate concentrations are at least four orders of magnitude lower than its DoD screening value.

Given the MC concentrations in surface water at the downstream off-range receptor locations were predicted to be significantly lower than the DoD freshwater screening values, potential ecological receptors are unlikely to be adversely impacted by MC release to the waters. Therefore, the MC loading areas are not considered areas of concern for surface water transport at this time, and further surface water assessment is not conducted. However, expenditure data at the MC loading areas of concern will continue to be monitored in order to evaluate changes in continued MC loading through time. If the expenditure data indicate a significant increase in MC loading before the next periodic review assessment for

MCAGCC Twentynine Palms, additional surface water screening assessment at the increased loading site and/or sampling will be conducted. Otherwise, the MC loading areas will be evaluated for surface water transport in the next periodic review.

Table 2-4: Screening-Level Estimates of Annual Average MC Concentrations in Surface Water at the Identified Downstream Off-Range Receptor Locations

Downstream Off-Range Receptor Locations Receiving Drainage from MC Loading Areas	Drainage Area (acres)	Estimated MC Concentration (µg/L)			
		HMX	RDX	TNT	Perchlorate
Ames Lake (1)	118,611	0.0128	6.62E-03	0.105	0.0131
Bristol Lake (entering from installation) (2)	151,723	0.0242	0.0741	**1.01**	0.0433
Deadman Lake (3)	136,200	0.0450	**0.143**	**1.93**	0.0403
Dry Lake (4)	251,000	0.0575	0.0576	**1.29**	**0.0741**
Emerson Lake (5)	153,206	0.0170	8.75E-03	**0.139**	0.0174
Galway Lake (6)	79,074	0.0229	8.85E-03	**0.282**	0.0188
Installation boundary within Cleghorn Pass WS 1 (7)[a]	4,226	8.30E-03	0.0338	**0.306**	0.0293
Installation boundary within Cleghorn Pass WS 2 (8)[a]	6,697	0.0171	0.0765	**0.623**	0.0566
Installation boundary within Cleghorn Pass WS 3 (9)[a]	1,203	**0.0780**	**1.61**	**3.07**	**0.161**
Installation boundary within Cleghorn Pass WS 4 (10)[a]	702	**0.103**	**2.12**	**4.04**	**0.212**
Installation boundary within Cleghorn Pass WS 5 (11)[a]	1,260	0.0757	**1.56**	**2.97**	**0.156**
Installation boundary within Cleghorn Pass WS 6 (12)[a]	437	0.0671	**1.39**	**2.64**	**0.138**
Installation boundary within Cleghorn Pass WS 7 (13)[a]	5,683	0.0274	0.0401	**1.01**	3.53E-03
Installation boundary within Cleghorn Pass WS 8 (14)[a]	3,262	0.0125	0.0481	3.82E-03	8.22E-04
Installation boundary within East and West Sunshine WS (15)[a]	15,815	6.92E-03	9.86E-03	**0.281**	**0.0636**
Lavic Lake (16)	88,400	0.0439	0.0302	**0.843**	**0.170**
Quackenbush Lake (17)	12,800	**0.185**	**0.111**	**1.80**	0.0496
Upper Emerson Lake (18)	15,321	**0.121**	0.0538	**1.21**	**0.107**
REVA median MDL for water		*0.077*	*0.097*	*0.108*	*0.06*
DoD Freshwater Screening Value		*150*	*360*	*100*	*9,300*

General Notes:
1. Numbers in parentheses beside receptor locations correspond to circled numbers in **Figure 2-4** and **Figure 2-5.**
2. **Bold** indicates concentration exceeds the median MDL.

Footnotes:
[a] Stream location

Acronyms and Abbreviations:
µg/L = micrograms per liter
WS = watershed

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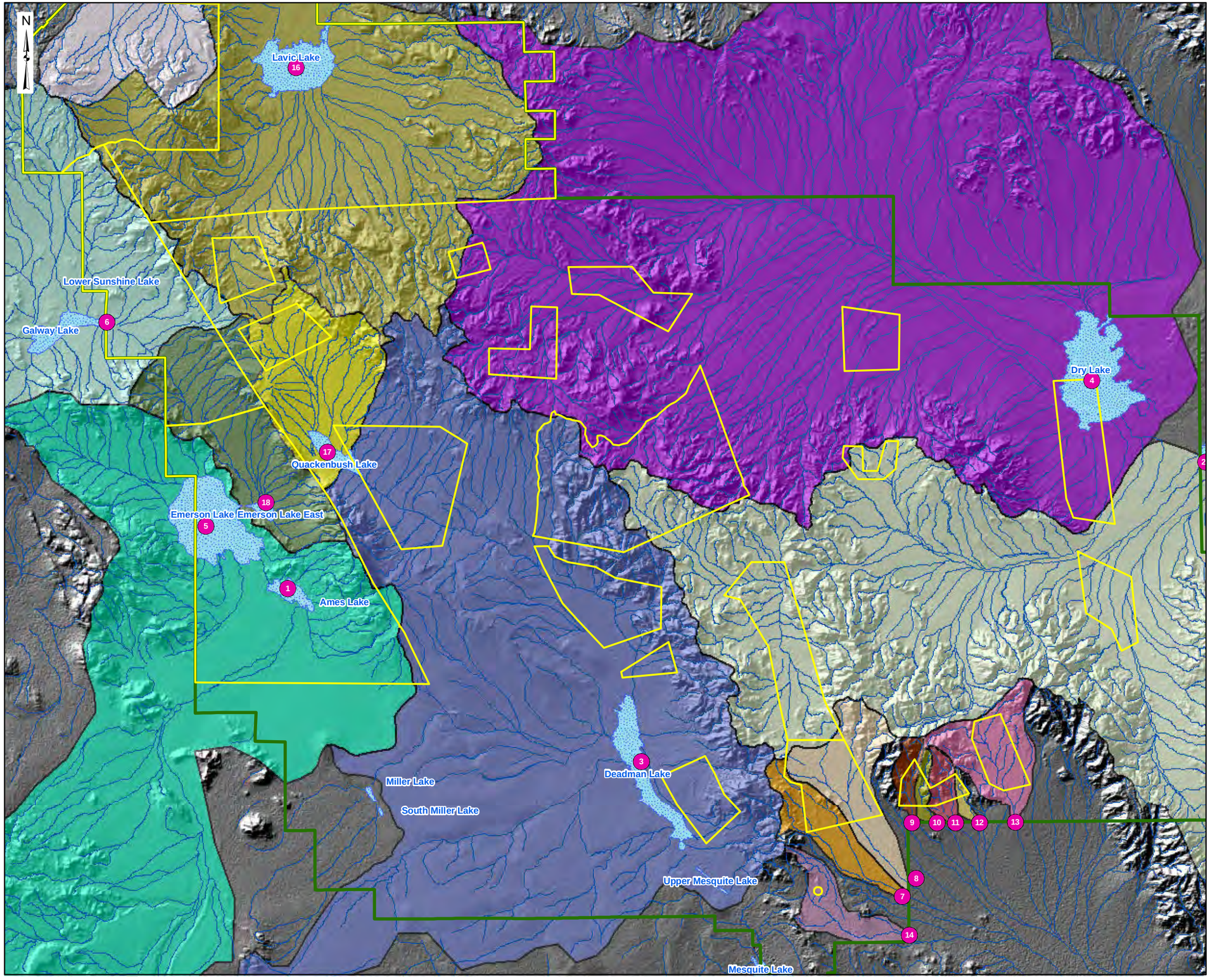


FIGURE 2-4
DRAINAGE AREAS OF
DOWNSTREAM OFF-RANGE
SURFACE WATER RECEPTOR
LOCATIONS

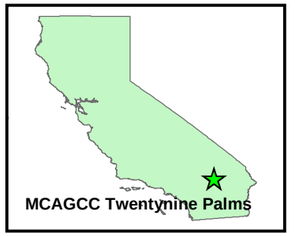
REVA
MCAGCC TWENTYNINE PALMS

Legend

- Installation Boundary
- Modeled MC Loading Area
- Playa Lake (Ephermal/Intermittent)
- Stream/Wash (Ephermal/Intermittent)
- Off-Range SW Receptor Location

Drainage Area

- Ames Lake (1)
- Bristol Lake (entering from installation) (2)
- Deadman Lake (3)
- Dry Lake (4)
- Emerson Lake (5)
- Galway Lake (6)
- Installation Boundary within Cleghorn Pass WS 1 (7)
- Installation Boundary within Cleghorn Pass WS 2 (8)
- Installation Boundary within Cleghorn Pass WS 3 (9)
- Installation Boundary within Cleghorn Pass WS 4 (10)
- Installation Boundary within Cleghorn Pass WS 5 (11)
- Installation Boundary within Cleghorn Pass WS 6 (12)
- Installation Boundary within Cleghorn Pass WS 7 (13)
- Installation Boundary within Cleghorn Pass WS 8 (14)
- Installation Boundary within East and West Sunshine WS (15)
- Lavic Lake (16)
- Quakenbush (17)
- Upper Emerson (18)



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Coordinate System: UTM
Zone: 11N
Datum: NAD83
Units: Meters

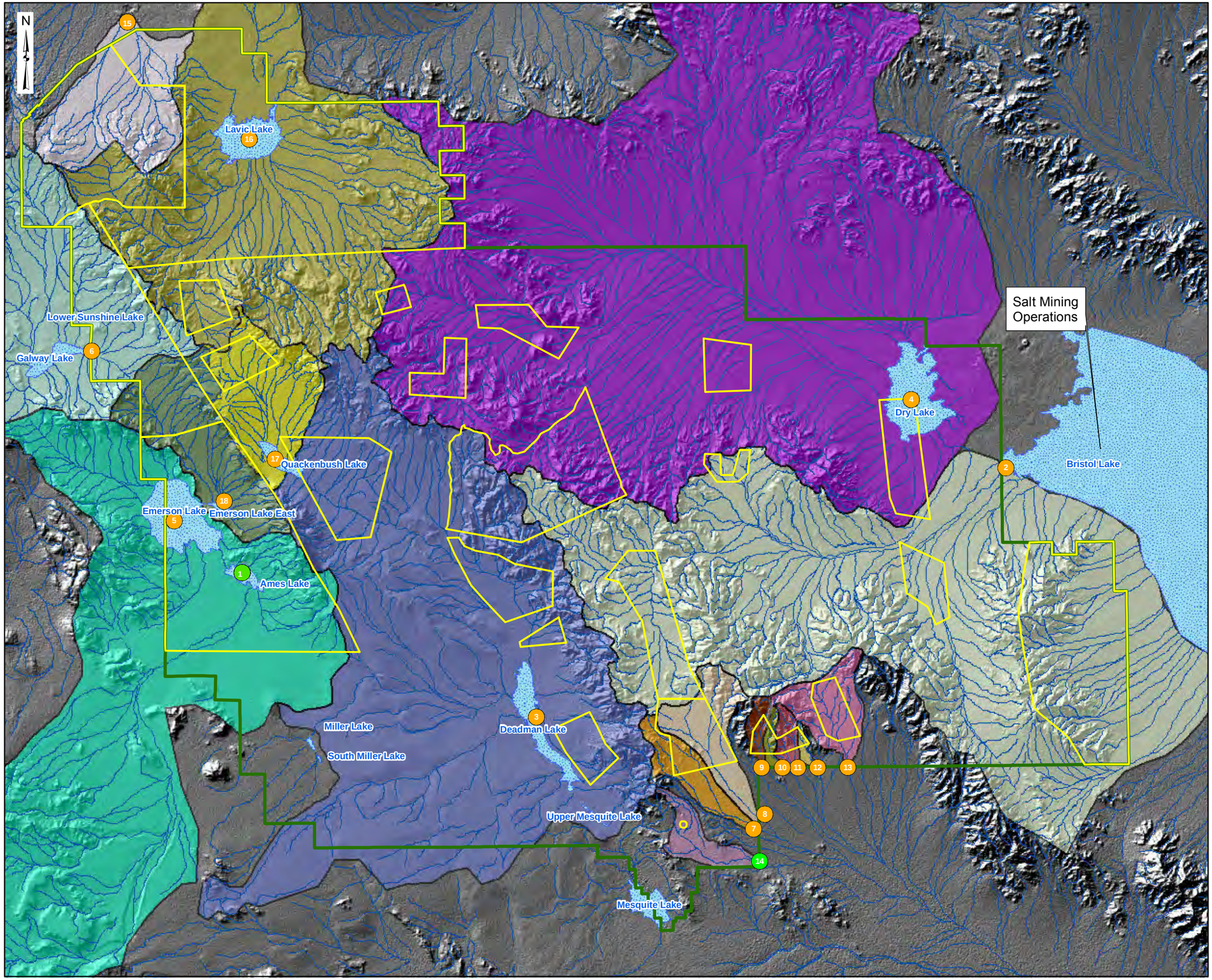
Date: August 2015

Source: MCAGCC Twentynine Palms, 2014b

ARCADIS

FIGURE 2-5
PREDICTED SURFACE WATER CONCENTRATION DETECTED AT OFF-RANGE RECEPTOR LOCATION

REVA
MCAGCC TWENTYNINE PALMS

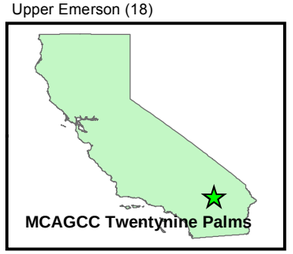


Legend

- Modeled MC Loading Area
- Installation Boundary
- Playa Lake (Ephermal/Intermittent)
- Stream/Wash (Ephermal/Intermittent)
- Off-Range Receptor Location with Predicted Detection
- Off-Range Receptor Location with no Predicted Detection

Drainage Area

- Ames Lake (1)
- Bristol Lake (entering from installation) (2)
- Deadman Lake (3)
- Dry Lake (4)
- Emerson Lake (5)
- Galway Lake (6)
- Installation Boundary within Cleghorn Pass WS 1 (7)
- Installation Boundary within Cleghorn Pass WS 2 (8)
- Installation Boundary within Cleghorn Pass WS 3 (9)
- Installation Boundary within Cleghorn Pass WS 4 (10)
- Installation Boundary within Cleghorn Pass WS 5 (11)
- Installation Boundary within Cleghorn Pass WS 6 (12)
- Installation Boundary within Cleghorn Pass WS 7 (13)
- Installation Boundary within Cleghorn Pass WS 8 (14)
- Installation Boundary within East and West Sunshine WS (15)
- Lavic Lake (16)
- Quakenbush (17)
- Upper Emerson (18)



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Coordinate System: UTM
Zone: 11N
Datum: NAD83
Units: Meters

Date: August 2015

Source: MCAGCC, Twentynine Palma, 2014b

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2.3.2 Sediment Screening-Level Results

Similar to the surface water screening-level assessment, average annual MC concentrations in sediment were estimated at the edge of the MC loading areas. The annual average MC concentrations in sediment at the edge of all MC loading areas were predicted to be below median MDLs. However, additional assessment was conducted for sediment to account for MC accumulated in the sediment of playas as a result of water evaporating from the playas and MC deposition to the lake bed. A conservative approach was used to estimate the MC mass that may accumulate in the sediment of a playa. The total MC mass transported to a playa with surface water runoff (both dissolved and associated with sediment) was assumed to remain in the sediment of the playa without accounting for loss terms, including decay and volatilization. This approach was used to estimate the accumulated MC concentrations in the playa sediments located within the installation boundary. For playas located outside the installation boundary (such as Bristol Lake), only concentrations leaving the installation and entering the playa were assessed versus MC concentrations in the playa that are also impacted by drainages outside the installation. A technical memorandum detailing the sediment assessment and result is included in **Appendix B**.

Table 2-5 presents estimated MC concentrations for sediment in the playas within the installation boundary. The results are presented for the eight playas (off-range receptor locations) located within the installation boundary. The off-range receptor locations with a predicted detectable concentration are bolded**.** The MC concentrations that were predicted to exceed DoD screening values are highlighted as well as identified with orange symbols on **Figure 2-6**. Results are summarized as follows:

- HMX concentrations in sediment potentially accumulating in all playas were predicted to be below median MDLs. However, the predicted HMX concentrations in sediment potentially accumulating in Lavic and Quackenbush Lakes playas were above the lowest DoD sediment screening value for HMX.
- RDX concentrations in sediment potentially accumulating in all playas were predicted to be below median MDLs. However, the predicted RDX concentrations in sediment potentially accumulating in Quackenbush Lake playa were above the lowest DoD sediment screening value for RDX.
- TNT concentrations in sediment potentially accumulating in Deadman Lake, Lavic Lake, and Quackenbush Lake playas were predicted to be above the median MDL and above the lowest DoD sediment screening value for TNT.
- Perchlorate concentrations in sediment potentially accumulating in all eight playas assessed were predicted to be above the median MDL. The predicted sediment concentrations for perchlorate could not be compared with a sediment benchmark, as there is no available sediment screening benchmark for perchlorate.

Table 2-5: Screening-Level Estimates of Cumulative MC Concentrations in Sediment at Playas

Downstream Off-Range Receptor Locations Receiving Drainage from MC Loading Areas	Drainage Area (acres)	Estimated MC Concentration (µg/kg)			
		HMX	RDX	TNT	Perchlorate
Ames Dry Lake (1)	118,611	0.79	0.40	6.5	**0.80**
Deadman Lake (3)	136,200	2.0	7.4	**95**	**2.1**
Dry Lake (4)	251,000	2.8	2.8	60	**3.6**
Emerson Lake (5)	153,206	0.36	0.18	2.9	**0.36**
Galway Lake (6)	79,074	1.7	0.66	21	**1.39**
Lavic Lake (16)	88,400	7.7	5.3	**142**	**28**
Quackenbush Lake (17)	12,800	24	14.1	**227**	**6.4**
Upper Emerson Lake (18)	15,321	3.9	1.7	39	**3.5**
REVA median MDL for sediment		77.9	78	63.1	0.213
DoD Freshwater Sediment Screening Value		*4.7–470*	*13–1,300*	*92 –9,200*	*NA*

General Notes:
1. Numbers in parentheses beside receptor locations correspond to circled numbers on **Figure 2-6**.
2. The range of DoD freshwater sediment screening values are dependent on the sediment percent total organic carbon (TOC). The lowest value is for a percent TOC of 1 and the highest value is for a percent TOC of 100.
3. **Bold** indicates concentration exceeds the median MDL.
4. Highlight indicates concentration exceeds the lowest DoD sediment screening level. Green shading indicates locations with exceedances.

Acronyms and Abbreviations:
µg/kg = micrograms per kilogram

The actual MC concentrations potentially accumulating in the sediment of playas are expected to be lower than the concentrations predicted in the screening assessment. This is because of the highly conservative approach used in the screening assessment, where loss terms such as degradation and volatilization which most likely occur were not incorporated into the screening approach. Based on the predicted MC concentrations in sediment of Deadman Lake, Lavic Lake and Quackenbush Lake playas that were above the lowest DoD freshwater sediment screening values, additional data collection activities (sediment sampling) were performed and are summarized in **Section 2.5.** The sediment sampling results for perchlorate concentrations from these three playas were used as representative of the perchlorate concentrations in the sediment of the eight playas (Ames Dry Lake, Deadman Lake, Dry Lake, Emerson Lake, Galway Lake, Lavic Lake, Quackenbush Lake and Upper Emerson Lake) that were predicted to have perchlorate concentration in sediment exceeding the median MDL.

FIGURE 2-6
PREDICTED SEDIMENT CONCENTRATION EXCEEDING DOD SCREENING VALUE AT OFF RANGE RECEPTOR LOCATION

REVA
MCAGCC TWENTYNINE PALMS

N

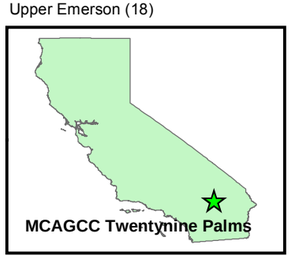
Lavic Lake
Lower Sunshine Lake
Galway Lake
Quackenbush Lake
Emerson Lake
Emerson Lake East
Ames Lake
Salt Mining Operations
Dry Lake
Bristol Lake
Deadman Lake
Miller Lake
South Miller Lake
Upper Mesquite Lake
Mesquite Lake
Dale Lake

Legend

- Modeled MC Loading Area
- Installation Boundary
- Playa Lake (Ephermal/Intermittent)
- Stream/Wash (Ephermal/Intermittent)
- Off-Range Receptor Location with Predicted Concentration Above DoD Screening Value
- Off-Range Receptor Location with no Predicted Concentration Below DoD Screening Value

Drainage Area

- Ames Lake (1)
- Bristol Lake (entering from installation) (2)
- Deadman Lake (3)
- Dry Lake (4)
- Emerson Lake (5)
- Galway Lake (6)
- Installation Boundary within Cleghorn Pass WS 1 (7)
- Installation Boundary within Cleghorn Pass WS 2 (8)
- Installation Boundary within Cleghorn Pass WS 3 (9)
- Installation Boundary within Cleghorn Pass WS 4 (10)
- Installation Boundary within Cleghorn Pass WS 5 (11)
- Installation Boundary within Cleghorn Pass WS 6 (12)
- Installation Boundary within Cleghorn Pass WS 7 (13)
- Installation Boundary within Cleghorn Pass WS 8 (14)
- Installation Boundary within East and West Sunshine WS (15)
- Lavic Lake (16)
- Quakenbush (17)
- Upper Emerson (18)



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Miles

Coordinate System: UTM
Zone: 11N
Datum: NAD83
Units: Meters

Date: August 2015

Source: MCAGCC Twentynine Palms, 2014b

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2.3.3 Groundwater Screening-Level Results

The groundwater screening-level assessment was conducted for seven MC loading areas located within the Deadman Lake and the Surprise Spring groundwater sub-basins that are future and existing drinking water sources. The REVA screening-level groundwater assessment at MCAGCC Twentynine Palms was a two-step process: 1) determine maximum MC concentrations in infiltrating water at each MC loading area assessed and 2) model the potential for MC to migrate from the MC loading areas vertically through the vadose zone to groundwater in the water-bearing units of the Deadman Lake and Surprise Spring sub-basins. This two-step process was applied to two different scenarios in order to address recharge that potentially occurs at the MC loading areas. The scenarios include 1) direct recharge from the portion of precipitation that falls on the MC loading areas and 2) preferential recharge in and around stream beds and local depressions, where runoff and standing water are concentrated.

At each step of the screening assessment process, the predicted MC concentrations were compared to median MDL values. Only MC exceeding median MDLs from the first step of the screening assessment were carried forward to the next step of the assessment. In the second step of the assessment, only MC exceeding median MDLs within a 30-year timeframe required further assessment involving screening-level modeling in the saturated zone to evaluate the potential for MC in groundwater to reach the existing and future water supply wells from the MC loading areas. The screening-level modeling in the saturated zone to evaluate MC transport to water supply wells was not conducted because MC were not predicted to reach the groundwater at concentrations exceeding median MDLs within a 30-year timeframe (from step 2 of the screening assessment process. The assessment methods of the two-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 B**.

Scenario 1 of the assessment, which accounts for direct recharge from the portion of precipitation that falls on the MC loading areas, leads to lower recharge (slower movement) and higher MC concentration. Scenario 2, which accounts for preferential recharge that constitutes a smaller proportion of the MC loading areas, leads to higher recharge (more rapid movement) and lower MC concentrations. Based on step 1 of the screening assessment, the results indicated the following:

- All MC (HMX, RDX, TNT, and perchlorate), with the exception of HMX at Range IV MC loading area, were estimated to have concentrations in recharge water above their respective median MDLs at MC loading areas assessed in Scenario 1.
- All MC, with the exception of HMX at Range IV MC loading area and perchlorate at Range I MC loading area, were estimated to have concentrations in recharge water above their respective median MDLs at MC loading areas assessed in Scenario 2.

As a result, all MC at the loading areas (except HMX at Range IV MC loading area for Scenario 1 and Scenario 2 and perchlorate at Range I MC loading area for Scenario 2) were modeled for migration through the vadose zone in step 2 of the screening assessment.

Based on the vadose zone modeling conducted in step 2 of the screening assessment, concentrations of HMX, RDX, and TNT were predicted to degrade to below their respective median MDL values before

reaching the groundwater. Perchlorate concentrations at all MC loading areas modeled in this step of the screening assessment were predicted to ultimately reach the groundwater at concentrations above the median MDL. **Table 2-6** presents the predicted maximum perchlorate concentration, the estimated travel time at a concentration equivalent to the median MDL value for model Scenarios 1 and 2 and the estimated travel time for the concentration for model Scenarios 1 and 2 to be equivalent to the maximum predicted. Model Scenario 1 was conducted for recharge rates ranging from 0.05 to 0.1 in/yr, and model Scenario 2 was conducted for recharge rates ranging from 2 to 2.8 in/yr. Both model scenarios were modeled for estimated depth to groundwater of approximately 33 to 189 feet below ground surface. The following was predicted:

- For model Scenario 1, perchlorate was predicted to reach the groundwater at a concentration equivalent to the median MDL of 0.06 µg/L after a minimum travel time of approximately 500 years at the Range III MC loading area. At this MC loading area, the perchlorate concentration was estimated to reach a maximum of 3.36 micrograms per liter (µg/L) in over 2,000 years.
- For model Scenario 2, perchlorate was predicted to reach the groundwater at a concentration equivalent to the median MDL of 0.06 µg/L after a minimum travel time of 40 years at the Range III MC loading area. At this MC loading area, the perchlorate concentration was estimated to reach a maximum of 0.113 µg/L in approximately 70 years.

Table 2-6: Model Predicted Perchlorate Concentration Reaching the Water Table and the Model Predicted Travel Time for Perchlorate to Reach the Water Table

MC Loading Area	Perchlorate Median MDL (µg/L)	Maximum Perchlorate Concentration Reaching Water Table (µg/L)		Time for Concentration to be equivalent to the Median MDL (years)		Time for Concentration to be the Maximum Predicted (years)	
		Scenario 1	Scenario 2	Scenario 1	Scenario 2	Scenario 1	Scenario 2
Emerson Lake	0.06	59.2	1.21	>1,000	~50	>10,000	~180
Gays Pass I	0.06	5.96	0.190	>2,000	~100	>10,000	>300
Gays Pass II	0.06	11.4	0.271	>3,000	~200	>10,000	>400
Quackenbush	0.06	6.51	0.281	~900	~70	>4,000	>100
Range I	0.06	1.45	NM	~900	NM	>2,000	NM
Range III	0.06	3.36	0.113	~500	~40	>2,000	~70
Range IV	0.06	23.5	0.461	>1,000	~70	>5,000	>200

General Notes:
µg/L = micrograms per liter
NM = not modeled because MC was eliminated for further assessment based on the first step of the groundwater screening assessment

Based on the groundwater screening assessment, perchlorate is the only MC from the MC loading areas predicted to reach the groundwater at levels above the median MDL. With a low recharge rate and depth to groundwater exceeding 30 feet, time of travel for perchlorate to potentially reach groundwater is in excess of 40 years; therefore, additional modeling to the groundwater wells was not conducted. The shortest time of

travel occurs where there is preferential recharge (such as near ephemeral streams), which generally occurs within a limited recharge area. However, when groundwater moves from these limited recharge areas, perchlorate levels will be reduced. The perchlorate concentration at the groundwater table is not expected to reach the California drinking water benchmark of 6 µg/L.

Given the very slow travel of perchlorate through the vadose zone over the MC loading areas, impact to groundwater receptors within the Deadman Lake and Surprise Spring groundwater sub-basins in not anticipated within the next 5 years based on current conditions. As a result, further evaluation of MC loading at MCAGCC Twentynine Palms for this REVA periodic review is considered complete and is recommended for reevaluation in the next periodic review.

2.4 Lead Assessment Results

Modeling parameters for lead fate and transport are contingent upon site-specific geochemical data that are generally unavailable unless site-specific investigations are conducted. Therefore, a qualitative approach is utilized for assessing lead deposited in MC loading areas and SARs.

2.4.1 Munitions Constituents Loading Area Lead Deposition

Lead components are present in a wide variety of munitions associated with RTAs and fixed ranges. Using the MC Calculator and the assumptions listed in the surface water and sediment technical memorandum (**Appendix B**), the following table presents potential lead deposition associated with MC loading areas in the drainage areas of identified receptor locations:

Table 2-7: Lead Deposition Associated with MC Loading Areas in Receptor Drainage Areas

Identified Receptor Location	MC Loading Area Draining to Identified Receptor	Estimated Lead Deposition in Drainage Area (lb/yr)	
Ames Dry Lake	Emerson Lake	589	589
Bristol Lake (drainages entering from installation)	America Mine	895	13,529
	Bullion	2,449	
	Delta	8,134	
	Lava	1,642	
	Lead Mountain	163	
	Noble Pass	195	
	Prospect	51	
Deadman Lake	Emerson Lake	27	61,547
	Noble Pass	447	
	Quackenbush	3,552	

Identified Receptor Location	MC Loading Area Draining to Identified Receptor	Estimated Lead Deposition in Drainage Area (lb/yr)	
	Range I	8,979	
	Range III	4,469	
	Range IV	44,073	
Dry Lake	Black Top I / Morgan's Well I	1,668	11,380
	Black Top II	862	
	Lava	162	
	Lavic Lake	262	
	Lead Mountain	3,100	
	Morgan's Well II	2,940	
	Noble Pass	504	
	Rainbow Canyon	1,882	
Emerson Lake	Emerson Lake	1,001	1,002
	Maumee Mine	1	
Galway Lake	Gays Pass II	4	93
	Lavic Lake	37	
	Maumee Mine	52	
	Sunshine Peak	--	
Installation boundary within Cleghorn Pass Watershed 1	Prospect	308	308
Installation boundary within Cleghorn Pass Watershed 2	Delta	82	1,005
	Prospect	923	
Installation boundary within Cleghorn Pass Watershed 3	Cleghorn Pass I	4,766	4,766
Installation boundary within Cleghorn Pass Watershed 4	Cleghorn Pass I	3,723	3,723
Installation boundary within Cleghorn Pass Watershed 5	Cleghorn Pass I	4,915	4,915
Installation boundary within Cleghorn Pass Watershed 6	Cleghorn Pass I	1,489	1,489

Identified Receptor Location	MC Loading Area Draining to Identified Receptor	Estimated Lead Deposition in Drainage Area (lb/yr)	
Installation boundary within Cleghorn Pass Watershed 7	Cleghorn Pass II	4,349	4,349
Installation boundary within Cleghorn Pass Watershed 8 (14)	Range 051	--	--
Installation boundary within East and West Sunshine Watershed (15)	Lavic Lake	224	224
	Sunshine Peak	--	
Lavic Lake	Gays Pass I	8	4,239
	Gays Pass II	381	
	Lavic Lake	3,254	
	Maumee Mine	2	
	Rainbow Canyon	594	
	Sunshine Peak	--	
Quackenbush Lake	Emerson Lake	14	525
	Gays Pass I	362	
	Maumee Mine	1	
	Quackenbush	148	
Upper Emerson Lake	Emerson Lake	343	383
	Gays Pass I	15	
	Maumee Mine	25	

General Notes:
lb/year = pounds per year
1. The percentage of each MC loading area that may contribute to a drainage area is presented in **Appendix B.**

Acronyms and Abbreviations:
-- = Not Available

Annual lead deposition is significantly high within the Deadman Lake subwatershed, with a total annual deposition estimated at over 61,500 lbs per year. This represents significant lead loading in a single watershed within the REVA program, therefore, further assessment for the potential transport of lead is recommended at this potential receptor location.

2.4.2 Small Arms Range Assessment

Eleven SARs (including a recreational skeet range) were identified at MCAGCC Twentynine Palms (**Figure 2-7**). Six of these ranges are associated with the MTU in the southeastern area of the Range RTA. The MTU conducts small arms proficiency and requalification for Marines and transiting units. Four other

identified SARs north of the MTU are also located in the Range RTA. The skeet range is located in the Mainside cantonment area.

The Small Arms Range Assessment Protocol (SARAP) is used to qualitatively evaluate SARs where lead deposition is concentrated or well defined. The assessment resulted in moderate evaluation rankings for surface water/sediment at seven SARs, and for groundwater at eight SARs. The overall scores were driven by high lead loading rates, soil type, and lack of vegetation. The scores were limited to moderate by factors including a low precipitation rate, large distances between the ranges, intermittent receiving surface water bodies, and the relatively deep depth of groundwater present at the installation, all of which limit lead migration and potential impacts. Best management practices for surface water run-on and runoff are implemented at many SARs and further limit impacts associated with lead migration off range. The other three SARs - Range 2A, Range 3, and the MCCS Skeet Range - received minimal evaluation rankings for surface water/sediment and groundwater, primarily due to very low lead loading (89 lb, 509 lb, and 0 lb, respectively).

The individual SARAP assessments are provided in **Appendix C**, and **Table 2-8** provides a summary of the findings.

Table 2-8: Summary of SARAP Results

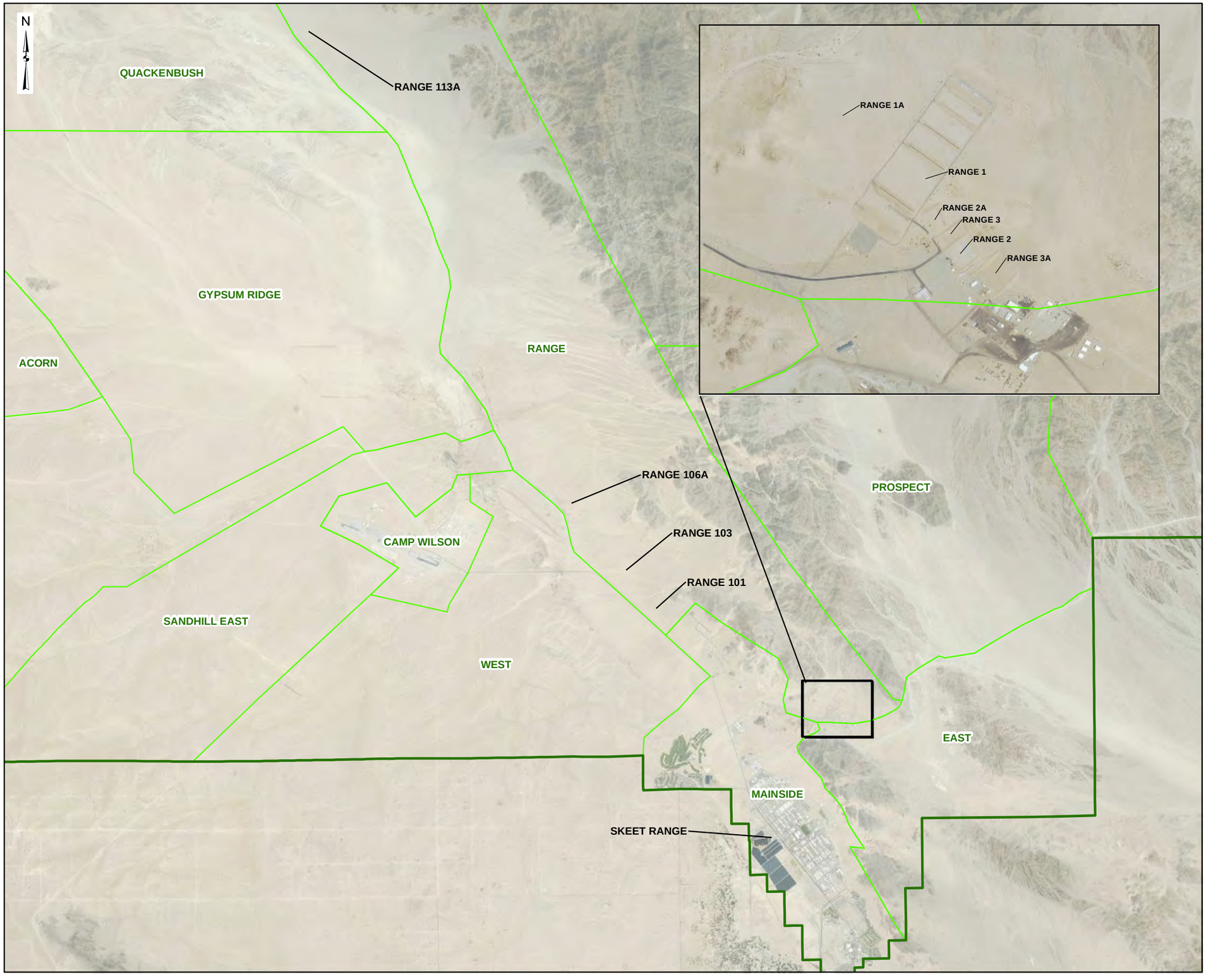
Small Arms Range	Surface Water / Sediment Ranking (Score)	Groundwater Ranking (Score)	Annual Lead Deposition Rate (lb/yr)
Range 1	Moderate (39)	Moderate (37)	9.51E+03
Range 1A	Moderate (36)	Moderate (34)	2.69E+03
Range 2	Minimal (31)	Moderate (35)	6.96E+03
Range 2A	Minimal (24)	Minimal (28)	8.84E+01
Range 3	Minimal (27)	Minimal (31)	5.09E+02
Range 3A	Minimal (32))	Moderate (35)	2.88E+03
Range 101	Moderate (35)	Moderate (33)	1.42E+03
Range 103	Moderate (33)	Moderate (33)	1.57E+03
Range 106A	Moderate (33)	Moderate (36)	3.99E+03
Range 113A	Moderate (35)	Moderate (40)	4.23E+03
MCCS Skeet Range	Minimal (26)	Minimal (30)	N/A

General Notes:
1. High ranking range: 45–65 points
2. Moderate ranking range: 33–44 points
3. Minimal ranking range: 0–32 points

Acronyms and Abbreviations:
N/A = Not Applicable - Only lead-free ammunition was used at the Skeet Range during the periodic review period.

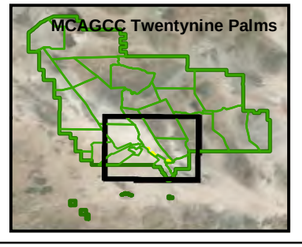
FIGURE 2-7
SMALL ARMS RANGES AT MCAGCC TWENTYNINE PALMS

REVA
MCAGCC TWENTYNINE PALMS



Legend

- Installation Boundary
- Range Training Area



0 0.35 0.7 1.4 2.1
Miles

Coordinate System: UTM
Zone: 11N
Datum: NAD83
Units: Meters

Date August 2015

Source: Aerial - ESRI
GIS - MCAGCC Twentynine Palms, 2014b

ARCADIS

The moderate surface water/sediment and groundwater rankings at these SARs indicate some factors are present that contribute to the potential for lead migration off range, but there is likely no immediate threat to human health or the environment.

2.5 Field Data Collection

Field data collection was completed 27 and 28 May 2015 as part of the periodic review at locations based upon the results of the screening-level assessments. This section summarizes the field results.

2.5.1 Samples

Sediment samples were collected at MCAGCC Twentynine Palms based on modeling results from the REVA periodic review and subwatershed lead loading estimates. Four field locations (five samples) within two dry lakes (playas) were sampled and analyzed for explosives, perchlorate, lead, total organic carbon (TOC), conductivity and pH. A reference location within a playa outside of an MC loading area was sampled and analyzed for explosives, perchlorate, TOC, conductivity and pH (one sample).

Table 2-9 presents sediment sample location identifications (IDs), associated ranges, MC loading areas, and analytes.

Table 2-9: Summary of Sediment Samples

Playa	Sample ID	Perchlorate	Explosives	Lead	TOC	Salinity	Conductivity	pH
Deadman Lake	DM-SED01	X	X	X	X	X	X	X
	DM-SED02	X	X	X	X	X	X	X
Quackenbush Lake	QK-SED03	X	X		X	X	X	X
	QK-SED04	X	X		X	X	X	X
Mesquite Lake	MQ-SEDRef	X	X		X	X	X	X

2.5.2 Screening Criteria

Sediment analysis results were compared to DoD screening values for freshwater sediment (DoD 2013).

2.5.3 Results

RTI Laboratories in Livonia, Michigan, analyzed the samples. Results are presented in **Table 2-10** and are summarized below.

Lead was detected in the three field samples collected at Deadman Lake playa, with concentrations ranging from 2.8 to 19.0 milligrams per kilogram (mg/kg). All detected concentrations of lead were below the applicable TOC-adjusted DoD lead screening criteria. Perchlorate was detected in only one sample, with a concentration of 4.0 μg/kg. Explosives were not detected in any samples.

2.5.4 Summary

Explosives residues were not detected in any samples; perchlorate was detected in only one sample at a level below the DoD screening criteria. Lead was detected in three samples but below the regulatory screening level. Based on the results of the sampling, it was determined that there was no unacceptable risk to receptors or the environment from sediment. Therefore, no further field assessment was deemed necessary at this time.

Table 2-10: Sediment Sample Results May 2015

Sediment ID	Screening Values		Playa					
			Deadman Lake			Quackenbush Lake		Mesquite Lake
	DoD Ecological Freshwater Sediment[a]	Laboratory Detection Limit	DM-SED01	DM-SED02	DM-SED02 Duplicate	QK-SED03	QK-SED04	MQ-SEDREF
Explosives (mg/kg)								
1,3,5-Trinitrobenzene	varies [b]	0.007	0.040 U	0.040 U	0.040 U	0.040 U	0.040 U	0.040 U
	Site-Specific Screening Value		0.0024	0.001	0.001	0.0004	0.0004	0.0024
1,3-Dinitrobenzene	varies [b]	0.018	0.040 U	0.040 U	0.040 U	0.040 U	0.040 U	0.040 U
	Site-Specific Screening Value		0.0067	0.0029	0.0029	0.0010	0.0010	0.0067
2,4,6-Trinitrotoluene	varies [b]	0.0045	0.040 U	0.040 U	0.040 U	0.040 U	0.040 U	0.040 U
	Site-Specific Screening Value		0.092	0.0396	0.0396	0.014	0.014	0.092
2,4-Dinitrotoluene	0.0751	0.011	0.040 U	0.040 U	0.040 U	0.040 U	0.040 U	0.040 U
2,6-Dinitrotoluene	0.0206	0.013	0.040 U	0.040 U	0.040 U	0.040 U	0.040 U	0.040 U
2-Amino-4,6-dinitrotoluene	---	0.014	0.040 U	0.040 U	0.040 U	0.040 U	0.040 U	0.040 U
2-Nitrotoluene	---	0.01	0.040 U	0.040 U	0.040 U	0.040 U	0.040 U	0.040 U
3-Nitrotoluene	---	0.01	0.040 U	0.040 U	0.040 U	0.040 U	0.040 U	0.040 U
4-Amino-2,6-dinitrotoluene	---	0.0089	0.040 U	0.040 U	0.040 U	0.040 U	0.040 U	0.040 U
4-Nitrotoluene	4.06	0.015	0.040 U	0.040 U	0.040 U	0.040 U	0.040 U	0.040 U
HMX	varies [b]	0.0027	0.040 U	0.040 U	0.040 U	0.040 U	0.040 U	0.040 U
	Site-Specific Screening Value		0.0047	0.0020	0.0020	0.0007	0.0007	0.0047
Nitrobenzene	0.488	0.0089	0.040 U	0.040 U	0.040 U	0.040 U	0.040 U	0.040 U
Nitroglycerin	---	0.019	0.080 U	0.080 U	0.080 U	0.080 U	0.080 U	0.080 U
PETN	---	0.05	0.200 U	0.200 U	0.200 U	0.200 U	0.200 U	0.200 U
RDX	varies [b]	0.0034	0.040 U	0.040 U	0.040 U	0.040 U	0.040 U	0.040 U
	Site-Specific Screening Value		0.0130	0.0056	0.0056	0.0020	0.0020	0.0130
Tetryl	53.4	0.0029	0.040 U	0.040 U	0.040 U	0.040 U	0.040 U	0.040 U
Metals (mg/kg)								
Lead	47.0	---	**2.8 J**	**19 J**	**16 J**	NA	NA	NA
Other								
Perchlorate (mg/kg)	---	---	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	**0.004**
Total Organic Carbon (mg/kg)	---	---	2,500 U	**4,300**	**4,300**	**1,500 J**	**1,500 J**	2,500 U
Specific Conductivity (µmhos/cm)	---	---	**130**	**980**	**840**	**81**	**87**	**7.1**
Hydrogen Ion (pH)	---	---	**9.28**	**8.86**	**8.65**	**8.82**	**8.70**	**8.65**

Note

"---" = Not listed in standards

mg/kg = milligram to kilogram

NA = Not analyzed

pH = measure of molar concentration of hydrogen ions

µmhos/cm = micromhos per centimeter

J = estimated value

U = analyte detected above laboratory detection limit

Red	= Detected above screening level
Yellow	= Detected concentration above laboratory detection limit
Gray	= Detected Non-analyte sample parameters

a. DoD operational range assessment screening values for ecological freshwater sediment, from USEPA Office of Solid Waste and Emergency Response Ecotox Thresholds, January 1996.

b. These values are dependent on the sediment TOC.

3. Findings and Conclusions

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

Ames Lake Watershed	
Analysis	**Findings/Results**
MC Loading Areas (% area in the drainage area)	**Acorn** (51%; MC loading area not modeled), **Emerson Lake** (43%)
Identified receptors	• Surface Water / Sediment: Ecological (special status species include Agassiz's desert tortoise and MFTL). • Groundwater: Human (drinking water production wells).
Surface water screening-level modeling	• Surface water MC concentrations in Ames Lake were predicted to be below detectable concentrations. • No additional surface water assessment is recommended at this time.
Sediment screening-level modeling	• Perchlorate concentration in sediment potentially accumulating in Ames Lake playa as a result of water evaporating from the playa was predicted to be above detectable concentration. There is no established DoD sediment screening benchmark for perchlorate to compare with the predicted concentration. • Additional sediment assessment is not recommended at this time.
Groundwater screening-level modeling	• Perchlorate at Emerson Lake MC loading area was predicted to reach the groundwater at detectable concentration, but it was predicted to take in excess of 50 years to reach the groundwater at a detectable concentration (approximately 50 years where there is preferential recharge and over 1,000 years where there is direct recharge). • Additional groundwater assessment in not recommended at this time.
Lead deposition	• Total lead deposition associated with the MC loading areas in this watershed is low (approximately 589 lb/yr). No additional assessment is recommended at this time.
SARs	None.
Sampling	Sediment sampling results from Deadman and Quackenbush Lake playas, which show perchlorate concentrations are below detectable levels, are considered representative of the perchlorate concentrations in the sediment of Ames Lake playa.
Conclusion	The screening-level and qualitative assessment results do not indicate a current release of HE, perchlorate, or lead to surface water, sediment, or groundwater at levels of concern for the environment from the MC loading areas identified within the Ames Lake watershed.

Bristol Lake Watershed	
Analysis	**Findings/Results**
MC Loading Areas (% area in the drainage area)	**America Mine** (100%)**, Bullion** (100%)**, Delta** (99%), **Lava** (91%), **Lead Mountain** (5%), **Noble Pass** (17%), **Prospect** (4%)
Identified receptors	• Surface Water/Sediment: Ecological (special status species include Agassiz's desert tortoise), Human (incidental contact by salt mine workers) • Groundwater: None
Surface water screening-level modeling	• TNT concentration in surface water entering Bristol Lake was predicted to be above detectable concentration, but the predicted concentration is two orders of magnitude lower than the DoD freshwater screening value for TNT. • 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. As a result, MC concentrations in sediment leaving the installation and entering Bristol Lake are below detectable concentrations. • No additional sediment assessment is recommended at this time.
Groundwater screening-level modeling	• Groundwater screening assessment was not conducted because the MC loading areas are located outside a drinking water source groundwater sub-basin where they have limited potential impact to groundwater resources. Qualitative assessment also indicates limited potential for MC migration to groundwater.
Lead deposition	• Total lead deposition associated with the MC loading areas in this watershed is moderate (approximately 13,529 lb/yr). No additional assessment is recommended at this time.
SARs	None.
Sampling	None.
Conclusion	The screening-level and qualitative assessment results do not indicate a current release of HE, perchlorate, or lead to surface water, sediment, or groundwater at levels of concern for the environment from the MC loading areas identified within the Bristol Lake watershed.

Cleghorn Pass / Dale Lake Watershed	
Analysis	**Findings/Results**
MC Loading Areas (% area in the drainage area)	**Cleghorn Pass I** (100%)**, Cleghorn Pass II** (100%), **Delta** (1%), **East** (92%; MC loading area not modeled), **Prospect** (96%), **Range 051**
Identified receptors	• Surface Water / Sediment: Ecological (special status species include Agassiz's desert tortoise and MFTL), Human (potential off installation through incidental contact) • Groundwater: None
Surface water screening-level modeling	• MC concentrations in surface water at seven streams leaving the installation boundary within the Cleghorn Pass / Dale Lake watershed, were predicted to be above detectable concentrations (HMX at two streams, RDX and perchlorate at four streams and TNT at seven streams), but the predicted MC concentrations are at least three orders (for HMX), two orders (for RDX), one order (for TNT), and four orders (for perchlorate) of magnitude lower than their respective DoD freshwater screening values. • 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. As a result, MC concentrations in sediment of streams leaving the installation within the Cleghorn Pass / Dale Lake watershed are below detectable concentrations. • No additional sediment assessment is recommended at this time.
Groundwater screening-level modeling	• Groundwater screening assessment was not conducted because the MC loading areas are located outside a drinking water source groundwater sub-basin where they have limited potential impact to groundwater resources. Qualitative assessment also indicates limited potential for MC migration to groundwater.
Lead deposition	• Total lead deposition associated with the MC loading areas in this watershed is moderate (approximately 20,556 lb/yr). No additional assessment is recommended at this time.
SARs	None.
Sampling	None.
Conclusion	The screening-level and qualitative assessment results do not indicate a current release of HE, perchlorate, or lead to surface water, sediment, or groundwater at levels of concern for the environment from the MC loading areas identified within the Cleghorn Pass / Dale Lake watershed.

Deadman Lake Watershed	
Analysis	**Findings/Results**
MC Loading Areas (% area in the drainage area)	**Acorn** (26%; MC loading area not modeled)**, Emerson Lake** (2%)**, Gypsum Ridge** (100%; MC loading area not modeled)**, Noble Pass** (39%), **Quackenbush** (96%), **Range I** (100%)**, Range II** (100%; MC loading area not modeled), **Range III** (100%)**,**, **Range IV** (100%)**, Sand Hill East** (100%; MC loading area not modeled)**, Sand Hill West** (13%; MC loading area not modeled)**, West** (87%; MC loading area not modeled)
Identified receptors	• Surface Water/Sediment: Ecological (special status species include Agassiz's desert tortoise and MFTL) • Groundwater: Human (future drinking water production wells)
Surface water screening-level modeling	• RDX and TNT concentrations in surface water at Deadman Lake were predicted to be above detectable concentrations, but the predicted concentrations are more than three orders (for RDX) and more than one order (for TNT) of magnitude lower than their respective DoD freshwater screening values. • No additional surface water assessment is recommended for this review.
Sediment screening-level modeling	• TNT and perchlorate concentrations in sediment potentially accumulating in Deadman Lake playa as a result of water evaporating from the playa were predicted to be above detectable concentrations. • The predicted TNT concentration in sediment potentially accumulating in Deadman Lake playa was above the lower bound DoD sediment screening value for TNT. • Sediment sampling was conducted.
Groundwater screening-level modeling	• Perchlorate at Emerson Lake, Quackenbush, Range I, Range III, and Range IV MC loading areas was predicted to reach the groundwater at detectable concentration, but the minimum travel time predicted for perchlorate to reach the groundwater at detectable concentration at these MC loading areas was in excess of 40 years (approximately 40 years where there is preferential recharge and approximately 500 years where there is direct recharge). • Additional groundwater assessment is not recommended for this review.
Lead deposition	• Total lead deposition associated with the MC loading areas in this watershed is moderate (approximately 61,547 lb/yr). Sediment sampling for lead was conducted based on the high lead deposition potentially occurring at Deadman Lake playa.
SARs	**Range 101, Range 103, Range 106A**
Qualitative evaluation	• Surface Water/sediment ranking = MODERATE • Groundwater ranking = MODERATE
Sampling	**Sediment samples at two locations in Deadman Lake playa** (DM-SED01 and DM-SED02)
Sample results	REVA MC explosives – non-detect Perchlorate – non-detect Lead – 2.8 to 19.0 mg/kg
Conclusion	The screening-level and qualitative assessment results do not indicate a current release of HE, perchlorate, or lead to surface water or groundwater at levels of concern for the environment but do indicate a current release of TNT to sediment in Deadman Lake playa at levels that could be a potential concern for the environment from the MC loading areas or SARs identified within the Deadman Lake watershed. However, sediment sampling results show that HE (including TNT) and perchlorate concentrations in the sediment of Deadman Lake playa are below laboratory detectable levels. Lead is present in sediment in the playa but at levels below DoD screening levels.

Dry Lake Watershed	
Analysis	**Findings/Results**
MC Loading Areas (% area in the drainage area)	**Black Top I / Morgan's Well I** (100%)**, Black Top II** (100%), **Lava** (9%), **Lavic Lake** (7%), **Lead Mountain** (95%), **Morgan's Well II** (100%)**, Noble Pass** (44%)**, Rainbow Canyon** (76%)
Identified Receptors	• Surface Water / Sediment: Ecological (special status species include Agassiz's desert tortoise and MFTL) • Groundwater: None
Surface water screening-level modeling	• TNT and perchlorate concentrations in surface water at Dry Lake were predicted to be above detectable concentrations, but the predicted concentrations are more than one order (for TNT) and more than five orders (for perchlorate) of magnitude lower than their respective DoD freshwater screening values. • No additional surface water assessment is recommended at this time.
Sediment screening-level modeling	• Perchlorate concentration in sediment potentially accumulating in Dry Lake playa as a result of water evaporating from the playa was predicted to be above detectable concentration. There is no established DoD sediment screening benchmark for perchlorate to compare with the predicted concentration. • Additional sediment assessment is not recommended at this time.
Groundwater screening-level modeling	• Groundwater screening assessment was not conducted because the MC loading areas are located outside a drinking water source groundwater sub-basin where they have limited potential impact to groundwater resources. Qualitative assessment also indicates limited potential for MC migration to groundwater.
Lead deposition	• Total lead deposition associated with the MC loading areas in this watershed is moderate (approximately 11,379 lb/yr). No additional assessment is recommended at this time.
SARs	None.
Sampling	Sediment sampling results from Deadman and Quackenbush Lake playas, which show perchlorate concentrations are below detectable levels, are considered representative of the perchlorate concentrations in the sediment of Dry Lake playa.
Conclusion	The screening-level and qualitative assessment results do not indicate a current release of HE, perchlorate, or lead to surface water, sediment, or groundwater at levels of concern for the environment from the MC loading areas identified within the Dry Lake watershed.

East and West Sunshine Watershed	
Analysis	**Findings/Results**
MC Loading Areas (% area in the drainage area)	**Lavic Lake** (6%), **Sunshine Peak** (58%)
Identified Receptors	• Surface Water / Sediment: Ecological (special status species include Agassiz's desert tortoise), Human (potential off installation through incidental contact) • Groundwater: None
Surface water screening-level modeling	• TNT and perchlorate concentrations in surface water at the stream leaving the installation boundary within the East and West Sunshine watershed were predicted to be above detectable concentrations, but the predicted concentrations are more than two orders (for TNT) and more than five orders (for perchlorate) of magnitude lower than their respective DoD freshwater screening values. • 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. As a result, MC concentrations in sediment of the stream leaving the installation within the East and West Sunshine watershed are below detectable concentrations. • No additional sediment assessment is recommended at this time.
Groundwater screening-level modeling	• Groundwater screening assessment was not conducted because the MC loading areas are located outside a drinking water source groundwater sub-basin where they have limited potential impact to groundwater resources. Qualitative assessment also indicates limited potential for MC migration to groundwater.
Lead deposition	• Total lead deposition associated with the MC loading areas in this watershed is low (approximately 224 lb/yr). No additional assessment is recommended at this time.
SARs	None.
Sampling	None.
Conclusion	The screening-level and qualitative assessment results do not indicate a current release of HE, perchlorate, or lead to surface water, sediment, or groundwater at levels of concern for the environment from the MC loading areas identified within the East and West Sunshine watershed.

Emerson Lake Watershed	
Analysis	**Findings/Results**
MC Loading Areas (% area in the drainage area)	**Acorn** (51%; MC loading area not modeled), **Emerson Lake** (73%), **Maumee Mine** (< 1%)
Identified Receptors	• Surface Water / Sediment: Ecological (special status species include Agassiz's desert tortoise and MFTL) • Groundwater: Human (drinking water production wells)
Surface water screening-level modeling	• TNT concentration in surface water at Emerson Lake was predicted to be above detectable concentration, but the predicted concentration is more than two orders of magnitude lower than the DoD freshwater screening value for TNT. • No additional surface water assessment is recommended at this time.
Sediment screening-level modeling	• Perchlorate concentration in sediment potentially accumulating in Emerson Lake playa as a result of water evaporating from the playa was predicted to be above detectable concentration. There is no established DoD sediment screening benchmark for perchlorate to compare with the predicted concentration. • Additional sediment assessment is not recommended at this time.
Groundwater screening-level modeling	• Perchlorate at Emerson Lake MC loading area was predicted to reach the groundwater at detectable concentration, but it was predicted to take in excess of 50 years to reach the groundwater at a detectable concentration (approximately 50 years where there is preferential recharge and over 1,000 years where there is direct recharge). • Additional groundwater assessment in not recommended at this time.
Lead deposition	• Total lead deposition associated with the MC loading areas in this watershed is low (approximately 1,001 lb/yr). No additional assessment is recommended at this time.
SARs	None.
Sampling	Sediment sampling results from Deadman and Quackenbush Lake playas, which show perchlorate concentrations are below detectable levels, are considered representative of the perchlorate concentrations in the sediment of Emerson Lake playa.
Conclusion	The screening-level and qualitative assessment results do not indicate a current release of HE, perchlorate, or lead to surface water, sediment, or groundwater at levels of concern for the environment from the MC loading areas identified within the Emerson Lake watershed.

Galway Lake Watershed	
Analysis	**Findings/Results**
MC Loading Areas (% area in the drainage area)	**Gays Pass II** (1%), **Lavic Lake** (<1%), **Maumee Mine** (65%), **Sunshine Peak** (15%)
Identified Receptors	• Surface Water / Sediment: Ecological (special status species include Agassiz's desert tortoise) • Groundwater: Human (future drinking water production wells)
Surface water screening-level modeling	• TNT concentration in surface water at Galway Lake was predicted to be above detectable concentration, but the predicted concentration is more than two orders of magnitude lower than the DoD freshwater screening value for TNT. • No additional surface water assessment is recommended at this time.
Sediment screening-level modeling	• Perchlorate concentration in sediment potentially accumulating in Galway Lake playa as a result of water evaporating from the playa was predicted to be above detectable concentration. There is no established DoD sediment screening benchmark for perchlorate to compare with the predicted concentration. • Additional sediment assessment is not recommended at this time.
Groundwater screening-level modeling	• Perchlorate at Gays Pass II MC loading area was predicted to reach the groundwater at detectable concentration, but it was predicted to take in excess of 200 years to reach the groundwater at a detectable concentration (approximately 200 years where there is preferential recharge and over 3,000 years where there is direct recharge). • Additional groundwater assessment in not recommended at this time.
Lead deposition	• Total lead deposition associated with the MC loading areas in this watershed is low (approximately 93 lb/yr). No additional assessment is recommended at this time.
SARs	None.
Sampling	Sediment sampling results from Deadman and Quackenbush Lake playas, which show perchlorate concentrations are below detectable levels, are considered representative of the perchlorate concentrations in the sediment of Galway Lake playa.
Conclusion	The screening-level and qualitative assessment results do not indicate a current release of HE, perchlorate, or lead to surface water, sediment, or groundwater at levels of concern for the environment from the MC loading areas identified within the Galway Lake watershed.

Lavic Lake Watershed	
Analysis	**Findings/Results**
MC Loading Areas (% area in the drainage area)	**Gays Pass I (**2%**), Gays Pass II** (99%), **Lavic Lake** (87%), **Maumee Mine** (3%), **Rainbow Canyon** (24%), **Sunshine Peak** (27%)
Identified Receptors	• Surface Water / Sediment: Ecological (special status species include Agassiz's desert tortoise and MFTL) • Groundwater: Human (future drinking water production wells)
Surface water screening-level modeling	• TNT and perchlorate concentrations in surface water at Lavic Lake were predicted to be above detectable concentrations, but the predicted concentrations are more than two orders (for TNT) and more than four orders (for perchlorate) of magnitude lower than their respective DoD freshwater screening values. • No additional surface water assessment is recommended at this time.
Sediment screening-level modeling	• TNT and perchlorate concentrations in sediment potentially accumulating in Lavic Lake playa as a result of water evaporating from the playa were predicted to be above detectable concentrations. • HMX concentration in sediment potentially accumulating in Lavic Lake playa was predicted to be below detectable concentration (i.e., below the median MDL for HMX), but the concentration was above the lower bound DoD sediment screening value for HMX. • The predicted TNT concentration in sediment potentially accumulating in Lavic Lake playa was also above the lower bound DoD sediment screening value for TNT. • Sediment sampling was recommended.
Groundwater screening-level modeling	• Perchlorate at Gays Pass I and Gays Pass II MC loading areas was predicted to reach the groundwater at detectable concentration, but the minimum travel time predicted for perchlorate to reach the groundwater at detectable concentration at these MC loading areas was in excess of 100 years (approximately 100 years where there is preferential recharge and over 2,000 years where there is direct recharge). • Additional groundwater assessment in not recommended at this time.
Lead deposition	• Total lead deposition associated with the MC loading areas in this watershed is low (approximately 4,240 lb/yr). No additional assessment is recommended at this time.
SARs	None.
Sampling	In order to simplify the sampling efforts, sampling was not conducted at Lavic Lake playa. Instead, sediment sampling results from Deadman and Quackenbush Lake playas were used as representatives of MC potentially present in the sediment of Lavic Lake playa. Based on the sampling results, concentrations of explosives and perchlorate in the sediments of Deadman and Quackenbush Lake playas were below detectable levels.
Conclusion	The screening-level and qualitative assessment results do not indicate a current release of HE, perchlorate, or lead to surface water and groundwater at levels of concern for the environment, but do indicate a current release of HMX and TNT to sediment in Lavic Lake playa at levels that could be a potential concern for the environment from the MC loading areas identified within the Lavic Lake watershed. However, sediment sampling results from Deadman and Quackenbush Lake playas show that HE (including HMX and TNT) and perchlorate concentrations in the sediment of these playas are below laboratory detectable levels. Given that the predicted sediment concentrations of TNT and HMX concentrations in Lavic Lake playa are lower than the concentrations predicted in Quackenbush Lake playa, the actual concentrations are expected to be at least similar to the sample results from Quackenbush Lake playa, which are below detectable levels.

Mesquite Lake Watershed	
Analysis	**Findings/Results**
MC Loading Areas (% area in the drainage area)	**East** (8%; MC loading area not modeled)**, West** (13%; MC loading area not modeled)
Identified Receptors	• Surface Water / Sediment:Ecological (special status species include Agassiz's desert tortoise and MFTL) • Groundwater: None
Surface water screening-level modeling	• Surface water screening assessment was not conducted because the MC loading areas within the watershed were estimated to have low MC loading and are expected to contribute very little MC in surface water to Mesquite Lake playa.
Sediment screening-level modeling	• Sediment screening assessment was not conducted because the MC loading areas within the watershed were estimated to have low MC loading and are expected to contribute very little MC in sediment to Mesquite Lake playa.
Groundwater screening-level modeling	• Groundwater screening assessment was not conducted because the MC loading areas were estimated to have low MC loading and are located outside a drinking water source groundwater sub-basin where they have limited potential impact to groundwater resources.
Lead deposition	• Total lead deposition was not estimated because the MC loading areas were estimated to have low deposition.
SARs	**Range 1, Range 1A, Range 2, Range 2A, Range 3, Range 3A, MCCS Skeet Range**
Qualitative evaluation	Range 1, Range 1A, and Range 3A Surface Water/sediment ranking = MODERATE Groundwater ranking = MODERATE Range 2 Surface Water/sediment ranking = MINIMAL Groundwater ranking = MODERATE Range 2A and Range 3 Surface Water/sediment ranking = MINIMAL Groundwater ranking = MINIMAL Skeet Range Surface Water/sediment ranking = MODERATE Groundwater ranking = MINIMAL
Sampling	**Reference sediment sample at one location in Mesquite Lake playa** (MQ-SEDREF)
Sample results	REVA MC explosives – non-detect Perchlorate – 4.0 µg/kg Lead – not analyzed
Conclusion	The qualitative assessment results do not indicate a current release of HE, perchlorate, or lead to surface water or groundwater at detectable concentrations from the MC loading areas or SARs identified within the Mesquite Lake watershed.

Quackenbush Lake Watershed	
Analysis	**Findings/Results**
MC Loading Areas (% area in the drainage area)	**Emerson Lake (**<1%**), Gays Pass I** (94%), **Maumee Mine** (<1%), **Quackenbush** (4%)
Identified Receptors	• Surface Water / Sediment: Ecological (special status species include Agassiz's desert tortoise) • Groundwater: Human (future drinking water production wells)
Surface water screening-level modeling	• HMX, RDX, and TNT concentrations in surface water at Quackenbush Lake were predicted to be above detectable concentrations, but the predicted concentrations are more than two orders (for HMX), more than three orders (for RDX), and more than one order (for TNT) of magnitude lower than their respective DoD freshwater screening values. • No additional surface water assessment is recommended at this time.
Sediment screening-level modeling	• TNT and perchlorate concentrations in sediment potentially accumulating in Quackenbush Lake playa as a result of water evaporating from the playa were predicted to be above detectable concentrations. • HMX and RDX concentrations in sediment potentially accumulating in the playa were predicted to be below detectable concentrations, but the concentrations were above their respective lower bound DoD sediment screening values. • The predicted TNT concentration in sediment potentially accumulating in Quackenbush Lake playa was also above the lower bound DoD sediment screening value for TNT. • Sediment sampling was conducted.
Groundwater screening-level modeling	• Perchlorate at Emerson Lake, Gays Pass I, and Quackenbush MC loading areas was predicted to reach the groundwater at detectable concentration, but the minimum travel time predicted for perchlorate to reach the groundwater at detectable concentration at these MC loading areas was in excess of 50 years (approximately 50 years where there is preferential recharge and approximately 900 years where there is direct recharge). • Additional groundwater assessment in not recommended at this time.
Lead deposition	• Total lead deposition associated with the MC loading areas in this watershed is low (approximately 524 lb/yr). No additional assessment is recommended at this time.
SARs	None.
Sampling	**Sediment samples at two locations in Quackenbush Lake playa** (QK-SED03 and QK-SED04)
Sample results	REVA MC explosives – non-detect Perchlorate – non-detect Lead – not analyzed
Conclusion	The screening-level and qualitative assessment results do not indicate a current release of HE, perchlorate, or lead to surface water and groundwater at levels of concern for the environment, but do indicate a current release of HMX, RDX, and TNT to sediment in Quackenbush Lake playa at levels that could be a potential concern for the environment from the MC loading areas identified within the Quackenbush Lake watershed. However, sediment sampling results from Quackenbush Lake playa show that HE (including HMX RDX and TNT) and perchlorate concentrations in the sediment of the playa are below laboratory detectable levels.

Upper Emerson Lake Watershed	
Analysis	**Findings/Results**
MC Loading Areas (% area in the drainage area)	**Emerson Lake** (25%), **Gays Pass I** (4%), **Maumee Mine** (32%)
Identified Receptors	• Surface Water / Sediment: Ecological (special status species include Agassiz's desert tortoise) • Groundwater: Human (existing and future drinking water production wells)
Surface water screening-level modeling	• HMX, TNT, and perchlorate concentrations in surface water at Upper Emerson Lake were predicted to be above detectable concentrations, but the predicted concentrations are three orders (for HMX), more than one order (for TNT), and more than four orders (for perchlorate) of magnitude lower than their respective DoD freshwater screening values. • No additional surface water assessment is recommended at this time.
Sediment screening-level modeling	• Perchlorate concentration in sediment potentially accumulating in Upper Emerson Lake playa as a result of water evaporating from the playa was predicted to be above detectable concentration. There is no established DoD sediment screening benchmark for perchlorate to compare with the predicted concentration. • Additional sediment assessment is not recommended at this time.
Groundwater screening-level modeling	• Perchlorate at Emerson Lake and Gays Pass I MC loading areas was predicted to reach the groundwater at detectable concentration, but the minimum travel time predicted for perchlorate to reach the groundwater at detectable concentration at these MC loading areas was in excess of 50 years (approximately 50 years where there is preferential recharge and over 1,000 years where there is direct recharge). • Additional groundwater assessment in not recommended at this time.
Lead deposition	• Total lead deposition associated with the MC loading areas in this watershed is low (approximately 383 lb/yr). No additional assessment is recommended at this time.
SARs	None.
Sampling	Sediment sampling results from Deadman and Quackenbush Lake playas, which show perchlorate concentrations are below detectable levels, are considered representatives of the perchlorate concentrations in the sediment of Upper Emerson Lake playa.
Conclusion	The screening-level and qualitative assessment results do not indicate a current release of HE, perchlorate, or lead to surface water, sediment, or groundwater at levels of concern for the environment from the MC loading areas identified within the Upper Emerson Lake watershed.

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Appendix A

Operational Range Summary

Table A-1: Summary of Operational Range Training Areas and Ranges at MCAGCC Twentynine Palms

Range Training Area	Fixed Range	Small Arms Range	MOUT	Size (acres)	Description/Notes
Acorn	--			**17,369**	**Non-live-fire RTA**
America Mine	--			**20,809**	**Live-fire RTA**
Black Top	--			**44,014**	**Live-fire RTA**
Bullion	--			**35,659**	**Live-fire RTA**
	Range 210		X	143	Live-fire MOUT facility
Cleghorn Pass	--			**36,359**	**Live-fire RTA**
	Range 400			801	Company fire and maneuver range
	Range 410			229	Platoon fire and maneuver range
	Range 410A			366	Platoon hasty attack and maneuver range
	Range 500			4,880	Multi-purpose range complex
Delta	--			**29,791**	**Live-fire RTA**
	Range 112 (portion in Range)			2,777	EOD training range. Identified in 2005 as an NREA range residue processing area; training capabilities were added to this range since the REVA five-year review.
	Range 205 (portion in Prospect)		X	84	Live-fire urban clearing facility. Range 205A was combined with Range 205 as of 2013.
	Range 230		X	45	Live-fire MOUT facility. Range Safety is establishing range regulations for R-230; it has never been used.
	Range 401			219	Company fire and maneuver range
East	--			**6,502**	**Non-live-fire RTA**
	Range 100 (portion in Mainside)			1,187	Squad maneuver range (non-live fire), land navigation
	Range 200		X	48	Non-live-fire MOUT
	Range 215		X	143	Non-live-fire MOUT
	Range 215A			1	Tactical site exploitation facility
Emerson Lake	--			**32,287**	**Live-fire RTA**
Gays Pass	--			**18,320**	**Live-fire RTA**
Gypsum Ridge	--			**18,265**	**Non-live-fire RTA**
Lava	--			**22,925**	**Live-fire RTA**
Lavic Lake	--			**56,983**	**Live-fire RTA**
Lead Mountain	--			**45,792**	**Live-fire RTA**
Mainside	--			**5,263**	**Non-live-fire RTA / cantonment area**
	Range 100 (portion in East)			1,187	Squad maneuver range (non-live-fire), land navigation
	Range 700			10	Training facilities, including rappelling tower, obstacle course, outdoor classroom, pneumatic mortar range
	Range 705 (portion in West)			193	CVOT course. Portion of range is located in Camp Wilson.
	Range 705A (portion in West)			1,193	CVOT course (intermediate/advanced)
	MCCS Skeet Range	X		--	Skeet-shooting range
Maumee Mine	--			**16,141**	**Live-fire RTA**

Range Training Area	Fixed Range	Small Arms Range	MOUT	Size (acres)	Description/Notes
Morgan's Well	--			**23,361**	**Live-fire RTA. Previously part of Blacktop, Noble Pass, and Rainbow Canyon. Designated as an RTA in 2013.**
	Range 601			246	Sensitive fuse munitions range
Noble Pass	--			**16,834**	**Live-fire RTA**
Prospect	--			**13,189**	**Live-fire RTA**
	Range 205 (portion in Delta)		X	84	Live-fire urban clearing facility. Range 205A was combined with Range 205 as of 2013.
Quackenbush	--			**41,814**	**Live-fire RTA**
	Range 220		X	892	Non-live-fire MOUT
	Range 620			248	Urban array (collateral damage only)
	Range 630			990	Live-fire urban developed aviation facility
Rainbow Canyon	--			**16,569**	**Live-fire RTA**
Range	--			**20,158**	**Live-fire RTA**
	Range 051			37	EOD training range. HESCO barriers were placed around the perimeter of the demolition pit for further fragmentation containment since the REVA five-year review.
	Range 101	X		7	Small arms BZO
	Range 103	X		44	Squad defensive fire range (automated)
	Range 104			26	Anti-mechanized/grenade range
	Range 105			4	Gas chamber
	Range 105A			6	Small arms BZO
	Range 106			939	Mortar/marksmanship assessment range
	Range 106A	X		5	Machine gun certification range, as of approximately 2012. Formerly listed as a grenade range during the REVA five-year review.
	Range 107			265	Infantry squad assault range
	Range 108			213	Infantry squad battle course
	Range 109			987	Anti-armor live-fire tracking range
	Range 110			224	Machine gun range unknown distance
	Range 110A			19	M203 grenade range
	Range 111		X	69	MAC made up of various lanes with a variety of conex and SACON structures. A sniper tower has been constructed since the REVA five-year review.
	Range 112 (portion in Delta)			2,777	EOD training range. Identified in 2005 as an NREA range residue processing area; training capabilities were added to this range since the REVA five-year review.
	Range 113			209	Machine gun range. Sniper tower was constructed in 2013.
	Range 113A	X		1	Machine gun BZO/EMP range
	Range 114			95	Combat engineer demolition range
	Range 1	X		47	Known distance rifle range
	Range 1A	X		23	Unknown distance rifle range
	Range 2	X		3	Known distance multipurpose range. Bullet trap was removed from this range in 2013.

Range Training Area	Fixed Range	Small Arms Range	MOUT	Size (acres)	Description/Notes
	Range 2A	X		1	Combat pistol range
	Range 3	X		1	Multipurpose rifle/pistol range. Formerly listed as a rifle field expedient BZO/grouping range during REVA five-year review. Bullet trap was removed from this range in 2013.
	Range 3A	X		3	Rifle field expedient BZO/grouping range. Formerly listed as a multipurpose rifle/pistol range during the REVA five-year review.
Sand Hill East	--			**9,326**	**Non-live-fire RTA. Sand Hill RTA split up into east and west portions due to expansion of restricted area.**
Sand Hill West	--			**2,578**	**Non-live-fire RTA. Sand Hill RTA split up into east and west portions due to expansion of restricted area.**
Sunshine Peak	--			**22,859**	**Live-fire RTA**
West	--			**9,966**	**Non-live-fire RTA.**
	Range 102			733	Squad maneuver range (land navigation)
	Range 225		X	46	Non-live-fire MOUT
	Range 705 (portion in Mainside)			193	CVOT course. Portion of range is located in Camp Wilson.
	Range 705A (portion in Mainside)			1,193	CVOT course (intermediate/advanced).
	Range 800			508	IED range. Size is based on length of course with an assumed width of 50 feet. After-action review camera system was installed since the REVA five-year review.

General Notes:

1. New range since the REVA five-year review
2. Fixed range and RTA acreages based on geographic information system (GIS) data provided by MCAGCC Twentynine Palms Range Control.
3. There are six terrain following routes, six drop zones, 70 landing zones present at MCAGCC Twentynine Palms. These areas are not included in this table since they do not directly support live-fire operations.
4. MCAGCC Twentynine Palms has recently reached an agreement to expand training activities to areas primarily associated with Johnson Valley; however, no training has taken place to date in these areas. Therefore, they are not assessed as part of this REVA periodic review.
5. Restricted areas are not included in this table. These include approximately 12,544 acres that may not be fired into and through which movement is prohibited due to the proximity of production wells.
6. Camp Wilson is not included in this table since it is not considered an operational RTA.

Acronyms and Abbreviations:

BZO = battle sight zero
CVOT = combat vehicle operator training
EMP = enhanced marksmanship program
EOD = explosive ordnance disposal
HESCO = Company which manufactures soil-filled barriers
IED = improvised explosive device
MAC = military operations in urban terrain assault course
MCCS = Marine Corps Community Service
MOUT = military operations in urban terrain
NREA = Natural Resources Environmental Affairs
SACON = shock absorbing concrete

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Appendix B
Screening-Level
Analysis Parameters
and Methodology

Technical Memorandum

Surface Water Screening-Level Assessment

Technical Memorandum

Date: 26 January 2014

To: Jennifer Wilber, Marine Corps Installations Command

Copy: Chris Elliot, Andy Chatlin (Marine Corps Air Ground Combat Center [MCAGCC] Twentynine Palms)
Michael Asakawa, Susan Herbert, Julie Dobschuetz, Ben Latham (ARCADIS)

From: Edidia Nefso (ARCADIS)

Re: Assessment of Munitions Constituent (MC) Concentrations in Surface Water and Sediment from MC Loading Areas at MCAGCC Twentynine Palms.

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 Air Ground Combat Center (MCAGCC) Twentynine Palms. The Range Environmental Vulnerability Assessment (REVA) screening-level assessment evaluated the potential for MC to migrate from operational range areas via surface water and sediment to potential off-range human and ecological receptor locations. Recommendations are presented for identified off-range 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 assessment based on range use and presence of surface drainage to potential receptor locations. A separate technical memorandum has been prepared to address MC transport in groundwater from the MC loading areas (ARCADIS, 2015).

Twenty-four MC loading areas were assessed (**Figure 1**):

- America Mine
- Black Top I/Morgan's Well I
- Black Top II
- Bullion
- Cleghorn Pass I
- Cleghorn Pass II
- Delta
- Emerson Lake
- Lead Mountain
- Maumee Mine
- Morgan's Well II
- Noble Pass
- Prospect
- Quackenbush
- Rainbow Canyon
- Range 051

- § Gays Pass I
- § Gays Pass II
- § Lava
- § Lavic Lake
- § Range I
- § Range III
- § Range IV
- § Sunshine Peak

METHODS

Screening-level assessments 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 then were grouped by drainage areas of identified downstream receptor locations, and the percentage of each MC loading area draining to the given downstream receptor location was approximated. These estimates were used to provide an area-weighted sum of the MC concentrations from the individual MC loading areas draining to the downstream off-range receptor location.

The off-range receptor locations of interest include nine playas and streams that drain off the installation boundary (**Figure 2**). Eight playas of interest (Lavic Lake, Galway Lake, Quackenbush Lake, Upper Emerson Lake, Emerson Lake, Ames Dry Lake, Deadman Lake, and Dry Lake) are located within the installation boundary. One playa of interest (Bristol Lake) is located just outside the installation boundary. The streams draining off the installation boundary include streams draining within the Cleghorn Pass watershed in the southern part of the installation and streams draining within the East and West Sunshine watershed in the northwestern part of the installation.

The primary receptors identified for surface water and sediment at MCAGCC Twentynine Palms are ecological receptors. These may include the federally threatened Agassiz's desert tortoise and the Mojave fringe-toed lizard, a California Species of Special Concern. Although there are no known human uses of surface water at MCAGCC Twentynine Palms, surface water is considered a potential receptor location for humans through incidental contact.

There is no permanent presence of surface water at MCAGCC Twentynine Palms. Streams are ephemeral and only contain water following rain storms; water accumulated in playas is temporary and only present for up to 2 months per year. Installation personnel are restricted from accessing playas located within the installation boundary, and there is no identified extensive recreational use of the playas anticipated outside of the installation. There are salt mining operations in Bristol Lake Playa, which is located just outside the eastern installation boundary. Salt at the existing operations in Bristol Lake Playa is extracted from briny groundwater; consequently, oncoming drainage is anticipated to have negligible impact to the produced salt. However, there is a possibility of a potential human exposure to MC in surface water and sediment via incidental contact by salt mine workers.

The off-range receptor locations, associated MC loading areas, and approximate percent of MC loading areas draining to the off-range receptor location are presented in **Table 1**, and drainage areas, off-range receptor locations, and MC loading areas are shown in **Figure 2**.

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

Off-Range Receptor Location (corresponding number in Figure 2)	MC Loading Area Draining to Off-Range Receptor Location	Approximate Percent of MC Loading Area Draining to the Off-Range Receptor Location
Ames Lake (1)	Emerson Lake	43[a]
Bristol Lake (drainages entering from installation) (2)	America Mine	100
	Bullion	100
	Delta	99
	Lava	91
	Lead Mountain	5
	Noble Pass	17
	Prospect	4
Deadman Lake (3)	Emerson Lake	2
	Noble Pass	39
	Quackenbush	96
	Range I	100
	Range III	100
	Range IV	100
Dry Lake (4)	Black Top I/Morgan's Well I	100
	Black Top II	100
	Lava	9
	Lavic Lake	7
	Lead Mountain	95
	Morgan's Well II	100
	Noble Pass	44
	Rainbow Canyon	76
Emerson Lake (5)	Emerson Lake	73
	Maumee Mine	<1
Galway Lake (6)	Gays Pass II	1
	Lavic Lake	<1
	Maumee Mine	65
	Sunshine Peak	15
Installation boundary within Cleghorn Pass Watershed 1 (7)[b]	Prospect	24
Installation boundary within Cleghorn Pass Watershed 2 (8)[b]	Delta	1
	Prospect	72
Installation boundary within Cleghorn Pass Watershed 3 (9)[b]	Cleghorn Pass I	32
Installation boundary within Cleghorn Pass Watershed 4 (10)[b]	Cleghorn Pass I	25
Installation boundary within Cleghorn Pass	Cleghorn Pass I	33

Off-Range Receptor Location (corresponding number in Figure 2)	MC Loading Area Draining to Off-Range Receptor Location	Approximate Percent of MC Loading Area Draining to the Off-Range Receptor Location
Watershed 5 (11)[b]		
Installation boundary within Cleghorn Pass Watershed 6 (12)[b]	Cleghorn Pass I	10
Installation boundary within Cleghorn Pass Watershed 7 (13)[b]	Cleghorn Pass II	100
Installation boundary within Cleghorn Pass Watershed 8 (14)[b]	Range 051	100
Installation boundary within East and West Sunshine Watershed (15)[b]	Lavic Lake	6
	Sunshine Peak	58
Lavic Lake (16)	Gays Pass I	2
	Gays Pass II	99
	Lavic Lake	87
	Maumee Mine	3
	Rainbow Canyon	24
	Sunshine Peak	27
Quackenbush Lake (17)	Emerson Lake	<1
	Gays Pass I	94
	Maumee Mine	<1
	Quackenbush	4
Upper Emerson Lake (18)	Emerson Lake	25
	Gays Pass I	4
	Maumee Mine	32

Note:
[a] Proportion further drains to Emerson Lake (it is part of the 73% total of the loading area draining to Emerson Lake) – drainage of Ames Dry Lake is part of the Emerson Lake drainage
[b] Stream location

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 MCAGCC Twentynine Palms. The screening-level surface water and sediment assessment was conducted for the period 2011–2014.

Surface Water Screening-Level Approach

The CalTOX partitioning model was used to estimate the total MC mass partitioned from surface soil deposition to surface water runoff leaving each MC loading area. 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). The estimates of edge-of-loading-area MC concentrations in surface water runoff were compared to median method detection limits

(MDLs) for each MC. Median MDLs are an established set of values for cyclotetramethylene tetranitramine (HMX), cyclomethylene trinitramine (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.

If an MC concentration in surface water runoff at the edge of the MC loading area was predicted to exceed its median MDL, additional screening-level assessment was conducted to estimate MC concentration in surface water at the downstream off-range receptor location. In this case, MC concentrations in surface water in or entering the downstream off-range 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.

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, an additional screening-level assessment was conducted to estimate MC concentration in sediment at the downstream off-range receptor location. This involved estimating the total MC mass transported in sediment to the off-range receptor location and the mass of sediment transported to the downstream off-range 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.

Additional calculations were performed to account for MC accumulated in the sediment of playas as a result of water evaporating from the playas and MC deposition to the lake bed. To estimate the MC mass that may accumulate in the sediment of a playa, it was conservatively assumed that the total annual average MC mass transported to a playa with surface water runoff (both dissolved and associated with sediment) would remain in the sediment of the playa without accounting for loss terms, including decay and volatilization. This mass was divided by the total estimated sediment mass in the playa environment resulting from surface erosion to estimate the accumulated sediment concentration in the playa. These calculations were done for the playas located within the installation boundary (Ames Dry Lake, Deadman Lake, Dry Lake, Emerson Lake, Galway Lake, Lavic Lake, Quackenbush Lake, and Upper Emerson Lake).

RESULTS

Surface Water

Table 2 presents the estimated annual average edge-of-loading-area concentrations in surface water runoff from individual MC loading areas. Values shown in bold exceed the median MDL, and the MC loading areas shown in bold have at least one MC that is predicted to have a concentration exceeding the median MDL value. All MC loading areas assessed have at least one MC that is predicted to have a concentration above the median MDL value, with the exception of Sunshine Peak MC loading area, which is predicted to have annual average edge-of-loading-area MC concentrations below median MDLs (**Table 2**).

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)**			
America Mine	**0.206**	0.0802	**4.10**	0.0403
Black Top I/Morgan's Well I	**0.629**	**0.949**	**18.2**	**1.27**
Black Top II	**0.626**	**0.581**	**21.2**	**1.07**
Bullion	**0.199**	**0.587**	**16.1**	**1.67**
Cleghorn Pass I	**0.123**	**2.54**	**4.83**	**0.253**
Cleghorn Pass II	0.0717	**0.105**	**2.64**	9.27E-03
Delta	**0.130**	**1.26**	**4.12**	**0.0842**
Emerson Lake	**1.11**	**0.574**	**9.14**	**1.14**
Gays Pass I	0.959	**0.422**	**5.46**	**0.223**
Gays Pass II	**0.810**	**0.422**	**4.43**	**0.192**
Lava	**2.02**	**1.78**	**86.4**	**1.57**
Lavic Lake	**0.318**	**0.285**	**12.6**	**2.93**
Lead Mountain	**1.73**	**1.72**	**44.4**	**2.13**
Maumee Mine	**1.69**	**0.637**	**20.9**	**1.39**
Morgan's Well II	**0.920**	**0.805**	**5.37**	**0.549**
Noble Pass	0.0691	**0.215**	**7.55**	**0.469**
Prospect	0.0343	**0.139**	1.26	**0.120**
Quackenbush	**0.694**	**1.49**	**34.0**	**0.366**
Rainbow Canyon	**2.69**	**1.70**	**9.35**	**1.14**
Range 051	**1.11**	**4.26**	**0.338**	**0.0729**
Range I	0.0604	**1.21**	**1.00**	0.0295

	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)**			
Range III	**0.126**	**4.47**	0.0917	**0.118**
Range IV	3.23E-04	**0.418**	**0.495**	**0.471**
Sunshine Peak	3.28E-06	0.0432	0.0655	1.522E-05

Note:
µg/L = micrograms per liter
Bolded value indicates predicted concentration exceeds the median MDL value.

Table 3 presents the annual average MC concentrations estimated in surface water at the identified off-range receptor locations. The off-range surface water receptor locations with a predicted detectable concentration are bolded in **Table 3** and identified with orange symbol in **Figure 3**. Results are summarized as follows:

- All MC concentrations were predicted to be below their respective median MDLs in Ames Lake (location number 1) at the installation boundary within Cleghorn Pass watershed 8 (location number 14).
- At least one MC was predicted to have a concentration above the median MDL at the other 15 downstream off-range receptor locations assessed**.**
- All MC concentrations were predicted to be significantly lower than the Department of Defense (DoD) freshwater screening values: HMX and RDX concentrations are at least two orders of magnitude lower than their respective DoD screening values; TNT concentrations are at least one order of magnitude lower than its DoD screening value; and perchlorate concentrations are at least four orders of magnitude lower than its DoD screening value.

Table 3: Screening-Level Estimates of Annual Average MC Concentrations in Surface Water at Downstream Off-Range Receptor Locations

	HMX	RDX	TNT	Perchlorate
Median MDL (µg/L)	*0.077*	*0.097*	*0.108*	*0.06*
DoD Freshwater value (µg/L)	*150*	*360*	*100*	*9300*
Off-Range Surface Water Receptor Location (corresponding number on Figure 3)	**Predicted Surface Water Concentration at Surface Water Receptor Location (µg/L)**			
Ames Lake (1)	0.0128	6.62E-03	0.105	0.0131
Bristol Lake (entering from installation) (2)	0.0242	0.0741	**1.01**	0.0433
Deadman Lake (3)	0.0450	**0.143**	**1.93**	0.0403
Dry Lake (4)	0.0575	0.0576	**1.29**	**0.0741**
Emerson Lake (5)	0.0170	8.75E-03	**0.139**	0.0174
Galway Lake (6)	0.0229	8.85E-03	**0.282**	0.0188
Installation boundary within Cleghorn Pass WS 1 (7)[a]	8.30E-03	0.0338	**0.306**	0.0293

	HMX	RDX	TNT	Perchlorate
Median MDL (µg/L)	*0.077*	*0.097*	*0.108*	*0.06*
DoD Freshwater value (µg/L)	*150*	*360*	*100*	*9300*
Off-Range Surface Water Receptor Location (corresponding number on Figure 3)	**Predicted Surface Water Concentration at Surface Water Receptor Location (µg/L)**			
Installation boundary within Cleghorn Pass WS 2 (8) [a]	0.0171	0.0765	**0.623**	0.0566
Installation boundary within Cleghorn Pass WS 3 (9) [a]	**0.0780**	**1.61**	**3.07**	**0.161**
Installation boundary within Cleghorn Pass WS 4 (10) [a]	**0.103**	**2.12**	**4.04**	**0.212**
Installation boundary within Cleghorn Pass WS 5 (11) [a]	0.0757	**1.56**	**2.97**	**0.156**
Installation boundary within Cleghorn Pass WS 6 (12) [a]	0.0671	**1.39**	**2.64**	**0.138**
Installation boundary within Cleghorn Pass WS 7 (13) [a]	0.0274	0.0401	**1.01**	3.53E-03
Installation boundary within Cleghorn Pass WS 8 (14)	0.0125	0.0481	3.82E-03	8.22E-04
Installation boundary within East and West Sunshine WS (15) [a]	6.92E-03	9.86E-03	**0.281**	**0.0636**
Lavic Lake (16)	0.0439	0.0302	**0.843**	**0.170**
Quackenbush Lake (17)	**0.185**	**0.111**	**1.80**	0.0496
Upper Emerson Lake (18)	**0.121**	0.0538	**1.21**	**0.107**

Note:
WS = watershed
Bold indicates the predicted concentration is above the median MDL.
[a] Stream location

Sediment

The estimated annual average edge-of-loading-area concentrations in sediment from individual MC loading areas are presented in **Table 4**. The average annual MC concentrations in sediment at the edge of all MC loading areas were predicted to be below median MDLs.

Table 4: 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 Concentration at Edge of Loading Area (µg/kg)**			
America Mine	1.16E-04	1.01E-04	0.348	4.51E-12
Black Top I/Morgan's Well I	4.62E-04	1.56E-03	2.01	1.86E-10
Black Top II	2.46E-04	5.11E-04	1.26	8.40E-11
Bullion	5.71E-05	3.76E-04	0.699	9.52E-11
Cleghorn Pass I	7.64E-05	3.52E-03	0.453	3.13E-11
Cleghorn Pass II	3.08E-05	1.01E-04	0.171	7.93E-13
Delta	6.01E-05	1.31E-03	0.289	7.78E-12

	HMX	RDX	TNT	Perchlorate
Median MDL (µg/kg)	*77.9*	*78*	*63.1*	*0.213*
MC Loading Area	**Predicted Sediment Concentration at Edge of Loading Area (µg/kg)**			
Emerson Lake	6.18E-04	7.12E-04	0.764	1.26E-10
Gays Pass I	3.43E-04	3.38E-04	0.296	1.59E-11
Gays Pass II	4.03E-04	4.70E-04	0.334	1.91E-11
Lava	1.05E-03	2.08E-03	6.80	1.63E-10
Lavic Lake	1.90E-04	3.80E-04	7.98	3.47E-10
Lead Mountain	9.59E-04	2.13E-03	3.71	2.35E-10
Maumee Mine	7.4E-04	6.24E-04	1.39	1.22E-10
Morgan's Well II	7.13E-04	1.40E-03	0.629	8.47E-11
Noble Pass	5.93E-05	4.13E-04	0.980	8.02E-11
Prospect	1.72E-05	1.55E-04	9.52E-02	1.20E-11
Quackenbush	4.97E-04	2.38E-03	3.68	5.21E-11
Rainbow Canyon	2.16E-03	3.05E-03	1.13	1.82E-10
Range 051	4.77E-04	4.09E-03	2.19E-02	6.23E-12
Range I	3.02E-05	1.36E-03	7.58E-02	2.94E-12
Range III	7.22E-05	5.73E-03	7.94E-03	1.35E-11
Range IV	1.85E-07	5.35E-04	4.28E-02	5.37E-11
Sunshine Peak	2.37E-09	6.99E-05	7.17E-03	2.20E-15

Note:
µg/kg = micrograms per kilogram

MC concentrations that would result from potential MC accumulation in the playas as a result of water evaporating from the playas were estimated for the eight playas located within the installation boundary. The results are presented in **Table 5**.

Table 5: Screening-Level Estimates of Cumulative MC Concentrations in Sediment of Playas

	HMX	RDX	TNT	Perchlorate
Median MDL (µg/kg)	*77.9*	*78*	*63.1*	*0.213*
DoD Freshwater screening value (µg/kg)	*4.7–470*	*13–1,300*	*92–9,200*	*NA*
Off-Range Surface Water Receptor Location (corresponding numbers on Figure 4)	**Cumulative Sediment Concentration (µg/kg)**			
Ames Lake (1)	0.79	0.40	6.5	**0.80**
Deadman Lake (3)	2.0	7.4	**95**	**2.1**
Dry Lake (4)	2.8	2.8	60	**3.6**

	HMX	RDX	TNT	Perchlorate
Median MDL (µg/kg)	*77.9*	*78*	*63.1*	*0.213*
DoD Freshwater screening value (µg/kg)	*4.7–470*	*13–1,300*	*92–9,200*	*NA*
Off-Range Surface Water Receptor Location (corresponding numbers on Figure 4)	**Cumulative Sediment Concentration (µg/kg)**			
Emerson Lake (5)	0.36	0.18	2.9	**0.36**
Galway Lake (6)	1.7	0.66	21	**1.39**
Lavic Lake (16)	7.7	5.3	**142**	**28**
Quackenbush Lake (17)	24	14.1	**227**	**6.4**
Upper Emerson Lake (18)	3.9	1.7	39	**3.5**

Note:
NA = not available (screening level was not developed due to the lack of scientific data on the constituent)
Bold indicates predicted concentration is above the median MDL.
Highlight indicates predicted concentration is above the lower bound DoD screening level.

The range of DoD freshwater sediment screening values is dependent on the sediment percent total organic carbon (TOC). The lower bound is for a % TOC of 1 and the upper bound is for a % TOC of 100.

Results of the predicted cumulative MC concentrations in the playas are summarized as follows (**Table 5**):

- Perchlorate concentrations in sediment potentially accumulating in all eight playas assessed were predicted to be above its median MDL.
- TNT concentrations in sediment potentially accumulating in Deadman, Lavic and Quackenbush playas were predicted to be above the median MDL.
- HMX and RDX concentrations in sediment potentially accumulating in all playas were predicted to be below median MDLs.
- The predicted TNT concentrations in sediment potentially accumulating in Deadman, Lavic, and Quackenbush playas were above the lower bound DoD sediment screening value for TNT.
- The predicted HMX concentration in sediment potentially accumulating in Lavic and Quackenbush playas and RDX concentration in sediment potentially accumulating in Quackenbush playa were above their respective lower bound DoD sediment screening values. It is important to note that the lower bound DoD sediment screening values for HMX and RDX are lower than their respective median MDL values. Thus, the predicted HMX and RDX concentrations potentially accumulating in sediment of Lavic and Quackenbush playas exceed the lower bound DoD sediment screening values but are below the median MDLs.

The off-range receptor locations with a predicted concentration exceeding the lower bound DoD sediment screening value are highlighted in **Table 5** and identified with orange symbol in **Figure 4.**

The actual MC concentrations in sediment are expected to be lower than the concentrations predicted from the screening assessment discussed above. This is because of the conservative approach used in the screening-level assessment, where loss terms such as degradation and volatilization which most likely occur were not incorporated into the calculations.

CONCLUSIONS

Based on the surface water and sediment screening assessment results, MC concentrations in surface water at 16 downstream off-range receptor locations (in eight playas and eight streams at the installation boundary) were predicted to be above median MDL values. However, because the predicted MC concentrations are significantly lower than the DoD freshwater screening values (two orders of magnitude lower for HMX and RDX, one order of magnitude lower for TNT, and four orders of magnitude lower for perchlorate), potential ecological receptors are unlikely to be adversely impacted by MC release to the waters. Therefore, the MC loading areas are not considered areas of concern for surface water transport at this time, and further surface water assessment is not recommended. However, it is recommended to continue monitoring expenditure data at MCAGCC Twentynine Palms in order to evaluate changes in continued MC loading through time. If the expenditure data indicate significant increase in MC loading before the next periodic review assessment, additional surface water screening assessment at the increased loading site and/or sampling will be conducted. Otherwise, the MC loading areas will be evaluated in the next periodic review.

MC concentrations (primarily perchlorate) in sediment potentially accumulating in playas as a result of water evaporating from the playas were predicted to be above median MDL values in all eight playas located within the installation boundary. The predicted HMX and TNT concentrations in sediment potentially accumulating in Lavic and Quackenbush playas, the predicted RDX concentration in sediment potentially accumulating in Quackenbush playa, and the predicted TNT concentration in sediment potentially accumulating in Deadman playa exceed the lower bound of respective DoD sediment screening values for HMX, RDX and TNT. Sediment sampling is recommended in Deadman and Quackenbush playas for explosives and perchlorate based on the results of the sediment screening-level assessment modeling. Sampling in these playas is recommended provided there are no unexploded ordnance (UXO) concerns or there will be no interference with training when accessing the recommended sampling locations. Sediment sampling in Lavic Playa is not recommended at this time because access to the playa is anticipated to be difficult due to UXO concerns in the area. For now, sampling results from the Deadman and Quackenbush Lake playas will be used as representative of MC potentially present in Lavic Playa. Based on sampling results and field conditions, additional sampling may be considered.

For the sediment samples to be collected from Deadman Playa, it is recommended to add lead to the sample analyses because expenditure data within the Deadman Lake drainage area show high lead deposition potentially occurring at Deadman Playa (approximately 61,400 pounds per year). Lead deposition in other drainage areas was estimated to be significantly lower than the lead deposition estimated for Deadman Playa. Also, qualitative evaluations of small arms ranges do

not indicate high impact to surface water or sediment at this time. Therefore, lead sampling is not recommended at other identified off-range receptor locations at this time due to low concern of lead release to these locations. **Table 6** presents the proposed sampling locations and the recommended constituents for analysis. Identified locations are shown in **Figure 5**.

Table 6: Proposed Sediment Sampling Locations at MCAGCC Twentynine Palms

Proposed Sediment Sample	Identification Method	Constituents for Analysis
Deadman Lake – 1	Screening-level modeling, lead deposition	Explosives, perchlorate, total lead, Total Organic Carbon, pH
Deadman Lake – 2	Screening-level modeling, lead deposition	Explosives, perchlorate, total lead, Total Organic Carbon, pH
Quackenbush Lake – 1	Screening-level modeling	Explosives, perchlorate, Total Organic Carbon, pH
Quackenbush Lake – 2	Screening-level modeling	Explosives, perchlorate, Total Organic Carbon, pH
Mesquite Lake – 1	Background sample	Explosives, perchlorate, Total Organic Carbon, pH

REFERENCES

ARCADIS. 2015. Technical Memorandum: *Screening-Level Assessment of Munitions Constituent (MC) Concentrations in Groundwater from MC Loading Areas at Marine Corps Air Ground Combat Center Twentynine Palms.*

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

Marine Corps Air Ground Combat Center Twentynine Palms, CA (MCAGCC). 2014. Geographic Information Systems files.

FIGURES

FIGURE 1
MCAGCC TWENTYNINE PALMS
MC LOADING AREAS

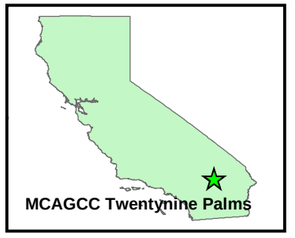
REVA
MCAGCC TWENTYNINE PALMS

N

Lavic Lake
Lower Sunshine Lake
Galway Lake
Quackenbush Lake
Emerson Lake East
Emerson Lake
Ames Lake
Miller Lake
South Miller Lake
Deadman Lake
Upper Mesquite Lake
Mesquite Lake
Dry Lake
Bristol Lake
Salt Mining Operations

Legend

- Modeled MC Loading Area
- Installation Boundary
- Playa Lake (Ephermal/Intermittent)
- Stream/Wash (Ephermal/Intermittent)



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Units: Meters

Date: August 2015

Source: MCAGCC, 2014

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FIGURE 2
MCAGCC TWENTYNINE PALMS SURFACE WATER FEATURES

REVA
MCAGCC TWENTYNINE PALMS

N

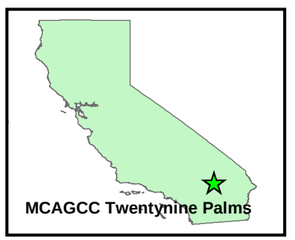
Lavic Lake
Lower Sunshine Lake
Galway Lake
Quackenbush Lake
Emerson Lake
Emerson Lake East
Ames Lake
Miller Lake
South Miller Lake
Deadman Lake
Upper Mesquite Lake
Mesquite Lake
Dry Lake
Bristol Lake
Salt Mining Operations

Legend

- Modeled MC Loading Area
- Installation Boundary
- Playa Lake (Ephermal/Intermittent)
- Stream/Wash (Ephermal/Intermittent)
- Off-Range SW Receptor Location

Drainage Area

- Ames Lake (1)
- Bristol Lake (entering from installation) (2)
- Deadman Lake (3)
- Dry Lake (4)
- Emerson Lake (5)
- Galway Lake (6)
- Installation Boundary within Cleghorn Pass WS 1 (7)
- Installation Boundary within Cleghorn Pass WS 2 (8)
- Installation Boundary within Cleghorn Pass WS 3 (9)
- Installation Boundary within Cleghorn Pass WS 4 (10)
- Installation Boundary within Cleghorn Pass WS 5 (11)
- Installation Boundary within Cleghorn Pass WS 6 (12)
- Installation Boundary within Cleghorn Pass WS 7 (13)
- Installation Boundary within Cleghorn Pass WS 8 (14)
- Installation Boundary within East and West Sunshine WS (15)
- Lavic Lake (16)
- Quakenbush (17)
- Upper Emerson (18)



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Date: August 2015

Source: MCAGCC, 2014

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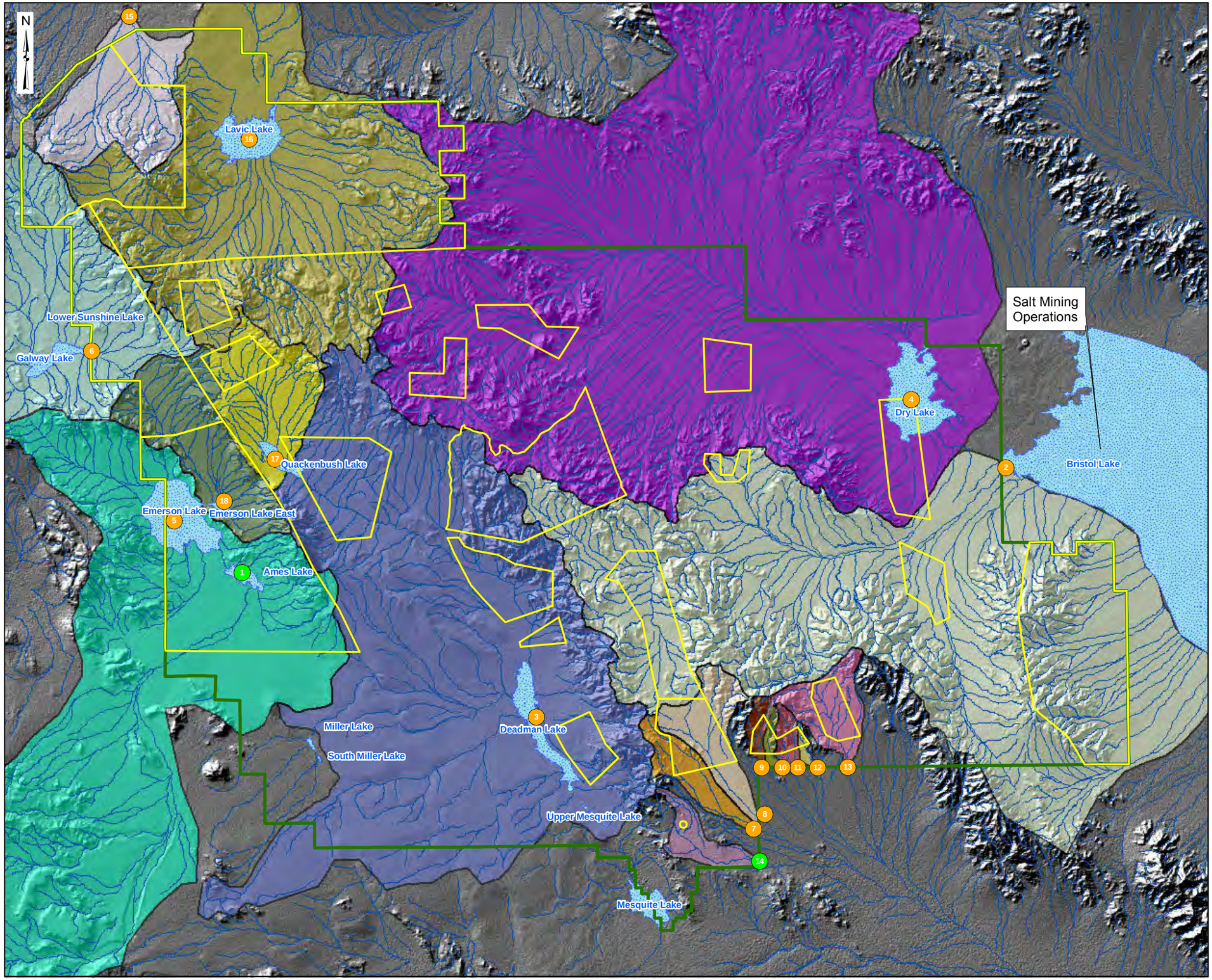
FIGURE 3
MCAGCC TWENTYNINE PALMS PRDICTED SURFACE WATER CONCENTRATION DETECTED AT OFF-RANGE RECEPTOR LOCATION

REVA
MCAGCC TWENTYNINE PALMS

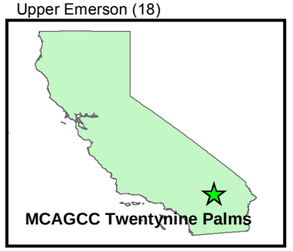


Legend

- Modeled MC Loading Area
- Installation Boundary
- Playa Lake (Ephermal/Intermittent)
- Stream/Wash (Ephermal/Intermittent)
- Off-Range Receptor Location with Predicted Detection
- Off-Range Receptor Location with no Predicted Detection

Drainage Area

- Ames Lake (1)
- Bristol Lake (entering from installation) (2)
- Deadman Lake (3)
- Dry Lake (4)
- Emerson Lake (5)
- Galway Lake (6)
- Installation Boundary within Cleghorn Pass WS 1 (7)
- Installation Boundary within Cleghorn Pass WS 2 (8)
- Installation Boundary within Cleghorn Pass WS 3 (9)
- Installation Boundary within Cleghorn Pass WS 4 (10)
- Installation Boundary within Cleghorn Pass WS 5 (11)
- Installation Boundary within Cleghorn Pass WS 6 (12)
- Installation Boundary within Cleghorn Pass WS 7 (13)
- Installation Boundary within Cleghorn Pass WS 8 (14)
- Installation Boundary within East and West Sunshine WS (15)
- Lavic Lake (16)
- Quakenbush (17)
- Upper Emerson (18)



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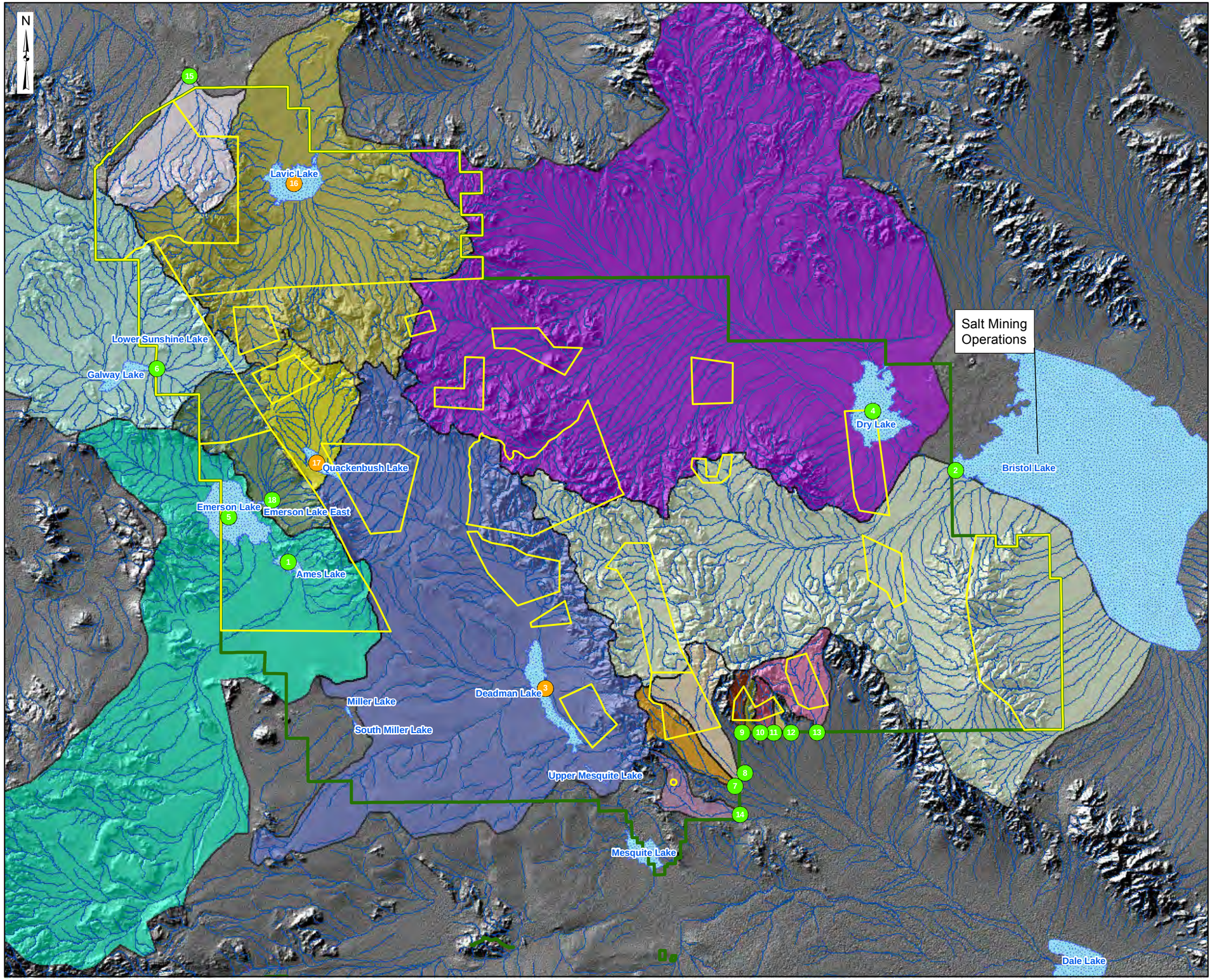


FIGURE 4
MCAGCC TWENTYNINE PALMS
PREDICTED SEDIMENT CONCENTRATION EXCEEDING DOD SCREENING VALUE AT OFF RANGE RECEPTOR LOCATION

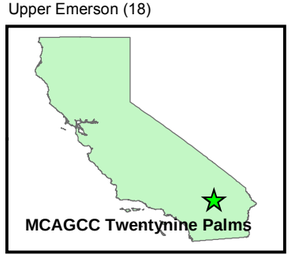
REVA
MCAGCC TWENTYNINE PALMS

Legend

- Modeled MC Loading Area
- Installation Boundary
- Playa Lake (Ephermal/Intermittent)
- Stream/Wash (Ephermal/Intermittent)
- Off-Range Receptor Location with Predicted Concentration Above DoD Screening Value
- Off-Range Receptor Location with no Predicted Concentration Below DoD Screening Value

Drainage Area

- Ames Lake (1)
- Bristol Lake (entering from installation) (2)
- Deadman Lake (3)
- Dry Lake (4)
- Emerson Lake (5)
- Galway Lake (6)
- Installation Boundary within Cleghorn Pass WS 1 (7)
- Installation Boundary within Cleghorn Pass WS 2 (8)
- Installation Boundary within Cleghorn Pass WS 3 (9)
- Installation Boundary within Cleghorn Pass WS 4 (10)
- Installation Boundary within Cleghorn Pass WS 5 (11)
- Installation Boundary within Cleghorn Pass WS 6 (12)
- Installation Boundary within Cleghorn Pass WS 7 (13)
- Installation Boundary within Cleghorn Pass WS 8 (14)
- Installation Boundary within East and West Sunshine WS (15)
- Lavic Lake (16)
- Quakenbush (17)
- Upper Emerson (18)



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Date: August 2015

Source: MCAGCC, 2014

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Additional Tables
Surface Water Screening-Level Assessment
Table B-1: Percent MC Mass Contributed by MC Loading Areas
Tables B-2 through B-9: Modeling Parameters

Table B-1 presents the estimated percent of total MC mass contributed by the individual MC loading areas draining to the 10 downstream off-range receptor locations receiving drainage from multiple MC loading areas.

Table B-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

Off-Range Receptor Location (Corresponding Number on Figure 2-4)	MC Loading Area	Percent MC Mass Contributed			
		HMX	RDX	TNT	Perchlorate
Bristol Lake (drainage entering from installation) (2)	America Mine	13	2	6	2
	Bullion	11	10	22	58
	Delta	23	72	18	10
	Lava	44	12	46	21
	Lead Mountain	8	3	5	6
	Noble Pass	1	1	2	3
	Prospect	<1	<1	<1	<1
Deadman Lake (3)	Emerson Lake	1	<1	<1	1
	Noble Pass	1	1	3	7
	Quackenbush	92	53	95	45
	Range I	3	17	1	1
	Range III	2	18	<1	2
	Range IV	<1	11	1	43
Dry Lake (4)	Black Top I/Morgan's Well I	14	22	19	23
	Black Top II	9	9	14	12
	Lava	1	1	2	1
	Lavic Lake	1	1	2	7
	Lead Mountain	45	45	54	43
	Morgan's Well II	17	15	5	8
	Noble Pass	<1	1	2	2
	Rainbow Canyon	12	7	2	4
Emerson Lake (5)	Emerson Lake	~100	~100	~100	~100
	Maumee Mine	<1	<1	<1	<1
Galway Lake (6)	Gays Pass II	1	2	1	<1
	Lavic Lake	<1	<1	<1	1
	Maumee Mine	99	96	99	99
	Sunshine Peak	<1	2	<1	<1

Off-Range Receptor Location (Corresponding Number on Figure 2-4)	MC Loading Area	Percent MC Mass Contributed			
		HMX	RDX	TNT	Perchlorate
Installation boundary within Cleghorn Pass Watershed 2 (8)[a]	Delta	8	17	7	2
	Prospect	92	83	93	98
Installation boundary within East and West Sunshine Watershed (15)[a]	Lavic Lake	~100	62	98	~100
	Sunshine Peak	<1	38	2	<1
Lavic Lake (16)	Gays Pass I	1	1	<1	<1
	Gays Pass II	47	36	14	3
	Lavic Lake	38	50	82	95
	Maumee Mine	2	1	1	<1
	Rainbow Canyon	12	11	2	1
	Sunshine Peak	<1	1	<1	<1
Quackenbush Lake (17)	Emerson Lake	1	1	1	5
	Gays Pass I	90	68	54	78
	Maumee Mine	<1	<1	<1	<1
	Quackenbush	9	31	44	17
Upper Emerson Lake (18)	Emerson Lake	48	56	39	55
	Gays Pass I	4	4	3	1
	Maumee Mine	47	40	58	44

[a] Stream location

Table B-2: Climate Data used in the Surface Water Screening Assessment

Data Type	Value	Reference(s)
Annual Average Precipitation (in/yr)	4.78	Average for 1948 through 2005 (MCAGCC 29 Palms, 2006)
Annual Average Wind Speed (mph)	5.8	NOAA Climate data
Annual Average Ambient Environmental Temperature (^{0}F)	5	Average for 1948 through 2005 (MCAGCC 29 Palms, 2006)

Note:

in/yr = inches per year

mph = miles per hour

^{0}F = degrees Fahrenheit

Table B-3: Soil Types and Hydrologic Properties at Modeled MC Loading Areas

MC Loading Area	Slope (%)[a]	Predominant Soil Map Symbol[b]	Soil Description[b]	Soil Moisture Content[c]	Soil Air Content[d]	Soil Bulk Density (kg/m^3)[b]	Runoff Coefficient[e]	Runoff ($m^3/m^2/d$)[f]	Annul Recharge (% ppt)[g]
America Mine	18.4	416, 315, 313	extremely gravelly coarse sand and extremely gravally sand	0.12	0.27	1550	0.56	0.000186324	1
Black Top I/Morgan's Well I	10.1	293, 142	extremely gravelly loamy sand and loam	0.22	0.21	1563	0.57	0.000189651	1.75
Black Top II	4.6	315, 313	extremely gravelly sand and sandy loam	0.17	0.25	1556	0.42	0.000139743	2.5
Bullion	4.4	313	extremely gravelly sand and sandy loam	0.17	0.25	1575	0.41	0.000136416	2.5
Cleghorn Pass I	23	416, 276	extremely gravelly coarse sand, sandy loam, extremely gravelly loamy sand and very gravelly silt loam	0.22	0.21	1569	0.62	0.000206287	1
Cleghorn Pass II	5.2	274	extremely gravelly loamy sand	0.22	0.21	1600	0.42	0.000139743	1.75
Delta	8	270, 276, 416	extremely gravelly loamy sand, very gravelly silt loam, extremely gravelly coarse sand, sandy loam	0.22	0.21	1579	0.54	0.000179669	1.75
Emerson Lake	13.3	278	loamy sand, coarse sand, silt loam, very cobbly sandy loam, extremely gravelly loam	0.22	0.21	1526	0.51	0.000169688	1
Gays Pass I	6.5	274, 223	extremely gravelly loamy sand	0.22	0.21	1550	0.45	0.000149724	1.75
Gays Pass II	11.6	276, 406, 223	extremely gravelly loamy sand and very gravelly silt loam	0.26	0.18	1542	0.58	0.000192978	1
Lava	5.8	315, 313, 143	extremely gravelly sand and sandy loam, fine sandy loam	0.19	0.24	1546	0.52	0.000173015	1.75
Lavic Lake	9.4	270, 274	extremely gravelly sandy loam, sand, extremely cobblly loam	0.22	0.203	1577	0.52	0.000173015	1.75
Lead Mountain	3.7	313, 252, 902	extremely gravelly sand and sandy loam, silt loam	0.22	0.21	1500	0.42	0.000139743	2.5
Maumee Mine	11.3	107, 270, 407	coarse sand, extremely gravelly loamy sand	0.17	0.24	1610	0.51	0.000169688	1
Morgan's Well II	12.8	407, 406, 293	extremely gravellly sandy loam	0.22	0.21	1552	0.58	0.000192978	1
Noble Pass	19.3	416, 406, 423	extremely gravelly coarse sand, extremely gravelly sandy loam	0.17	0.24	1531	0.6	0.000199632	1
Prospect	6.2	276, 203	extremely gravelly loamy sand and very gravelly silt loam, gravelly loamy coarse sand	0.26	0.17	1625	0.48	0.000159706	1.75
Quackenbush	4.9	295, 365	extremely gravelly loamy sand, very gravelly fine sandy loam and loamy sand	0.22	0.21	1550	0.42	0.000139743	2.5
Rainbow Canyon	9	130, 131	very gravelly sandy loam	0.22	0.21	1500	0.56	0.000186324	1.75
Range 051	8.1	108, 261, 416	extremely gravelly loam, loamy sand, extremely gravelly coarse sand	0.21	0.20	1600	0.48	0.000159706	1.75
Range I	10.5	110, 276	sand, extremely gravelly loamy sand and very gravelly silt loam	0.22	0.21	1613	0.48	0.000159706	1
Range III	9.7	274, 110	extremely gravelly loamy sand, sand	0.17	0.25	1613	0.48	0.000159706	1.75
Range IV	12.2	274, 279	extremely gravelly loamy sand, sand	0.17	0.25	1613	0.49	0.000163033	1
Sunshine Peak	14	406	very gravelly loamy coarse sand, extremely gravelly sandy loam	0.22	0.19	1554	0.55	0.000182996	1

Note:
Land cover at all areas is sparsely vegetated with creosote bush shrubland
(MCAGCC Twentynine Palms, 2014)

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 (MCAGCC Twentynine Palms, 2014)
[b] Soil survey report (USDA NRCS, 1999)
[c] Field capacity value based on soil type (Fetter, 1994)
[d] Estimated based on porosity less soil moisture
[e] Estimated from Caltrans, 2006
[f] Estimated from runoff coefficient and precipitation
[g] Estimated from annual groundwater inflow into the Surprise Spring basin (Londquist and Martin, 1991) and adjusted for MC loading areas based on slope and land cover

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

MC Loading Area/Drainage Area	Area (m^2)	K[a]	LS[b]	A ($kg/m^2/d$)
MC Loading Areas				
America Mine	8.42E+06	0.06	3.6	3.63E-03
Black Top I/Morgan's Well I	1.12E+07	0.09	2.5	3.62E-03
Black Top II	9.81E+06	0.09	1.2	1.68E-03
Bullion	1.00E+07	0.02	1.2	3.79E-04
Cleghorn Pass I	9.57E+06	0.06	4.1	3.75E-03
Cleghorn Pass II	8.77E+06	0.02	1.4	4.45E-04
Delta	2.53E+07	0.05	2.1	1.51E-03
Emerson Lake	1.30E+07	0.17	3.0	8.27E-03
Gays Pass I	9.57E+06	0.06	1.7	1.65E-03
Gays Pass II	8.77E+06	0.07	2.7	3.13E-03
Lava	3.42E+06	0.08	1.5	2.01E-03
Lavic Lake	2.28E+07	0.05	2.4	1.83E-03
Lead Mountain	1.81E+07	0.18	1.0	2.90E-03
Maumee Mine	6.53E+06	0.05	2.7	2.15E-03
Morgan's Well II	8.77E+06	0.06	2.9	2.78E-03
Noble Pass	6.81E+06	0.02	3.7	1.18E-03
Prospect	1.75E+07	0.11	1.6	2.78E-03
Quackenbush	3.13E+07	0.06	1.3	1.16E-03
Rainbow Canyon	2.89E+06	0.09	2.3	3.22E-03
Range 051	1.49E+05	0.09	2.1	3.08E-03
Range I	1.01E+07	0.07	2.6	2.98E-03
Range III	2.98E+06	0.04	2.4	1.37E-03
Range IV	1.92E+07	0.06	2.8	2.70E-03
Sunshine Peak	9.25E+06	0.05	3.1	2.36E-03
Drainage area of off-range surface water receptor locations				
Ames Dry Lake	4.80E+08	0.06	3.0	2.77E-03
Bristol Lake	6.14E+08	0.02	3.1	9.97E-04
Deadman Lake	5.51E+08	0.08	2.4	2.88E-03
Dry Lake	1.02E+09	0.09	2.4	3.26E-03
Emerson Lake	6.20E+08	0.17	3.1	8.10E-03
Galway Lake	3.20E+08	0.04	3.4	2.30E-03
Installation boundary within Cleghorn Pass watershed 1	1.71E+07	0.07	2.5	2.82E-03
Installation boundary within Cleghorn Pass watershed 2	2.71E+07	0.07	2.5	2.82E-03
Installation boundary within Cleghorn Pass watershed 3	4.87E+06	0.13	4.6	9.60E-03
Installation boundary within Cleghorn Pass watershed 4	2.84E+06	0.13	4.1	8.59E-03
Installation boundary within Cleghorn Pass watershed 5	5.10E+06	0.13	4.3	8.97E-03
Installation boundary within Cleghorn Pass watershed 6	1.77E+06	0.13	2.9	6.01E-03
Installation boundary within Cleghorn Pass watershed 7	2.30E+07	0.02	3.1	9.77E-04
Installation boundary within Cleghorn Pass watershed 8	1.32E+07	0.13	1.9	3.94E-03
Installation boundary within East and West Sunshine watershed	6.40E+07	0.04	2.8	1.54E-03
Lavic Lake	3.58E+08	0.02	2.8	1.04E-03
Quackenbush Lake	5.18E+07	0.03	2.6	1.15E-03
Upper Emerson Lake	6.20E+07	0.11	3.0	5.22E-03

Note:

R factor value of 35 was picked for all loading areas (Brady, 1984)

C factor value of 0.75 was conservatively estimated for all areas based on similar land cover and occurance of flush flood events that can lead to rapid sediment transport

P factor of 1 was conservatively assumed for all areas

A = predicted soil loss
C = cover and management factor
K = soil erodibility factor
LS = topographic factor (influence of length and steepness of slope)
P = erosion control practice factor
R = rainfall and runoff factor

$kg/m^2/d$ = kilogram per square meter per day

[a] Soil survey report (USDA NRSCS, 1999)

[b] Slope length and gradient used to get LS (USDA ARS, 1997)

Table B-5: Chemical Properties of TNT

Installation name:	MCAGCC Twentynine Palms
Date:	April, 2015
Munitions Constituent:	TNT

Row	Data Type	Description	Source Type	Rationale	Reference(s)	Value/Result		Units
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: Maximum:	 5.72E-01 	mol/m^3
3	Vapor pressure	Vapor pressure of TNT	☑ Literature ☐ Site Data ☐ Assumption		Walsh et al., 1995	Minimum: Average: Maximum:	 1.47E-04 	Pa
4	Henry's law constant	Henry's law constant of TNT	☑ Literature ☐ Site Data ☐ Assumption		HQMC, 2009	Minimum: Average: Maximum:	 1.10E-08 	atm-m^3/mol
5	Kow	Octanol-water partition coefficient for TNT	☑ Literature ☐ Site Data ☐ Assumption		HQMC, 2009	Minimum: Average: Maximum:	 72.4 	unitless
6	Koc	Organic carbon partition coefficient for TNT	☐ Literature ☐ Site Data ☑ Assumption		HQMC, 2009	Minimum: Average: Maximum:	 525 	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 E-9**)		Minimum: Average: Maximum:	 	
8	Diffusion coefficient in air	Diffusion coefficient of TNT in air	☑ Literature ☐ Site Data ☐ Assumption		HQMC, 2009	Minimum: Average: Maximum:	 6.40E-02 	cm^2/sec
9	Diffusion coefficient in water	Diffusion coefficient of TNT in water	☑ Literature ☐ Site Data ☐ Assumption		HQMC, 2009	Minimum: Average: Maximum:	 6.71E-06 	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: Maximum:	 23.1 	days

Table B-6: Chemical Properties of HMX

Installation name:	MCAGCC Twentynine Palms
Date:	April, 2015
Munitions Constituent:	HMX

Row	Data Type	Description	Source Type	Rationale	Reference(s)	Value/Result		Units
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 HMX	☑ 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 E-9**)		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 B-7: Chemical Properties of RDX

Installation name:	MCAGCC Twentynine Palms
Date:	April, 2015
Munitions Constituent:	RDX

Row	Data Type	Description	Source Type	Rationale	Reference(s)	Value/Result		Units
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 RDX	☑ 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 E-9**)		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 B-8: Chemical Properties of Perchlorate

Installation name:	MCAGCC Twentynine Palms
Date:	April, 2015
Munitions Constituent:	Perchlorate

Row	Data Type	Description	Source Type	Rationale	Reference(s)	Value/Result		Units
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: Maximum:	 2.01E+03 	mol/m^3
3	Vapor pressure	Vapor pressure of perchlorate	☑ Literature ☐ Site Data ☐ Assumption		Walsh et al., 1995	Minimum: Average: Maximum:	 3.75E-09 	Pa
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: Maximum:	 1.85E-17 	atm-m^3/mol
5	Kow	Octanol-water partition coefficient for Perchlorate	☑ Literature ☐ Site Data ☐ Assumption		Walsh et al., 1995 Meylan and Howard, 1995	Minimum: Average: Maximum:	 1.40E-06 	unitless
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: Maximum:	 6.94E-07 	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 E-9**)		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: Maximum:	 7.00E-10 	cm^2/sec
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: Maximum:	 1.90E-12 	cm^2/sec
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: Maximum:	 1.00E+07 	days

Table B-9: 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]
America Mine	0.001	HMX	3.47	0.00
		RDX	7.76	0.01
		TNT	525	1
		Perhlorate	6.94E-07	6.94E-10
Black Top I/Morgan's Well I	0.0013	HMX	3.47	0.00
		RDX	7.76	0.01
		TNT	525	1
		Perhlorate	6.94E-07	9.02E-10
Black Top II	0.0008	HMX	3.47	0.00
		RDX	7.76	0.01
		TNT	525	0
		Perhlorate	6.94E-07	5.55E-10
Bullion	0.0006	HMX	3.47	0.00
		RDX	7.76	0.00
		TNT	525	0
		Perhlorate	6.94E-07	4.16E-10
Cleghorn Pass I	0.001	HMX	3.47	0.00
		RDX	7.76	0.01
		TNT	525	1
		Perhlorate	6.94E-07	6.94E-10
Cleghorn Pass II	0.0009	HMX	3.47	0.00
		RDX	7.76	0.01
		TNT	525	0
		Perhlorate	6.94E-07	6.25E-10
Delta	0.0011	HMX	3.47	0.00
		RDX	7.76	0.01
		TNT	525	1
		Perhlorate	6.94E-07	7.63E-10
Emerson Lake	0.0011	HMX	3.47	0.00
		RDX	7.76	0.01
		TNT	525	1
		Perhlorate	6.94E-07	7.63E-10
Gays Pass I	0.0007	HMX	3.47	0.00
		RDX	7.76	0.01
		TNT	525	0
		Perhlorate	6.94E-07	4.86E-10
Gays Pass II	0.0009	HMX	3.47	0.00
		RDX	7.76	0.01
		TNT	525	0
		Perhlorate	6.94E-07	6.25E-10
Lava	0.001	HMX	3.47	0.00
		RDX	7.76	0.01
		TNT	525	1
		Perhlorate	6.94E-07	6.94E-10
Lavic Lake	0.0012	HMX	3.47	0.00
		RDX	7.76	0.01
		TNT	525	1
		Perhlorate	6.94E-07	8.33E-10
Lead Mountain	0.0011	HMX	3.47	0.00
		RDX	7.76	0.01
		TNT	525	1
		Perhlorate	6.94E-07	7.63E-10
Meamee Mine	0.0009	HMX	3.47	0.00
		RDX	7.76	0.01
		TNT	525	0
		Perhlorate	6.94E-07	6.25E-10
Morgan's Well II	0.0014	HMX	3.47	0.00
		RDX	7.76	0.01
		TNT	525	1
		Perhlorate	6.94E-07	9.72E-10
Noble Pass	0.0015	HMX	3.47	0.01
		RDX	7.76	0.01
		TNT	525	1
		Perhlorate	6.94E-07	1.04E-09
Prospect	0.001	HMX	3.47	0.00
		RDX	7.76	0.01
		TNT	525	1
		Perhlorate	6.94E-07	6.94E-10
Quackenbush	0.0015	HMX	3.47	0.01
		RDX	7.76	0.01
		TNT	525	1
		Perhlorate	6.94E-07	1.04E-09
Rainbow Canyon	0.0015	HMX	3.47	0.01
		RDX	7.76	0.01
		TNT	525	1
		Perhlorate	6.94E-07	1.04E-09
Range 051	0.0009	HMX	3.47	0.00
		RDX	7.76	0.01
		TNT	525	0
		Perhlorate	6.94E-07	6.25E-10
		HMX	3.47	0.00
		RDX	7.76	0.01
		TNT	525	1

Table B-9: 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]
Range I	0.001	Perhlorate	6.94E-07	6.94E-10
		HMX	3.47	0.00
		RDX	7.76	0.01
		TNT	525	1
Range III	0.0012	Perhlorate	6.94E-07	8.33E-10
		HMX	3.47	0.00
		RDX	7.76	0.01
		TNT	525	1
Range IV	0.0012	Perhlorate	6.94E-07	8.33E-10
		HMX	3.47	0.00
		RDX	7.76	0.01
		TNT	525	1
Sunshine Peak	0.0013	Perhlorate	6.94E-07	9.02E-10

Note:

[a] Estimated from the soil survey organic conent value (USDA NRCS, 1999)

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

Technical Memorandum

Groundwater Screening-Level Assessment

Technical Memorandum

Date: 26 January 2015

To: Jennifer Wilber, Marine Corps Installations Command

Copy: Chris Elliot, Andy Chatlin (Marine Corps Air Ground Combat Center [MCAGCC] Twentynine Palms)
Michael Asakawa, Susan Herbert, Julie Dobschuetz, Britt McMillan (ARCADIS)

From: Edidia Nefso (ARCADIS)

Re: Assessment of Munitions Constituent (MC) Concentrations in Groundwater from MC Loading Areas at MCAGCC Twentynine Palms.

Project No.: 06285043.0000

INTRODUCTION

This memorandum documents the results and recommended path forward based on the Range Environmental Vulnerability Assessment (REVA) screening-level assessment of potential munitions constituent (MC) concentrations in groundwater at Marine Corps Air Ground Combat Center (MCAGCC) Twentynine Palms. The 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 water-bearing units of the Deadman Lake and the Surprise Spring groundwater sub-basins where they may potentially impact groundwater receptors (existing and future drinking water wells). The procedures used to conduct this screening-level assessment are presented in the REVA 5-Year Review Manual (HQMC, 2010). A separate technical memorandum has been prepared to address MC transport in surface water and sediment from the MC loading areas (ARCADIS, 2015).

Seven MC loading areas were assessed (**Figure 1**). These MC loading areas were selected for screening-level modeling based on range use and presence of a groundwater pathway to potential receptor locations.

- Emerson Lake
- Gays Pass I
- Gays Pass II
- Quackenbush
- Range I
- Range III
- Range IV

METHODS

Overall, MC migration to groundwater within the Deadman Lake and Surprise Spring groundwater sub-basins is very slow and limited due to 1) the infrequent nature of rainfall in the area, 2) high evaporation rate, and 3) deep depth to groundwater. Direct recharge can occur from the limited portion of precipitation that falls on the MC loading areas and infiltrates the underlying water-bearing units within the Deadman Lake and Surprise Spring groundwater sub-basins. Preferential recharge also can occur in and around ephemeral streambeds and local depressions, where runoff and standing water are concentrated. MCAGCC Twentynine Palms currently uses 11 production wells located within the Surprise Spring groundwater sub-basin for drinking water. In the near future, the installation is planning to install two or three production wells within the Deadman Lake groundwater sub-basin as additional sources of drinking water (**Figure 1**). The screening-level groundwater assessment assessed the potential for MC loading areas located within the Deadman Lake and Surprise Spring groundwater sub-basins to impact the groundwater within these sub-basins.

A three-step process was followed to assess the potential for MC from the MC loading areas to migrate vertically from the ground surface through the vadose zone to groundwater in the water-bearing units then horizontally through the groundwater to potential receptor locations (existing and future installation drinking water wells). At each step of the process, estimated concentrations were compared to calculated median method detection limits (MDLs). Median MDLs are an established set of values for cyclotetramethylene tetranitramine (HMX), cyclomethylene trinitramine (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 may be present at a detectable concentration. The screening-level groundwater assessment was conducted for the MC loading period 2011–2014 using the following three-step process:

> Step 1: Initial Groundwater Screening-Level Assessment – MC concentrations were estimated in the portion of precipitation water that infiltrates to the groundwater and were assumed to arrive at the groundwater at that concentration. Two scenarios were assessed in order to evaluate two different types of infiltration: 1) direct recharge from the portion of precipitation that falls on the MC loading areas and 2) preferential recharge in and around stream beds and local depressions. The recharge rate for Scenario 1 was assumed to range from 1% to 2.5% of the precipitation for the MC loading areas assessed (0.05 to 0.1 inches/year) based on the estimated annual groundwater inflow into Surprise Spring sub-basin and adjusted for slope variations at MC loading areas. Scenario 1 led to lower recharge and higher MC concentration. The recharge rate for Scenario 2, which constitutes a smaller portion of the total MC loading areas, was assumed to be the annual precipitation rate less site runoff (2 to 2.8 inches/year). Scenario 2 led to higher recharge and lower MC concentrations. If the calculated MC concentration in recharge exceeded its median MDL, Step 2 was performed. If all calculated MC concentrations in the

recharge were lower than the median MDLs, the MC loading area was not evaluated further.

Step 2: Vadose Zone Modeling – The VLEACH vadose zone model, with a post-processing step to include decay, was used to evaluate the potential for MC to migrate through the vadose zone to the groundwater at concentrations greater than the median MDL within a 30-year timeframe. The model was simulated for the two scenarios discussed in Step 1. If a modeled MC concentration arriving at the water table was predicted to be greater than its median MDL within a 30-year timeframe, Step 3 was performed; otherwise, the MC loading area was not evaluated further.

Step 3: Saturated Zone Modeling – The screening-level groundwater model, BIOCHLOR, was used to evaluate if MC in groundwater from the MC loading areas have the potential to reach receptors locations (existing and future installation drinking water wells) at levels above the median MDL through saturated groundwater flow. If a detectable MC concentration was predicted to reach receptor locations, additional assessment and/or sampling was carried out; otherwise, the MC loading area was not evaluated further.

RESULTS

Table 1 and **Table 2** present the estimated MC concentrations in recharge water at the MC loading areas assessed for Scenario 1 (direct recharge from the portion of precipitation—low recharge, high concentration) and Scenario 2 (preferential recharge—high recharge, low concentration). A bolded value in the tables indicates that the concentration is predicted to be detectable in the recharge water at the MC loading area. These concentrations were carried forward into Step 2 of the evaluation.

- With the exception of HMX at Range IV MC loading area, all MC (HMX, RDX, TNT, and perchlorate) were estimated to have concentrations in recharge water above their respective median MDLs at MC loading areas assessed in Scenario 1 (**Table 1**).
- With the exception of HMX at Range IV MC loading area and perchlorate at Range I MC loading area, all MC were estimated to have concentrations in recharge water above their respective median MDLs at MC loading areas assessed in Scenario 2 (**Table 2**).

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 Recharge Water at MC Loading Areas – Scenario 1
(Low Recharge Rate, High Concentration)

		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)**			
Emerson Lake[a]	0.004	**81.2**	**219**	**2510**	**59.2**
Gays Pass I[b]	0.007	**36.7**	**91.0**	**658**	**5.96**
Gays Pass II[b]	0.004	**70.1**	**174**	**1260**	**11.4**
Quackenbush[b]	0.01	**18.1**	**223**	**4330**	**6.51**
Range I[b]	0.004	**4.19**	**463**	**264**	**1.45**
Range III[b]	0.007	**4.77**	**1210**	**14.5**	**3.36**
Range IV[b]	0.004	0.021	**193**	**137**	**23.5**

Note:
ft/yr = feet per year
µg/L = micrograms per liter
Bolded value indicates concentration is above the median MDL and continues to the next step of the evaluation.

[a] Located within Surprise Spring sub-basin
[b] Located within Deadman Lake sub-basin

Table 2: Maximum MC Concentrations in Recharge Water at MC Loading Areas – Scenario 2
(High Recharge Rate, Low Concentration)

		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)**			
Emerson Lake[a]	0.195	**1.66**	**4.48**	**51.2**	**1.21**
Gays Pass I[b]	0.219	**1.17**	**2.90**	**20.9**	**0.190**
Gays Pass II[b]	0.167	**1.67**	**4.14**	**29.9**	**0.271**
Quackenbush[b]	0.231	**0.780**	**9.61**	**187**	**0.281**
Range I[b]	0.207	**0.0807**	**8.90**	**5.07**	0.0278
Range III[b]	0.207	**0.161**	**40.6**	**0.487**	**0.113**
Range IV[b]	0.203	0.000420	**3.78**	**2.68**	**0.461**

Note:
Bold indicates concentration is above the median MDL and continues to the next step of the evaluation.

[a] Located within Surprise Spring sub-basin
[b] Located within Deadman Lake sub-basin

Results of the vadose zone modeling for Scenarios 1 and 2 are presented in **Table 3** and **Table 4**. Values in bold indicate concentrations are above median MDLs. 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; 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 columns in **Table 3** and **Table 4** provide an estimate of the time for MC to reach the groundwater at detectable concentrations.

Table 3: Estimated MC Concentrations Reaching the Water Table at the MC Loading Areas – Scenario 1 *(Low Recharge, High Concentration)*

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)
Emerson Lake	HMX	*0.077*	**81.2**	> 1,000	< MMDL	--
	RDX	*0.097*	**219**	> 1,000	< MMDL	--
	TNT	*0.108*	**2,510**	> 4,000	< MMDL	--
	Perchlorate	*0.06*	**59.2**	> 1,000	**59.2**	>1,000
Gays Pass I	HMX	*0.077*	**36.7**	> 1,000	< MMDL	--
	RDX	*0.097*	**91.0**	> 1,000	< MMDL	--
	TNT	*0.108*	**658**	> 3,000	< MMDL	--
	Perchlorate	*0.06*	**5.96**	> 2,000	**5.96**	>2,000
Gays Pass II	HMX	*0.077*	**70.1**	> 2,000	< MMDL	--
	RDX	*0.097*	**174**	> 2,000	< MMDL	--
	TNT	*0.108*	**1,260**	> 4,000	< MMDL	--
	Perchlorate	*0.06*	**11.4**	> 3,000	**11.4**	>3,000
Quackenbush	HMX	*0.077*	**18.1**	~600	< MMDL	--
	RDX	*0.097*	**223**	~500	< MMDL	--
	TNT	*0.108*	**4,330**	> 2,000	< MMDL	--
	Perchlorate	*0.06*	**6.51**	~900	**6.51**	~900
Range I	HMX	*0.077*	**4.19**	~500	< MMDL	--
	RDX	*0.097*	**463**	~300	< MMDL	--
	TNT	*0.108*	**264**	> 2,000	< MMDL	--
	Perchlorate	*0.06*	**1.45**	~900	**1.45**	~900
Range III	HMX	*0.077*	**4.77**	~500	< MMDL	--
	RDX	*0.097*	**1,210**	~100	< MMDL	--
	TNT	*0.108*	**14.5**	> 1,000	< MMDL	--
	Perchlorate	*0.06*	**3.36**	~500	**3.36**	~500

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)
Range IV	HMX	*0.077*	NM	NM	NM	NM
	RDX	*0.097*	**193**	~1,000	< MMDL	--
	TNT	*0.108*	**137**	> 3,000	< MMDL	--
	Perchlorate	*0.06*	**23.5**	> 1,000	**23.5**	>1,000

Note:
MMDL = median MDL
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 degrades before reaching the water table.
Bold indicates concentration exceeds the median MDL.

Table 4: Estimated MC Concentrations Reaching the Water Table at the MC Loading Areas – Scenario 2 *(High Recharge, Low Concentration)*

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)
Emerson Lake	HMX	*0.077*	**1.66**	~50	< MMDL	--
	RDX	*0.097*	**4.48**	~50	< MMDL	--
	TNT	*0.108*	**51.2**	~100	< MMDL	--
	Perchlorate	*0.06*	**1.21**	~50	**1.21**	~50
Gays Pass I	HMX	*0.077*	**1.17**	~100	< MMDL	--
	RDX	*0.097*	**2.90**	~100	< MMDL	--
	TNT	*0.108*	**20.9**	~200	< MMDL	--
	Perchlorate	*0.06*	**0.190**	~100	**0.190**	~100
Gays Pass II	HMX	*0.077*	**1.67**	~100	< MMDL	--
	RDX	*0.097*	**4.14**	~100	< MMDL	--
	TNT	*0.108*	**29.9**	~300	< MMDL	--
	Perchlorate	*0.06*	**0.271**	~200	**0.271**	~200
Quackenbush	HMX	*0.077*	**0.780**	~70	< MMDL	--
	RDX	*0.097*	**9.61**	~40	< MMDL	--
	TNT	*0.108*	**187**	~100	< MMDL	--
	Perchlorate	*0.06*	**0.281**	~70	**0.281**	~70

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)
Range I	HMX	*0.077*	**0.0807**	~20	< MMDL	--
	RDX	*0.097*	**8.90**	~15	< MMDL	--
	TNT	*0.108*	**5.07**	~60	< MMDL	--
	Perchlorate	*0.06*	NM	NM	NM	NM
Range III	HMX	*0.077*	**0.16**	~40	< MMDL	--
	RDX	*0.097*	**40.6**	~20	< MMDL	--
	TNT	*0.108*	**0.487**	~100	< MMDL	--
	Perchlorate	*0.06*	**0.113**	~40	**0.113**	~40
Range IV	HMX	*0.077*	NM	NM	NM	NM
	RDX	*0.097*	**3.78**	~50	< MMDL	--
	TNT	*0.108*	**2.68**	~200	< MMDL	--
	Perchlorate	*0.06*	**0.461**	~70	**0.461**	~70

Note:
-- denotes that the MC degrade before reaching the water table.
Bold indicates concentration exceeds the median MDL.

For Scenario 1, based on estimated infiltration rates ranging from 0.05 to 0.1 inches/year and a depth to groundwater of approximately 33 to 189 feet below ground surface, the minimum travel time for MC to reach the water table at concentrations greater than or equal to the respective median MDL value for the no decay and decay scenarios modeled is approximately 100 years (**Table 3**). When decay is included, all MC except perchlorate are predicted to degrade to below their respective median MDL values before reaching the water table. The perchlorate concentration is estimated to exceed the median MDL value after a travel time in excess of 500 years at the Range III MC loading area. At this MC loading area, the perchlorate concentration was estimated to reach a maximum of 3.36 µg/L in over 2,000 years.

For Scenario 2, which was modeled for estimated infiltrated rates ranging from 2 to 2.8 inches/year and a depth to groundwater of approximately 33 to 189 feet below ground surface, the minimum travel time for MC to reach the water table at concentrations greater than or equal to the respective median MDL value for the no decay and decay scenarios is at approximately 15 years (**Table 4**). When decay is included, all MC except perchlorate are predicted to degrade to below their respective median MDL values before reaching the water table. The perchlorate concentration is estimated to exceed the median MDL value after a minimum travel time of approximately 40 years at the Range III MC loading area (**Table 4**). At this MC loading area, the perchlorate concentration was estimated to reach a maximum of 0.113 µg/L in approximately 80 years.

Although perchlorate was predicted to ultimately reach the water table at detectable levels, it takes a long time to reach the water table at detectable concentrations (over 500 years in Scenario 1 and approximately 40 years in Scenario 2). Consequently, impact to groundwater receptors within the Deadman Lake and Surprise Spring sub-basins is not anticipated at least within the next 5 years (until the next REVA periodic review for MCAGCC Twentynine Palms). As a result, further modeling for transport through the saturated zone (Step 3 of the screening assessment) is not warranted at this time.

CONCLUSIONS

The only MC from the MC loading areas predicted to reach the groundwater at levels above the median MDL is perchlorate. With low recharge rate and depth to groundwater exceeding 30 feet, time of travel for perchlorate to potentially reach groundwater is in excess of 40 years. The shortest time of travel occurs where there is preferential recharge (such as near ephemeral streams) that generally occurs within a limited recharge area. However, when groundwater moves from these limited recharge areas, perchlorate levels will be reduced. The perchlorate concentration at the groundwater is not expected to reach the California drinking water benchmark of 6 µg/L for perchlorate.

Given the very slow travel of perchlorate through the vadose zone over the MC loading areas, impact to groundwater receptors within the Deadman Lake and Surprise Spring groundwater sub-basins is not anticipated within the next 5 years. As a result, further evaluation of MC loading at MCAGCC Twentynine Palms for this REVA Periodic Review is not recommended.

REFERENCES

ARCADIS. 2015. Technical Memorandum: Screening-Level Assessment of Munitions Constituent (MC) Concentrations in Surface Water and Sediment from MC Loading Areas at Marine Corps Air Ground Combat Center Twentynine Palms.

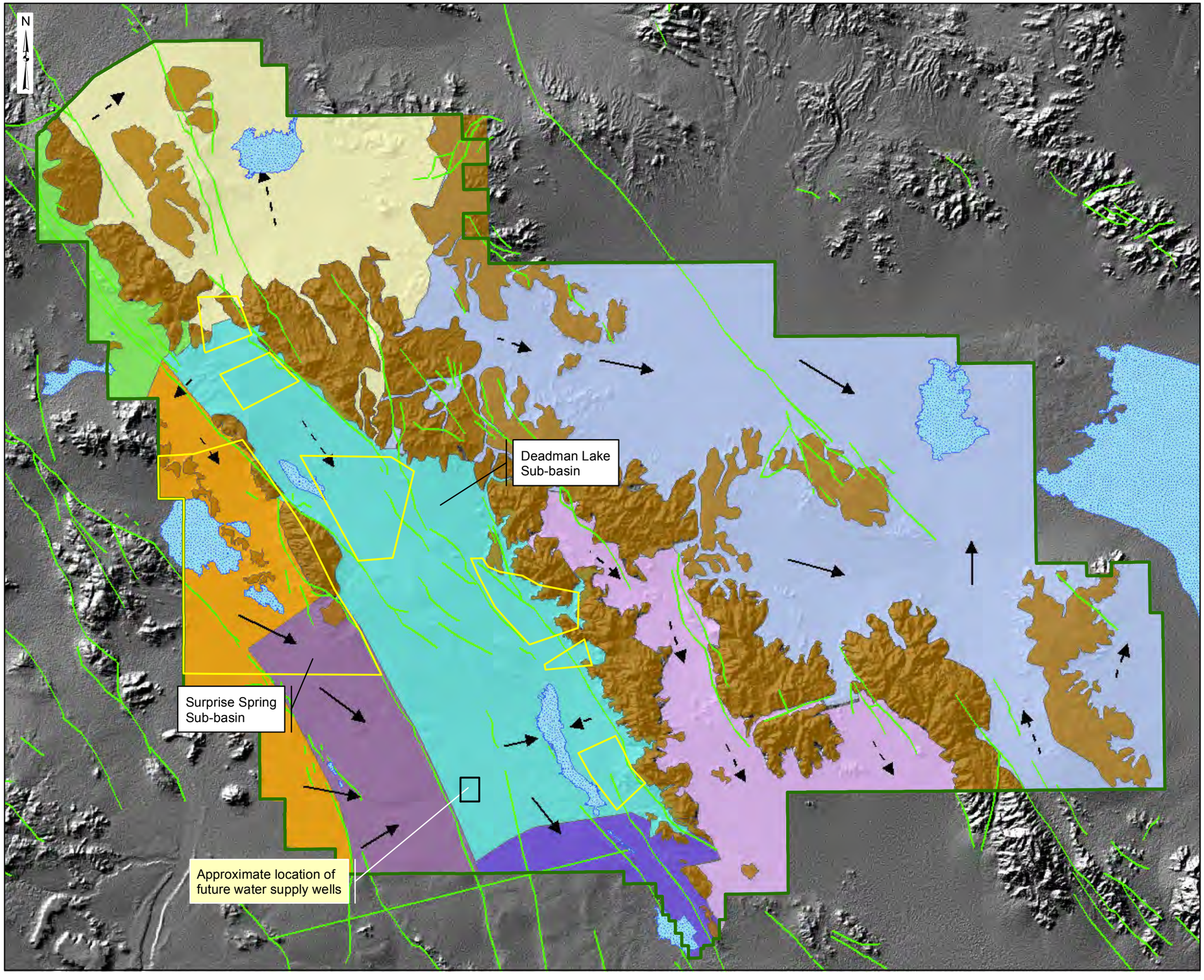
Headquarters Marine Corps (HQMC). 2010. REVA Five-Year Review Manual.

Marine Corps Air Ground Combat Center Twentynine Palms, CA (MCAGCC). 2014. Geographic information systems files.

FIGURE 1

FIGURE 1
MCAGCC TWENTYNINE PALMS GROUNDWATER FEATURES

REVA
MCAGCC TWENTYNINE PALMS



Legend

- Installation Boundary
- Modeled MC Loading Area
- Playa Lake (Ephermal/Intermittent)
- Groundwater Flow (Known)
- Groundwater Flow (Inferred)
- Geologic Fault
- Exposed Bedrock

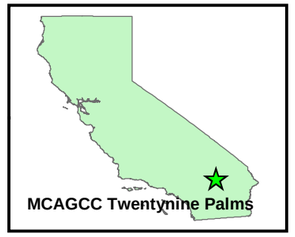
Twentynine Palms Basin

- Bessemer Valley Subbasin
- Deadman Lake Subbasin
- Giant Rock Subbasin
- Surprise Spring Subbasin
- Twentynine Pams Valley Subbasin

Intramountain Basin

- Dale Valley Subbasin
- Lavic Valley Subbasin

Bristol Valley Basin



0 0.75 1.5 3 4.5
Miles

Coordinate System: UTM
Zone: 11N
Datum: NAD83
Units: Meters

Date: August 2015

Source: MCAGCC, 2014b

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Additional Tables
Groundwater Screening-Level Assessment
Tables B-10 through B-11: Modeling Parameters

Table B-10: Groundwater Modeling Parameters - Vadose Zone Properties for MC Loading Areas

VLEACH Parameters									
1) Polygon Data	**MC Loading Areas**								
Parameter	**Emerson Lake**	**Gays Pass I**	**Gays Pass II**	**Quackenbush**	**Range I**	**Range III**	**Range IV**	**Rationale**	**Reference(s)**
Area (feet^2)	1.40E+08	1.03E+08	9.44E+07	3.37E+08	1.09E+08	3.21E+07	2.07E+08		
Vertical Cell Dimension (feet)	9	18.9	18.9	10.7	3.3	4.7	12		
Number of Cells (-)	10	10	10	10	10	10	10		
Height of Polygon (feet)	90	189	189	107	33	47	120	Equivalent to groundwater depth. Based on available measurement closest to MC laoding area	Li and Martin, 2008; MCAGCC Twentynine Palms, 2010
2) Soil Parameter									
Parameter	**Emerson Lake**	**Gays Pass I**	**Gays Pass II**	**Quackenbush**	**Range I**	**Range III**	**Range IV**		
Dry Bulk Density (g/cm^2)	1.526	1.55	1.542	1.550	1.613	1.613	1.613	Obtained from soil survey report	USDA NRCS, 1999
Effective Porosity (-)	0.3	0.43	0.27	0.33	0.28	0.33	0.33	Value chosen from literature based on soil type	McWhorter and Sundada, 1977
Volumetric Water Content (-)	0.22	0.22	0.26	0.22	0.22	0.17	0.17	Estimated field capacity value	Fetter, 1994
Soil Organic Carbon Content (-)	0.0011	0.000725	0.00087	0.00145	0.00102	0.00116	0.00116	Estimated from soil organic content	USDA NRCS, 1999
3a) Boundary Condition - High Recharge Low Concentration (Scenario 2)									
Parameter	**Emerson Lake**	**Gays Pass I**	**Gays Pass II**	**Quackenbush**	**Range I**	**Range III**	**Range IV**		
Recharge Rate (feet/year)	0.195	0.219	0.167	0.231	0.207	0.207	0.203	Estimated preferential recharge to streams as precipitation less runoff	MCAGCC Twentynine Palms, 2010; Caltrans, 2006
Concentration of HMX in Recharge Water (ug/L)	1.66	1.17	1.67	0.78	0.0807	0.161	BMMDL	Results from the initial groundwater screening analysis	
Concentration of RDX in Recharge Water (ug/L)	4.48	2.9	4.14	9.61	8090	40.6	3.78	Results from the initial groundwater screening analysis	
Concentration of TNT in Recharge Water (ug/L)	51.2	20.9	29.9	187	5.07	0.487	2.68	Results from the initial groundwater screening analysis	
Concentration of Perchlorate in Recharge Water (ug/L)	1.21	0.19	0.271	0.281	BMMDL	0.113	0.461	Results from the initial groundwater screening analysis	
Upper Boundary Vapor Condition (mg/L)	0	0	0	0	0	0	0		
Lower Boundary Vapor Condition (mg/L)	0	0	0	0	0	0	0		
Upper Cell Number (-)	1	1	1	1	1	1	1		
Lower Cell Number (-)	90	189	189	107	33	47	120		
Initial Contaminant Concentration in Cells (µg/Kg)	0	0	0	0	0	0	0		
3b) Boundary Condition - Low Recharge High Concentration (Scenario 1)									
Parameter	**Emerson Lake**	**Gays Pass I**	**Gays Pass II**	**Quackenbush**	**Range I**	**Range III**	**Range IV**		
Recharge Rate (feet/year)	3.98E-03	6.97E-03	3.98E-03	9.96E-03	3.98E-03	6.97E-03	3.98E-03	Estimated annual average recharge based on the annual groundwater inflow into the Surprise Spring subbasin and adjusted for slope and land cover at loading area	Londquist and Martin, 1991
Concentration of HMX in Recharge Water (ug/L)	81.2	36.7	70.1	18.1	4.19	4.77	BMMDL	Results from the initial groundwater screening analysis	
Concentration of RDX in Recharge Water (ug/L)	219	91	174	223	463	1210	193	Results from the initial groundwater screening analysis	
Concentration of TNT in Recharge Water (ug/L)	2510	658	1260	4330	264	14.5	137	Results from the initial groundwater screening analysis	
Concentration of Perchlorate in Recharge Water (ug/L)	59.2	5.96	11.4	6.51	1.45	3.36	23.5	Results from the initial groundwater screening analysis	
Upper Boundary Vapor Condition (mg/L)	0	0	0	0	0	0	0		
Lower Boundary Vapor Condition (mg/L)	0	0	0	0	0	0	0		
Upper Cell Number (-)	1	1	1	1	1	1	1		
Lower Cell Number (-)	90	189	189	107	33	47	120		
Initial Contaminant Concentration in Cells (µg/Kg)				0	0	0	0		

Note:

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

Table B-11: Chemical Properties of MC used in the VLEACH Vadose zone Model

CHEMICAL PARAMETER	HMX	RDX	TNT	PERCHLORATE	Rationale	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 (-)	1.09E-13	4.99E-04	4.6E-07	7.77E-11	Equivalent to the Henry's constant divided by the ideal gas constant multiplied by the ambient temperature. Value for perchlorate is a conservative assumption	HQMC, 2009
Water Solubility (mg/L)	5	42.2	130	200000	Published values	Walsh et al., 1995
Free Air Diffusion Coefficient (m2/day)	0.544	6.39E-01	0.55296	7.00E-10	Published values. 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		

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Appendix C
Small Arms Range
Assessment Protocol

RANGE 1
MCAGCC TWENTYNINE PALMS
Twentynine Palms – San Bernardino County, California

Date of SARAP update: 9 September 2014

DESCRIPTION

Range Mission:	Known distance rifle range
Training Start Date:	1955
Direction of Fire:	Northeast
Firing Positions:	50
Target Range:	30, 100, 200, 300, 500, 600, and 1,000 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: Berm face treated with copolymer soil stabilizer.
Reference(s):	

FINDINGS

Review Period		**Periodic Review**
Estimated Lead Deposition (lb/yr)		9,509
Surface Water / Sediment	***RANK***	Moderate
	Source	16
	Pathway	15
	Receptor	8
	TOTAL SCORE	39
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.

RANGE 1
MCAGCC TWENTYNINE PALMS

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	-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*			16

Notes:

Approximately 9,509 pounds of lead were deposited annually on Range 1 between 2011 and 2014.

Range 1 has been used for operational training since 1955 (USACE, 2001).

MCAGCC was conducting lead mining activities of the impact berm at Range 1 during the time of the site visit. Such mining events occur at least once every 5 years. Sand is periodically added to the face of the berm where bullet pockets are formed from range use.

RANGE 1
MCAGCC TWENTYNINE PALMS

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	4
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%	6
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	1
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

RANGE 1
MCAGCC TWENTYNINE PALMS

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:

The average amount of rainfall at Twentynine Palms is between 3 and 4 inches per year (USDA NRCS, 1999).

The berms are covered by less than 10% vegetation. The area contains patches of creosote bushes and other scrub.

The average slope from the Range 1 deposition area to the storm sewers on Del Valle is approximately 4.9%.

The soils at the MTU are classified as entisols and aridisols and are moderately to strongly alkaline with pH values in the range of 8.0 to 9.1 (Battelle, 1998). Surface soil pH readings collected during the site visit at the adjacent Range 3 were 7.31 in the berm and 7.98 in the range drainage pathway. Based on USDA soil surveys, the pH of the soil map symbol ranges from 7.4 to 8.4 (USDA NRCS, 1999).

Range 1 contains soils characterized as Cajon loamy sand, with 2 to 8 percent slopes. This soil series consists of loamy sand and loamy coarse sand, which are very deep, somewhat excessively drained soils, with negligible to low runoff (NRCS, 2002).

A protective berm is present on the backside of the range to prevent run-on of surface water from the higher elevations to the north. The face of the impact berm is treated with a copolymer soil stabilizer to prevent erosion of the berm. Bullet pockets were observed in the face of the impact berm.

RANGE 1
MCAGCC TWENTYNINE PALMS

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	1
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	0
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%	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	1
Groundwater Pathway Score *Minimum: 4* *Maximum: 27*			15

Notes:

The average amount of rainfall at Twentynine Palms between 3 and 4 inches per year (USDA NRCS, 1999).

The nearest depth-to-groundwater measurement is from a well approximately 1.3 mile west of the range (IRP Site 16); it was approximately 400 feet (Battelle, 1998).

RANGE 1
MCAGCC TWENTYNINE PALMS

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**
Range 1 (and the entire MTU) contains soils characterized as Cajon loamy sand, with 2 to 8 percent slopes. This soil series consists of loamy sand and loamy coarse sand, which are very deep, somewhat excessively drained soils, with negligible to low runoff (NRCS, 2002). The berms are covered by less than 10% vegetation. The area contains patches of creosote bushes and other scrub. The average slope from the Range 1 deposition area to the storm sewers on Del Valle is approximately 4.9%. The soils at the MTU are classified as entisols and aridisols and are moderately to strongly alkaline with pH values in the range of 8.0 to 9.1 (Battelle, 1998). Surface soil pH readings collected during the site visit at the adjacent Range 3 were 7.31 in the berm and 7.98 in the range drainage pathway. Based on USDA soil surveys, the pH of the soil map symbol ranges from 7.4 to 8.4 (USDA NRCS, 1999).			

RANGE 1
MCAGCC TWENTYNINE PALMS

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, the closest downgradient surface water body to Range 1 is an ephemeral stream located approximately 1,400 feet to the northwest (USGS, 2014).

Surface water is not used as a drinking water source at the installation, and there are no surface water bodies used as drinking water sources within six miles of this range.

Surface water from this range drains northwest towards an ephemeral stream that generally flows southwest. According to the USGS National Hydrography Map, the ephemeral stream terminates at the installation golf course approximately 2.3 miles from the bullet deposition area. From this point, the installation boundary is approximately 1 mile downgradient.

RANGE 1
MCAGCC TWENTYNINE PALMS

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	6
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:

Water supply wells are located in the Surprise Springs groundwater basin, located 10 miles west-northwest of the MTU. All wells draw water from the unconfined portions of the upper and middle aquifers. Surprise Springs is located upgradient of the Mesquite Basin. The Mesquite Basin is not used as a drinking water source because of high mineral content. The known depth to groundwater near the MTU is approximately 400 feet.

There are no known agricultural wells located on the installation. Surface water and stormwater is used for irrigation purposes. Based on soil sampling results from the Small Arms Range Maintenance and Repair Project at MCAGCC Twentynine Palms (Battelle, 1998) and previous Navy studies, the vertical migration of lead in the soil column is between four and eight inches from the soil surface.

While groundwater is likely found at shallow depths near playas, there are no known groundwater discharge locations near the range which could result in lead migration from groundwater to surface water.

RANGE 1
MCAGCC TWENTYNINE PALMS

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	15
Surface Water / Sediment Receptors	4	8
Sum of Surface Water / Sediment Element Scores *Minimum: 0 Maximum: 65*		**39**

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** ☒ 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	**Moderate**

Notes:

RANGE 1A
MCAGCC TWENTYNINE PALMS
Twentynine Palms – San Bernardino County, California

Date of SARAP update: 9 September 2014

DESCRIPTION

Range Mission:	Unknown distance rifle range	
Training Start Date:	1998	
Direction of Fire:	North	
Firing Positions:	20	
Target Range:	150 to 500 yards	
Impact Area(s):	☐ Open area ☐ Building ☐ Bullet trap	☐ Hillside ☒ Earthen berm
Existing BMPs:	☐ Basin/vault ☐ Diversion ☐ Silt check	☐ Control fabric ☐ Fencing ☐ Vegetation ☐ Rip-rap
	Other:	Berm face treated with copolymer soil stabilizer.
Reference(s):		

FINDINGS

Review Period		**Periodic Review**
Estimated Lead Deposition (lb/yr)		2,690
Surface Water / Sediment	***RANK***	Moderate
	Source	13
	Pathway	13
	Receptor	10
	TOTAL SCORE	36
Groundwater	***RANK***	Moderate
	Source	13
	Pathway	15
	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.

RANGE 1A
MCAGCC TWENTYNINE PALMS

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:

Approximately 2,690 pounds of lead were deposited annually on Range 1A between 2011 and 2014.

Range 1A has been used for operational training since the early 2000s (ARCADIS/Malcolm Pirnie, 2011). The range was under construction when the Archives Search Report was being prepared in 1998 (USACE, 2001).

Lead recovery has not been conducted at this range. Sand is periodically added to the face of the berm where bullet pockets are formed from range use.

RANGE 1A
MCAGCC TWENTYNINE PALMS

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	4
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%	6
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	1
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

RANGE 1A
MCAGCC TWENTYNINE PALMS

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*			13

Notes:

The average amount of rainfall at Twentynine Palms is between 3 and 4 inches per year (USDA NRCS, 1999).

The berms are covered by less than 10% vegetation. The area contains patches of creosote bushes and other scrub.

The average slope from the Range 1A deposition area to the storm sewers on Del Valle is approximately 3.9%.

The soils at the MTU are classified as entisols and aridisols and are moderately to strongly alkaline with pH values in the range of 8.0 to 9.1 (Battelle, 1998). A very small part of the range area also consists of the Dalvord–Goldroad-Rock outcrop association which consists of very gravelly loamy sand and extremely gravelly sandy loam soils. Based on USDA soil surveys, the pH of the soil map symbols range from 7.4 to 8.4 (USDA NRCS, 1999). Surface soil pH readings were collected during the 2014 site visit at the adjacent Range 3. pH readings taken on the berm were 7.31 and 7.98 in the range drainage pathway.

Range 1A (and the entire MTU) contains soils characterized as Cajon loamy sand, 2 to 8 percent slopes. This soil series consists of loamy sand and loamy coarse sand, that are very deep, somewhat excessively drained soils, with negligible to low runoff (NRCS, 2002).

A protective berm is present behind the rear impact berm of the range to prevent run-on of surface water from the higher elevations to the north. The face of the impact berm is treated with a copolymer soil stabilizer to prevent erosion of the berm.

RANGE 1A
MCAGCC TWENTYNINE PALMS

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	1
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	0
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%	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	1
Groundwater Pathway Score *Minimum: 4* *Maximum: 27*			15

Notes:

The average amount of rainfall at Twentynine Palms is between 3 and 4 inches per year (USDA NRCS, 1999).

RANGE 1A
MCAGCC TWENTYNINE PALMS

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 nearest depth-to-groundwater measurement is from a well approximately 1.3 mile west of the range (IRP Site 16). Depth to groundwater at that point was approximately 400 feet (Battelle 1998). Range 1A (and the entire MTU) contains soils characterized as Cajon loamy sand, 2 to 8 percent slopes. This soil series consists of loamy sand and loamy coarse sand, that are very deep, somewhat excessively drained soils with negligible to low runoff (NRCS, 2002). The berms are covered by less than 10% vegetation. The area contains patches of creosote bushes and other scrub. The average slope from the Range 1A deposition area to the storm sewers on Del Valle is approximately 3.9%. The soils at the MTU are classified as entisols and aridisols and are moderately to strongly alkaline with pH values in the range of 8.0 to 9.1 (Battelle, 1998). A very small part of the range area also consists of the Dalvord–Goldroad-Rock outcrop association which consists of very gravelly loamy sand and extremely gravelly sandy loam soils. Based on USDA soil surveys, the pH of the soil map symbols range from 7.4 to 8.4 (USDA NRCS, 1999). Surface soil pH readings collected during the 2014 site visit at the adjacent Range 3 were 7.31 in the berm and 7.98 in the range drainage pathway.			

RANGE 1A
MCAGCC TWENTYNINE PALMS

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 surface water body to Range 1A is an ephemeral stream located downgradient approximately 320 feet to the northwest (USGS, 2014).

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 northwest towards an ephemeral stream that generally flows southwest. According to the USGS National Hydrography Map, the ephemeral stream terminates at the installation golf course approximately 2 miles from the bullet deposition area. From this point, the installation boundary is approximately 1 mile downgradient.

RANGE 1A
MCAGCC TWENTYNINE PALMS

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	6
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:

Water supply wells are located in the Surprise Springs groundwater basin, located 10 miles west-northwest of the MTU. All wells draw water from the unconfined portions of the upper and middle aquifers. Surprise Springs is located upgradient of the Mesquite Basin. The Mesquite Basin is not used as a drinking water source because of high mineral content. The known depth to groundwater near the MTU is approximately 400 feet.

There are no known agricultural wells located on the installation. Surface water and stormwater is used for irrigation purposes. Based on soil sampling results from the Small Arms Range Maintenance and Repair Project at MCAGCC Twentynine Palms (Battelle, 1998) and previous Navy studies, the vertical migration of lead in the soil column is between four and eight inches from the soil surface.

While groundwater is likely found at shallow depths near playas, there are no known groundwater discharge locations near the range which could result in lead migration from groundwater to surface water.

RANGE 1A
MCAGCC TWENTYNINE PALMS

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	13
Surface Water / Sediment Receptors	4	10
Sum of Surface Water / Sediment Element Scores *Minimum: 0 Maximum: 65*		**36**

Groundwater

Element	Table	Score
Range Use and Range Management (Source)	1	13
Groundwater Pathways	3	15
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** ☒ 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	**Moderate**

Notes:

RANGE 2
MCAGCC TWENTYNINE PALMS
Twentynine Palms – San Bernardino County, California

Date of SARAP update: 9 September 2014

DESCRIPTION

Range Mission:	Known distance multi-purpose range	
Training Start Date:	1955	
Direction of Fire:	Northeast	
Firing Positions:	50	
Target Range:	7, 15, 25, and 50 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:	Berm face treated with copolymer soil stabilizer.
Reference(s):		

FINDINGS

Review Period		**Periodic Review**
Estimated Lead Deposition (lb/yr)		6,964
Surface Water / Sediment	***RANK***	Minimal
	Source	13
	Pathway	12
	Receptor	6
	TOTAL SCORE	31
Groundwater	***RANK***	Moderate
	Source	13
	Pathway	16
	Receptor	6
	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.

RANGE 2
MCAGCC TWENTYNINE PALMS

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	-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*			13

Notes:

Range 2 has been used for operational training since 1955 (USACE, 2001). Approximately 6,964 pounds of lead were deposited annually on Range 2 between 2011 and 2014.

According to Range Control personnel, the bullet trap at Range 2 was removed in 2011.

MCAGCC was conducting lead mining activities of the impact berm at Range 2 during the time of the site visit. Such mining events occur at least once every 5 years. Sand is periodically added to the face of the berm where bullet pockets are formed from range use.

RANGE 2
MCAGCC TWENTYNINE PALMS

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	4
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%	6
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

RANGE 2
MCAGCC TWENTYNINE PALMS

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*			12

Notes:

The average amount of rainfall at Twentynine Palms between 3 and 4 inches per year (USDA NRCS, 1999).

The berms are covered by less than 10% vegetation. The area contains patches of creosote bushes and other scrub.

The average slope from the Range 2 deposition area to the storm sewers on Del Valle is approximately 2.6%.

The soils at the MTU are classified as entisols and aridisols and are moderately to strongly alkaline with pH values in the range of 8.0 to 9.1 (Battelle, 1998). Based on USDA soil surveys, the pH of the soil map symbol ranges from 7.4 to 8.4 (USDA NRCS, 1999). Surface soil pH collected during the 2014 site visit were 6.43 and 6.57 at the base of the impact berm.

Range 2 (and the entire MTU) contains soils characterized as Cajon loamy sand, 2 to 8 percent slopes. This soil series consists of loamy sand and loamy coarse sand, that are very deep, somewhat excessively drained soils with negligible to low runoff (NRCS, 2002).

The range is equipped with side berms and impact berm which aid in preventing run-on. Additionally, the range floor is sloped towards a concrete drainage swale that leads to a retention basin in the northern corner of the range preventing run-off. As with the other ranges in the MTU, the impact berm is regularly treated with a copolymer soil stabilizer to prevent erosion on the face of the impact berm.

RANGE 2
MCAGCC TWENTYNINE PALMS

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	1
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	0
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%	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*			16

Notes:

The average amount of rainfall at Twentynine Palms between 3 and 4 inches per year (USDA NRCS, 1999).

The nearest depth-to-groundwater measurement is from a well approximately 1.3 mile west of the range

RANGE 2
MCAGCC TWENTYNINE PALMS

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**
(IRP Site 16). Depth to groundwater at that point was approximately 400 feet (Battelle 1998). Range 2 (and the entire MTU) contains soils characterized as Cajon loamy sand, 2 to 8 percent slopes. This soil series consists of loamy sand and loamy coarse sand, that are very deep, somewhat excessively drained soils with negligible to low runoff (NRCS, 2002). The berms are covered by less than 10% vegetation. The area contains patches of creosote bushes and other scrub. The average slope from the Range 2 deposition area to the storm sewers on Del Valle is approximately 2.6%. The soils at the MTU are classified as entisols and aridisols and are moderately to strongly alkaline with pH values in the range of 8.0 to 9.1 (Battelle, 1998). Based on USDA soil surveys, the pH of the soil map symbol ranges from 7.4 to 8.4 (USDA NRCS, 1999). Surface soil pH collected during the 2014 site visit were 6.43 and 6.57 at the base of the impact berm.			

RANGE 2
MCAGCC TWENTYNINE PALMS

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	0
Surface Water Receptor Score *Minimum: 0 Maximum: 16*			4

Notes:

According to the USGS National Hydrography Map, the closest downgradient surface water body to Range 2 is an ephemeral stream located approximately 2,400 feet to the southeast (USGS, 2014).

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 southeast towards an ephemeral stream that generally flows southeast. According to the USGS National Hydrography Map, the drainage pathway from Range 2 crosses the installation boundary approximately 4.2 miles southeast from the bullet deposition area.

RANGE 2
MCAGCC TWENTYNINE PALMS

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	6
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:

Water supply wells are located in the Surprise Springs groundwater basin, located 10 miles west-northwest of the MTU. All wells draw water from the unconfined portions of the upper and middle aquifers. Surprise Springs is located upgradient of the Mesquite Basin. The Mesquite Basin is not used as a drinking water source because of high mineral content. The known depth to groundwater near the MTU is approximately 400 feet.

There are no known agricultural wells located on the installation. Surface water and stormwater are used for irrigation purposes. Based on soil sampling results from the Small Arms Range Maintenance and Repair Project at MCAGCC Twentynine Palms (Battelle, 1998) and previous Navy studies, the vertical migration of lead in the soil column is between four and eight inches from the soil surface.

While groundwater is likely found at shallow depths near playas, there are no known groundwater discharge locations near the range which could result in lead migration from groundwater to surface water.

RANGE 2
MCAGCC TWENTYNINE PALMS

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	12
Surface Water / Sediment Receptors	4	4
Sum of Surface Water / Sediment Element Scores *Minimum: 0 Maximum: 65*		**29**

Groundwater		
Element	**Table**	**Score**
Range Use and Range Management (Source)	1	13
Groundwater Pathways	3	16
Groundwater Receptors	5	6
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** ☒ 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	**Minimal**
Groundwater Evaluation Ranking	**Moderate**

Notes:

RANGE 2A
MCAGCC TWENTYNINE PALMS
Twentynine Palms – San Bernardino County, California

Date of SARAP update: 9 September 2014

DESCRIPTION

Range Mission:	Combat pistol range
Training Start Date:	Between 1979 and 1999
Direction of Fire:	Northeast
Firing Positions:	8 lanes
Target Range:	Up to 25 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: Berm face treated with copolymer soil stabilizer.
Reference(s):	

FINDINGS

Review Period		**Periodic Review**
Estimated Lead Deposition (lb/yr)		88
Surface Water / Sediment	***RANK***	Minimal
	Source	7
	Pathway	13
	Receptor	4
	TOTAL SCORE	24
Groundwater	***RANK***	Minimal
	Source	7
	Pathway	15
	Receptor	6
	TOTAL SCORE	28

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.

RANGE 2A
MCAGCC TWENTYNINE PALMS

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	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*			7

Notes:

Approximately 89 pounds of lead were deposited annually on Range 2A between 2011 and 2014.

The date of establishment of Range 2A is not known; however, based on information from the Archive Search Report, it is estimated that Range 2A has been used for operational training for approximately 10 to 30 years (USACE, 2001).

Lead recovery has not been conducted at this range. Sand is periodically added to the face of the berm where bullet pockets are formed from range use.

RANGE 2A
MCAGCC TWENTYNINE PALMS

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	4
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%	6
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	1
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

RANGE 2A
MCAGCC TWENTYNINE PALMS

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*			13

Notes:

The average amount of rainfall at Twentynine Palms between 3 and 4 inches per year (USDA NRCS, 1999).

The berms are covered by less than 10% vegetation. The area contains patches of creosote bushes and other scrub.

The average slope from the Range 2A deposition area to the storm sewers on Del Valle is approximately 4.7%.

The soils at the MTU are classified as entisols and aridisols and are moderately to strongly alkaline with pH values in the range of 8.0 to 9.1 (Battelle, 1998). Based on USDA soil surveys, pH ranges from 7.4 to 8.4 (USDA NRCS, 1999). Surface soil pH readings collected during the 2014 site visit at the adjacent Range 3 were 7.31 in the berm and 7.98 in the range drainage pathway.

Range 2A (and the entire MTU) contains soils characterized as Cajon loamy sand, 2 to 8 percent slopes. This soil series consists of loamy sand and loamy coarse sands, that are very deep, somewhat excessively drained soils with negligible to low runoff (NRCS, 2002).

A protective berm is present behind the rear impact berm as well as along the northern side of the range to prevent run-on of surface water from the higher elevations to the north. The face of the impact berm is treated with a copolymer soil stabilizer to prevent erosion of the berm.

RANGE 2A
MCAGCC TWENTYNINE PALMS

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	1
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	0
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%	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	1
Groundwater Pathway Score *Minimum: 4* *Maximum: 27*			15

Notes:

The average amount of rainfall at Twentynine Palms is between 3 and 4 inches per year (USDA NRCS, 1999).

RANGE 2A
MCAGCC TWENTYNINE PALMS

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 nearest depth-to-groundwater measurement is from a well approximately 1.3 mile west of the range (IRP Site 16). Depth to groundwater at that point was approximately 400 feet (Battelle 1998). Range 2A (and the entire MTU) contains soils characterized as Cajon loamy sand, 2 to 8 percent slopes. This soil series consists of loamy sand and loamy coarse sands, that are very deep, somewhat excessively drained soils with negligible to low runoff (NRCS, 2002). The berms are covered by less than 10% vegetation. The area contains patches of creosote bushes and other scrub. The average slope from the Range 2A deposition area to the storm sewers on Del Valle is approximately 4.7%. The soils at the MTU are classified as entisols and aridisols and are moderately to strongly alkaline with pH values in the range of 8.0 to 9.1 (Battelle, 1998). Based on USDA soil surveys, pH ranges from 7.4 to 8.4 (USDA NRCS, 1999). Surface soil pH readings collected during the 2014 site visit at the adjacent Range 3 were 7.31 in the berm and 7.98 in the range drainage pathway.			

RANGE 2A
MCAGCC TWENTYNINE PALMS

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	0
Surface Water Receptor Score *Minimum: 0 Maximum: 16*			4

Notes:

According to the USGS National Hydrography Map, the closest downgradient surface water body to Range 2A is an ephemeral stream located approximately 3,500 feet to the northwest (USGS, 2014).

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 northwest towards an ephemeral stream that generally flows southwest. According to the USGS National Hydrography Map, the ephemeral stream terminates at the installation golf course approximately 2.1 miles from the bullet deposition area. From this point, the installation boundary is approximately 1 mile downgradient.

RANGE 2A
MCAGCC TWENTYNINE PALMS

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	6
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:

Water supply wells are located in the Surprise Springs groundwater basin, located 10 miles west-northwest of the MTU. All wells draw water from the unconfined portions of the upper and middle aquifers. Surprise Springs is located upgradient of the Mesquite Basin. The Mesquite Basin is not used as a drinking water source because of high mineral content. The known depth to groundwater near the MTU is approximately 400 feet.

There are no known agricultural wells located on the installation. Surface water and stormwater are used for irrigation purposes. Based on soil sampling results from the Small Arms Range Maintenance and Repair Project at MCAGCC Twentynine Palms (Battelle, 1998) and previous Navy studies, the vertical migration of lead in the soil column is between four and eight inches from the soil surface.

While groundwater is likely found at shallow depths near playas, there are no known groundwater discharge locations near the range which could result in lead migration from groundwater to surface water.

RANGE 2A
MCAGCC TWENTYNINE PALMS

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	7
Surface Water / Sediment Pathways	2	13
Surface Water / Sediment Receptors	4	4
Sum of Surface Water / Sediment Element Scores *Minimum: 0 Maximum: 65*		**24**

Groundwater

Element	Table	Score
Range Use and Range Management (Source)	1	7
Groundwater Pathways	3	15
Groundwater Receptors	5	6
Sum of Groundwater Element Scores *Minimum: 0 Maximum: 62*		**28**

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	**Minimal**
Groundwater Evaluation Ranking	**Minimal**

Notes:

RANGE 3
MCAGCC TWENTYNINE PALMS
Twentynine Palms – San Bernardino County, California

Date of SARAP update: 9 September 2014

DESCRIPTION

Range Mission:	Multi-purpose rifle/pistol range
Training Start Date:	1974
Direction of Fire:	Northeast
Firing Positions:	20
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: Berm face treated with copolymer soil stabilizer.
Reference(s):	

FINDINGS

Review Period		**Periodic Review**
Estimated Lead Deposition (lb/yr)		509
Surface Water / Sediment	***RANK***	Minimal
	Source	10
	Pathway	13
	Receptor	4
	TOTAL SCORE	27
Groundwater	***RANK***	Minimal
	Source	10
	Pathway	15
	Receptor	6
	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.

RANGE 3
MCAGCC TWENTYNINE PALMS

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:

Approximately 509 pounds of lead are deposited annually on Range 3 between 2011 and 2014.

Range 3 has been used for operational training since 1974 (USACE, 2001).

According to Range Control personnel, the bullet trap at Range 3 was removed in 2013.

RANGE 3
MCAGCC TWENTYNINE PALMS

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	4
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%	6
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	1
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

RANGE 3
MCAGCC TWENTYNINE PALMS

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*			13

Notes:

The average amount of rainfall at Twentynine Palms is between 3 and 4 inches per year (USDA NRCS, 1999).

The berms are covered by less than 10% vegetation. The area contains patches of creosote bushes and other scrub.

The average slope from the Range 3 deposition area to the storm sewers on Del Valle is approximately 4.7%.

The soils at the MTU are classified as entisols and aridisols and are moderately to strongly alkaline with pH values in the range of 8.0 to 9.1 (Battelle, 1998). Based on USDA soil surveys, pH ranges from 7.4 to 8.4 (USDA NRCS, 1999). Surface soil pH readings collected during the 2014 site visit were 7.31 in the berm and 7.98 in the range drainage pathway.

Range 3 (and the entire MTU) contains soils characterized as Cajon loamy sand, 2 to 8 percent slopes. This soil series consists of loamy sands and loamy coarse sands, that are very deep, somewhat excessively drained soils with negligible to low runoff (NRCS, 2002).

The face of the impact berm is treated with a copolymer soil stabilizer to prevent erosion of the berm. The range is also equipped with side berms to prevent surface water run-on.

RANGE 3
MCAGCC TWENTYNINE PALMS

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	1
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	0
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%	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	1
Groundwater Pathway Score *Minimum: 4* *Maximum: 27*			15

Notes:

The average amount of rainfall at Twentynine Palms is between 3 and 4 inches per year (USDA NRCS, 1999).

RANGE 3
MCAGCC TWENTYNINE PALMS

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 nearest depth-to-groundwater measurement is from a well approximately 1.3 mile west of the range (IRP Site 16). Depth to groundwater at that point was approximately 400 feet (Battelle 1998). Range 3 (and the entire MTU) contains soils characterized as Cajon loamy sand, 2 to 8 percent slopes. This soil series consists of loamy sands and loamy coarse sands, that are very deep, somewhat excessively drained soils with negligible to low runoff (NRCS, 2002). The berms are covered by less than 10% vegetation. The area contains patches of creosote bushes and other scrub. The average slope from the Range 3 deposition area to the storm sewers on Del Valle is approximately 4.7%. The soils at the MTU are classified as entisols and aridisols and are moderately to strongly alkaline with pH values in the range of 8.0 to 9.1 (Battelle, 1998). Based on USDA soil surveys, pH ranges from 7.4 to 8.4 (USDA NRCS, 1999). Surface soil pH readings collected during the 2014 site visit were 7.31 in the berm and 7.98 in the range drainage pathway.			

RANGE 3
MCAGCC TWENTYNINE PALMS

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	0
Surface Water Receptor Score *Minimum: 0 Maximum: 16*			4

Notes:

According to the USGS National Hydrography Map, the closest downgradient surface water body to Range 3 is an ephemeral stream located approximately 3,600 feet to the northwest (USGS, 2014).

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 northwest towards an ephemeral stream that generally flows southwest. According to the USGS National Hydrography Map, the ephemeral stream terminates at the installation golf course approximately 2.2 miles from the bullet deposition area. From this point, the installation boundary is approximately 1 mile downgradient.

RANGE 3
MCAGCC TWENTYNINE PALMS

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	6
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:

Water supply wells are located in the Surprise Springs groundwater basin, located 10 miles west-northwest of the MTU. All wells draw water from the unconfined portions of the upper and middle aquifers. Surprise Springs is located upgradient of the Mesquite Basin. The Mesquite Basin is not used as a drinking water source because of high mineral content. The known depth to groundwater near the MTU is approximately 400 feet.

There are no known agricultural wells located on the installation. Surface water and stormwater are used for irrigation purposes. Based on soil sampling results from the Small Arms Range Maintenance and Repair Project at MCAGCC Twentynine Palms (Battelle, 1998) and previous Navy studies, the vertical migration of lead in the soil column is between four and eight inches from the soil surface.

While groundwater is likely found at shallow depths near playas, there are no known groundwater discharge locations near the range which could result in lead migration from groundwater to surface water.

RANGE 3
MCAGCC TWENTYNINE PALMS

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	13
Surface Water / Sediment Receptors	4	4
Sum of Surface Water / Sediment Element Scores *Minimum: 0 Maximum: 65*		**27**

Groundwater		
Element	**Table**	**Score**
Range Use and Range Management (Source)	1	10
Groundwater Pathways	3	15
Groundwater Receptors	5	6
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** ☒ 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	**Minimal**
Groundwater Evaluation Ranking	**Minimal**

Notes:

RANGE 3A
MCAGCC TWENTYNINE PALMS
Twentynine Palms – San Bernardino County, California

Date of SARAP update: 9 September 2014

DESCRIPTION

Range Mission:	Rifle field expedient BZO/grouping range
Training Start Date:	1969
Direction of Fire:	Northeast
Firing Positions:	50
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: Berm face treated with copolymer soil stabilizer.
Reference(s):	

FINDINGS

Review Period		**Periodic Review**
Estimated Lead Deposition (lb/yr)		2,881
Surface Water / Sediment	***RANK***	Minimal
	Source	13
	Pathway	15
	Receptor	4
	TOTAL SCORE	32
Groundwater	***RANK***	Moderate
	Source	13
	Pathway	16
	Receptor	6
	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.

RANGE 3A
MCAGCC TWENTYNINE PALMS

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:

Approximately 2,881 pounds of lead were deposited on Range 3A between 2011 and 2014.

Range 3A has been used for operational training since 1969 (USACE, 2001). The range was initially established as the Skeet Range Facility #2135 and the Small Arms Range, Facility #2142, in 1969.

It is listed in the Archives Search Report as the Moving Target Pistol Range (USACE, 2001).

Lead recovery has not been conducted at this range. Sand is periodically added to the face of the berm where bullet pockets are formed from range use.

RANGE 3A
MCAGCC TWENTYNINE PALMS

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	4
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%	6
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	1
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

RANGE 3A
MCAGCC TWENTYNINE PALMS

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**
	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:

The average amount of rainfall at Twentynine Palms is between 3 and 4 inches per year (USDA NRCS, 1999).

The berms are covered by less than 10% vegetation. The area contains patches of creosote bushes and other scrub.

The average slope from the Range 3A deposition area to the storm sewers on Del Valle is approximately 4%.

The soils at the MTU are classified as entisols and aridisols and are moderately to strongly alkaline with pH values in the range of 8.0 to 9.1 (Battelle, 1998). Based on USDA soil surveys, the pH of the soil map symbol ranges from 7.4 to 8.4 (USDA NRCS, 1999). Surface soil pH readings collected during the 2014 site visit were 6.88 at the base of the impact berm and 7.49 at the range floor.

Range 3A (and the entire MTU) contains soils characterized as Cajon loamy sand, 2 to 8 percent slopes. This soil series is composed of loamy sand and loamy coarse sand, that are very deep, somewhat excessively drained soils with negligible to low runoff (NRCS, 2002). Bullet pockets were observed in the face of the impact berm.

Minor erosion was observed along the side and main impact berms.

The range is equipped with side berms and impact berm which aid in preventing run-on. As with the other ranges in the MTU, the impact berm regularly is treated with a copolymer soil stabilizer to prevent erosion on the face of the impact berm.

RANGE 3A
MCAGCC TWENTYNINE PALMS

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	1
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	0
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%	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*			16

Notes:

The average amount of rainfall at Twentynine Palms is between 3 and 4 inches per year (USDA NRCS, 1999).

The nearest depth-to-groundwater measurement is from a well approximately 1.3 mile west of the range

RANGE 3A
MCAGCC TWENTYNINE PALMS

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**
(IRP Site 16). Depth to groundwater at that point was approximately 400 feet (Battelle, 1998). Range 3A (and the entire MTU) contains soils characterized as Cajon loamy sand, 2 to 8 percent slopes. This soil series is composed of loamy sand and loamy coarse sand, that are very deep, somewhat excessively drained soils with negligible to low runoff (NRCS, 2002). The berms are covered by less than 10% vegetation. The area contains patches of creosote bushes and other scrub. The average slope from the Range 3A deposition area to the storm sewers on Del Valle is approximately 4%. The soils at the MTU are classified as entisols and aridisols and are moderately to strongly alkaline with pH values in the range of 8.0 to 9.1 (Battelle, 1998). Based on USDA soil surveys, the pH of the soil map symbol ranges from 7.4 to 8.4 (USDA NRCS, 1999). Surface soil pH readings collected during the 2014 site visit were 6.88 at the base of the impact berm and 7.49 at the range floor.			

RANGE 3A
MCAGCC TWENTYNINE PALMS

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	0
Surface Water Receptor Score *Minimum: 0 Maximum: 16*			4

Notes:

According to the USGS National Hydrography Map, the closest downgradient surface water body to Range 3A is an ephemeral stream located approximately 1,900 feet to the southeast (USGS, 2014).

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 southeast towards an ephemeral stream that generally flows southeast. According to the USGS National Hydrography Map, the drainage pathway from Range 3A crosses the installation boundary approximately 4 miles southeast from the bullet deposition area.

RANGE 3A
MCAGCC TWENTYNINE PALMS

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	6
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:

Water supply wells are located in the Surprise Springs groundwater basin, located 10 miles west-northwest of the MTU. All wells draw water from the unconfined portions of the upper and middle aquifers. Surprise Springs is located upgradient of the Mesquite Basin. The Mesquite Basin is not used as a drinking water source because of high mineral content. The known depth to groundwater near the MTU is approximately 400 feet.

There are no known agricultural wells located on the installation. Surface water and stormwater are used for irrigation purposes. Based on soil sampling results from the Small Arms Range Maintenance and Repair Project at MCAGCC Twentynine Palms (Battelle, 1998) and previous Navy studies, the vertical migration of lead in the soil column is between four and eight inches from the soil surface.

While groundwater is likely found at shallow depths near playas, there are no known groundwater discharge locations near the range which could result in lead migration from groundwater to surface water.

RANGE 3A
MCAGCC TWENTYNINE PALMS

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	15
Surface Water / Sediment Receptors	4	4
Sum of Surface Water / Sediment Element Scores *Minimum: 0 Maximum: 65*		**32**

Groundwater

Element	Table	Score
Range Use and Range Management (Source)	1	13
Groundwater Pathways	3	16
Groundwater Receptors	5	6
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** ☒ 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	**Minimal**
Groundwater Evaluation Ranking	**Moderate**

Notes:

RANGE 101
MCAGCC TWENTYNINE PALMS
Twentynine Palms – San Bernardino County, California

Date of SARAP update: 9 September 2014

DESCRIPTION

Range Mission:	Small arms BZO, CMP tables 3 and 4
Training Start Date:	1980
Direction of Fire:	Northeast
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)		1,415
Surface Water / Sediment	***RANK***	Moderate
	Source	11
	Pathway	16
	Receptor	8
	TOTAL SCORE	35
Groundwater	***RANK***	Moderate
	Source	11
	Pathway	16
	Receptor	6
	TOTAL SCORE	33

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.

RANGE 101
MCAGCC TWENTYNINE PALMS

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:

Approximately 1,415 pounds of lead were deposited on Range 101 between 2011 and 2014.

Range 101 has been used for operational training since 1980. It was first documented in the 1984 Range Standard Operating Procedure (MCAGCC Twentynine Palms, 1984). Range 101 was combined with Range 101A after the 2006 REVA Baseline Assessment (ARCADIS/Malcolm Pirnie, 2011).

The range does not have a specific impact berm; lead recovery is not conducted at this range.

RANGE 101
MCAGCC TWENTYNINE PALMS

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	4
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%	6
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	1
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

RANGE 101
MCAGCC TWENTYNINE PALMS

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*			16

Notes:

The average amount of rainfall at Twentynine Palms is between 3 and 4 inches per year (USDA NRCS, 1999).

The range is covered by less than 10% vegetation. The area contains patches of creosote bushes and other scrub.

The average slope from the Range 101 deposition area to the gully to the west is approximately 4.9%.

The range contains soils characterized as Bluepoint sand, 2 to 8 percent slopes. This soil series consists of very deep, somewhat excessively drained, predominately sandy soils with very low or low runoff and rapid infiltration (NRCS, 2006). Based on the USDA soil survey, the pH of the soil map symbol ranges from 7.4 to 8.4 (USDA NRCS, 1999). Surface soil pH readings collected during the 2014 site visit from the range floor at approximately 100 yards and 250 yards down-range were 6.76 and 6.85, respectively.

Based on aerial photographs and site reconnaissance, there are no engineered controls present at the site to prevent erosion or to control surface water. Two large surface drainages bisect the northern and central sections of the range fan.

RANGE 101
MCAGCC TWENTYNINE PALMS

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	1
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	1
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%	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	1
Groundwater Pathway Score *Minimum: 4 Maximum: 27*			16

Notes:

The average amount of rainfall at Twentynine Palms is between 3 and 4 inches per year (USDA NRCS, 1999).

RANGE 101
MCAGCC TWENTYNINE PALMS

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 groundwater well is located on the southwestern edge of Deadman Lake, located approximately 2 miles from Range 101. The depth to groundwater at the well was about 25 feet below ground surface when it was measured in 1982 (USGS, 1984). However, there is a geologic groundwater barrier located under Deadman Lake. The depth to groundwater east of Deadman Lake is generally unknown. The downgradient groundwater flow is towards Mainside, which is of generally poor water quality due to high mineral content. The range contains soils characterized as Bluepoint sand, 2 to 8 percent slopes. This soil series is consists of very deep, somewhat excessively drained, predominantly sandy soils with very low or low runoff and rapid infiltration (NRCS, 2006). The range is covered by less than 10% vegetation. The area contains patches of creosote bushes and other scrub. The average slope from the Range 101 deposition area to the gully to the west is approximately 4.9%. Bluepoint sands, which are typically associated with Sandhill soil types are generally slightly alkaline to strongly alkaline (USDA NCRS – Official Soil Description). Based on the USDA soil survey, the pH of the soil map symbol ranges from 7.4 to 8.4 (USDA NRCS, 1999). Surface soil pH readings collected during the 2014 site visit from the range floor at approximately 100 yards and 250 yards down-range were 6.76 and 6.85, respectively.			

RANGE 101
MCAGCC TWENTYNINE PALMS

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, the closest surface water body to Range 101 is an ephemeral stream located downgradient approximately 730 feet to the northwest (USGS, 2014).

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 northwest towards an ephemeral stream that generally flows 0.7 miles southwest. According to the USGS National Hydrography Map, the ephemeral stream terminates just prior to reaching Deadman Lake which is an additional 0.73 miles downgradient from that point. Upon reaching Deadman Lake, the surface water from Range 101 either infiltrates or evaporates. Since the installation boundary is upgradient from Deadman Lake, the drainage pathway from Range 101 does not cross the installation boundary.

RANGE 101
MCAGCC TWENTYNINE PALMS

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	6
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:

The depth to water at the well on the southwestern edge of Deadman Lake is 25 feet below ground surface; given the higher elevation, it is likely the depth to water is greater 1.25 miles to the east where the range is located.

There are no water supply wells near Range 101. Water supply wells are located in the Surprise Springs groundwater basin, located approximately 7.5 miles to the west. All wells draw water from the unconfined portions of the upper and middle aquifers. Surprise Springs is located upgradient of the range and is hydrogeologically separated from the range by a large fault. The downgradient groundwater basin, Mesquite Basin, is not used as a drinking water source because of high mineral content.

There are no known agricultural wells located on MCAGCC. Surface water and stormwater are used for irrigation purposes. The surface water that accumulates in Deadman Lake generally evaporates.

RANGE 101
MCAGCC TWENTYNINE PALMS

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	16
Surface Water / Sediment Receptors	4	8
Sum of Surface Water / Sediment Element Scores *Minimum: 0 Maximum: 65*		**35**

Groundwater

Element	Table	Score
Range Use and Range Management (Source)	1	11
Groundwater Pathways	3	16
Groundwater Receptors	5	6
Sum of Groundwater Element Scores *Minimum: 0 Maximum: 62*		**33**

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	**Moderate**

Notes:

RANGE 103
MCAGCC TWENTYNINE PALMS
Twentynine Palms – San Bernardino County, California

Date of SARAP update: 9 September 2014

DESCRIPTION

Range Mission:	Squad defensive fire range (automated)
Training Start Date:	Unknown
Direction of Fire:	Northeast
Firing Positions:	12
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)		1,572
Surface Water / Sediment	***RANK***	Moderate
	Source	11
	Pathway	14
	Receptor	8
	TOTAL SCORE	33
Groundwater	***RANK***	Moderate
	Source	11
	Pathway	16
	Receptor	6
	TOTAL SCORE	33

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.

RANGE 103
MCAGCC TWENTYNINE PALMS

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:

Approximately 1,572 pounds of lead were deposited annually on Range 103 between 2011 and 2014.

It is unknown when operational training was initiated on Range 103.

The range does not have a specific impact berm; lead recovery is not conducted at this range.

RANGE 103
MCAGCC TWENTYNINE PALMS

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	4
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%	6
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	1
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	1
	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

RANGE 103
MCAGCC TWENTYNINE PALMS

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*			14

Notes:

The average amount of rainfall at Twentynine Palms between 3 and 4 inches per year (USDA NRCS, 1999).

The range is covered by less than 10% vegetation. The area contains patches of creosote bushes and other scrub.

The average slope from the Range 103 deposition area to the surface drainage gully to the west is approximately 4.5%.

The range contains soils characterized as Arizo, dry-Twobitter association, 2 to 8 percent slopes. This soil consists of stratified extremely gravelly coarse sand to very gravelly coarse sand. Based on the USDA soil survey, the pH of the soil map symbol ranges from 7.9 to 8.4 (USDA NRCS, 1999). Surface soil pH readings collected during the 2014 site visit on the range floor of the adjacent Range 101 were 6.76 at approximately 100 yards down-range, and 6.85 at approximately 250 yards down-range.

A large surface drainage gully flows from the central section of the range fan towards the west. Based on aerial photographs it appears a drainage pathway is in place surrounding the northern perimeter of the target locations diverting surface water flow around the range thus reducing run-on. There appear to be no engineering controls in place to prevent run-off/erosion.

RANGE 103
MCAGCC TWENTYNINE PALMS

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	1
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	1
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%	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	1
Groundwater Pathway Score *Minimum: 4* *Maximum: 27*			16

Notes:

The average amount of rainfall at Twentynine Palms is between 3 and 4 inches per year (USDA NRCS, 1999).

A groundwater well is located on the southwestern edge of Deadman Lake, located approximately 2

RANGE 103
MCAGCC TWENTYNINE PALMS

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**
miles from Range 103. The depth to groundwater at the well was about 100 ft below ground surface when it was measured in 1982 (USGS, 1984). However, there is a geologic groundwater barrier located under Deadman Lake. The depth to groundwater east of Deadman Lake is generally unknown. The downgradient groundwater flow is towards Mainside, which is of generally poor water quality due to high mineral content. The range contains soils characterized as Arizo, dry-Twobitter association, 2 to 8 percent slopes. This soil consists of stratified extremely gravelly coarse sand to very gravelly coarse sand. Based on the USDA soil survey, the pH of the soil map symbol ranges from 7.9 to 8.4 (USDA NRCS, 1999). Surface soil pH readings collected during the 2014 site visit on the range floor of the adjacent Range 101 were 6.76 at approximately 100 yards down-range, and 6.85 at approximately 250 yards down-range. The range is covered by less than 10% vegetation. The area contains patches of creosote bushes and other scrub. The average slope from the Range 103 deposition area to the surface drainage gully to the west is approximately 4.5%.			

RANGE 103
MCAGCC TWENTYNINE PALMS

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, the closest surface water body to Range 103 is an ephemeral stream located approximately 1,400 feet downgradient to the south of the bullet deposition area (USGS, 2014).

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 south towards an ephemeral stream that generally flows 0.4 miles southwest. According to the USGS National Hydrography Map, the ephemeral stream terminates just prior to reaching Deadman Lake which is an additional 0.73 miles downgradient from that point. Upon reaching Deadman Lake, the surface water from Range 103 either infiltrates or evaporates. Since the installation boundary is upgradient from Deadman Lake, the drainage pathway from Range 103 does not cross the installation boundary.

RANGE 103
MCAGCC TWENTYNINE PALMS

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	6
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:

The depth to water at the well on the southwestern edge of Deadman Lake is 100 feet below ground surface; given the higher elevation, it is likely the depth to water is greater 1.25 miles to the east where the range is located.

There are no water supply wells near Range 103. Water supply wells are located in the Surprise Springs groundwater basin, located approximately 7.5 miles to the west. All wells draw water from the unconfined portions of the upper and middle aquifers. Surprise Springs is located upgradient of the range and is hydrogeologically separated from the range by a large fault. The downgradient groundwater basin, Mesquite Basin, is not used as a drinking water source because of high mineral content.

There are no known agricultural wells located on MCAGCC. Surface water and stormwater are used for irrigation purposes. The surface water that accumulates in Deadman Lake generally evaporates.

RANGE 103
MCAGCC TWENTYNINE PALMS

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	14
Surface Water / Sediment Receptors	4	8
Sum of Surface Water / Sediment Element Scores *Minimum: 0 Maximum: 65*		**33**

Groundwater

Element	Table	Score
Range Use and Range Management (Source)	1	11
Groundwater Pathways	3	16
Groundwater Receptors	5	6
Sum of Groundwater Element Scores *Minimum: 0 Maximum: 62*		**33**

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	**Moderate**

Notes:

RANGE 106A
MCAGCC TWENTYNINE PALMS
Twentynine Palms – San Bernardino County, California

Date of SARAP update: 9 September 2014

DESCRIPTION

Range Mission:	Machine gun certification
Training Start Date:	Training as SAR started in 2012
Direction of Fire:	Northeast
Firing Positions:	12
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)		3,987
Surface Water / Sediment	***RANK***	Moderate
	Source	14
	Pathway	15
	Receptor	4
	TOTAL SCORE	33
Groundwater	***RANK***	Moderate
	Source	14
	Pathway	16
	Receptor	6
	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.

RANGE 106A
MCAGCC TWENTYNINE PALMS

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	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*			14

Notes:

Approximately 3,987 pounds of lead were deposited annually on Range 106A between 2012 and 2014.

Range 106A has been used for small arms operational training since 2012.

The range does not have a specific impact berm; lead recovery is not conducted at this range.

RANGE 106A
MCAGCC TWENTYNINE PALMS

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	4
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%	6
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	1
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	1
	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

RANGE 106A
MCAGCC TWENTYNINE PALMS

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*			15

Notes:

The average amount of rainfall at Twentynine Palms is between 3 and 4 inches per year (USDA NRCS, 1999).

The range is covered by less than 10% vegetation. The area contains patches of creosote bushes and other scrub.

Range 106A drains from the deposition area southwest towards the firing line and then into Deadman Lake. The average slope from the Range 106A deposition area to Deadman Lake is approximately 4.8%.

The range contains soils characterized as Arizo, dry-Twobitter association, 2 to 8 percent slopes. This soil consists of stratified extremely gravelly coarse sand to very gravelly coarse sand. Based on the USDA soil survey, Arizo soil pH ranges from 7.9 to 8.4 (USDA NRCS, 1999). Surface soil pH readings collected during the 2014 site visit on the range floor from the nearby Range 101 were 6.76 at approximately 100 yard down-range, and 6.85 at approximately 250 yards down range.

RANGE 106A
MCAGCC TWENTYNINE PALMS

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	1
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	1
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%	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	1
Groundwater Pathway Score *Minimum: 4* *Maximum: 27*			16

Notes:

The average amount of rainfall at Twentynine Palms is between 3 and 4 inches per year (USDA NRCS, 1999).

A groundwater well is located on the southwestern edge of Deadman Lake, located approximately 1.5

RANGE 106A
MCAGCC TWENTYNINE PALMS

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**
miles west of Range 106A. The depth to groundwater at the well was about 100 ft below ground surface when it was measured in 1982 (USGS, 1984). However, there is a geologic groundwater barrier located under Deadman Lake. The depth to groundwater east of Deadman Lake is generally unknown. The downgradient groundwater flow is towards Mainside, which is of generally poor water quality due to high mineral content. The range contains soils characterized as Arizo, dry-Twobitter association, 2 to 8 percent slopes. This soil consists of stratified extremely gravelly coarse sand to very gravelly coarse sand. The range is covered by less than 10% vegetation. The area contains patches of creosote bushes and other scrub. Range 106A drains from the deposition area southwest towards the firing line and then into Deadman Lake. The average slope from the Range 106A deposition area to Deadman Lake is approximately 4.8%. Based on the USDA soil survey, Arizo soil pH ranges from 7.9 to 8.4 (USDA NRCS, 1999). Surface soil pH readings collected during the 2014 site visit on the range floor from the nearby Range 101 were 6.76 at approximately 100 yards down-range, and 6.85 at approximately 250 yards down-range.			

RANGE 106A
MCAGCC TWENTYNINE PALMS

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	0
Surface Water Receptor Score *Minimum: 0 Maximum: 16*			4

Notes:

According to the USGS National Hydrography Map, the closest surface water body to Range 106A is Deadman Lake located approximately 1,600 feet downgradient to the southwest of the bullet deposition area (USGS, 2014).

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 southwest towards Deadman Lake which is approximately 0.3 miles downgradient from the range. Upon reaching Deadman Lake, the surface water from Range 106A either infiltrates or evaporates. Since the installation boundary is upgradient from Deadman Lake, the drainage pathway from Range 106A does not cross the installation boundary.

RANGE 106A
MCAGCC TWENTYNINE PALMS

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	6
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:

The depth to water at the well on the southwestern edge of Deadman Lake is 100 feet below ground surface; given the higher elevation, it is likely the depth to water is greater 1.50 miles to the east where the range is located.

There are no water supply wells near Range 106A. Water supply wells are located in the Surprise Springs groundwater basin, located approximately 7 miles to the west. All wells draw water from the unconfined portions of the upper and middle aquifers. Surprise Springs is located upgradient of the range and is hydrogeologically separated from the range by a large fault. The downgradient groundwater basin, Mesquite Basin, is not used as a drinking water source because of high mineral content.

There are no known agricultural wells located on MCAGCC. Surface water and stormwater are used for irrigation purposes. The surface water that accumulates in Deadman Lake generally evaporates.

RANGE 106A
MCAGCC TWENTYNINE PALMS

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	14
Surface Water / Sediment Pathways	2	15
Surface Water / Sediment Receptors	4	4
Sum of Surface Water / Sediment Element Scores *Minimum: 0 Maximum: 65*		**33**

Groundwater

Element	Table	Score
Range Use and Range Management (Source)	1	14
Groundwater Pathways	3	16
Groundwater Receptors	5	6
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** ☒ 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	**Moderate**

Notes:

RANGE 113A
MCAGCC TWENTYNINE PALMS
Twentynine Palms – San Bernardino County, California

Date of SARAP update: 9 September 2014

DESCRIPTION

Range Mission:	Machine gun BZO/EMP range
Training Start Date:	Approximately 1998
Direction of Fire:	Northeast/east
Firing Positions:	Variable
Target Range:	Up to 100 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)		4,226
Surface Water / Sediment	***RANK***	Moderate
	Source	16
	Pathway	15
	Receptor	4
	TOTAL SCORE	35
Groundwater	***RANK***	Moderate
	Source	16
	Pathway	18
	Receptor	6
	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.

RANGE 113A
MCAGCC TWENTYNINE PALMS

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

Notes:

Approximately 4,226 pounds of lead were deposited annually on Range 113A between 2011 and 2014.

Date of construction of Range 113A is not known. Based on the date that Range 113 was established (1998), it is assumed that the BZO range is approximately the same age.

Lead recovery has not been conducted at this range. Sand is periodically added to the face of the berm where bullet pockets are formed from range use.

RANGE 113A
MCAGCC TWENTYNINE PALMS

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	4
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%	6
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	1
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	1
	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

RANGE 113A
MCAGCC TWENTYNINE PALMS

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*			15

Notes:

The average amount of rainfall at Twentynine Palms is between 3 and 4 inches per year (USDA NRCS, 1999).

The berms are covered by less than 10% vegetation. The area contains patches of creosote bushes and other scrub.

The average slope from the Range 113A deposition area to the drainage gully to the southeast adjacent to Range 113 is approximately 5.3%.

The range contains soils characterized as Arizo, dry-Twobitter association, 2 to 8 percent slopes. This soil consists of stratified extremely gravelly coarse sand to very gravelly coarse sand. Based on the USDA soil survey, Arizo soil pH ranges from 7.9 to 8.4 (USDA NRCS, 1999).

Range 113A is equipped with earthen impact and side berms which help prevent range run-on of surface water from higher elevations to the north.

RANGE 113A
MCAGCC TWENTYNINE PALMS

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	1
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	1
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%	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°)	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	1
Groundwater Pathway Score *Minimum: 4* *Maximum: 27*			18

Notes:

The average amount of rainfall at Twentynine Palms is between 3 and 4 inches per year (USDA NRCS, 1999).

A groundwater well is located on the southwestern edge of Deadman Lake, located approximately 7

RANGE 113A
MCAGCC TWENTYNINE PALMS

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**
miles south of Range 113A. Based on groundwater level measurements near Range 113A within the Deadman Lake subbasin, the depth to groundwater is estimated to range from 93 to 189 feet below ground surface (ARCADIS/Malcolm Pirnie, 2011). The downgradient groundwater flow is towards Mainside, which is of generally poor water quality due to high mineral content The berms are covered by less than 10% vegetation. The area contains patches of creosote bushes and other scrub. The average slope from the Range 113A deposition area to the drainage gully to the southeast adjacent to Range 113 is approximately 1.3%. The range contains soils characterized as Arizo, dry-Twobitter association, 2 to 8 percent slopes. This soil consists of stratified extremely gravelly coarse sand to very gravelly coarse sand. Based on the USDA soil survey, Arizo soil pH ranges from 7.9 to 8.4 (USDA NRCS, 1999).			

RANGE 113A
MCAGCC TWENTYNINE PALMS

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	0
Surface Water Receptor Score *Minimum: 0 Maximum: 16*			4

Notes:

According to the USGS National Hydrography Map, the closest surface water body to Range 113A is an ephemeral stream located approximately 3,500 feet downgradient to the southwest of the bullet deposition area (USGS, 2014).

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 southwest towards an ephemeral stream that generally flows approximately 5.4 miles south towards Deadman Lake. Upon reaching Deadman Lake, the surface water from Range 113A either infiltrates or evaporates. Since the installation boundary is upgradient from Deadman Lake, the drainage pathway from Range 113A does not cross the installation boundary.

RANGE 113A
MCAGCC TWENTYNINE PALMS

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	6
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 are no water supply wells near Range 113A. Water supply wells are located in the Surprise Springs groundwater basin, located approximately 8.5 miles to the west. All wells draw water from the unconfined portions of the upper and middle aquifers. Surprise Springs is located upgradient of the range and is hydrogeologically separated from the range by a large fault. The downgradient groundwater basin, Mesquite Basin, is not used as a drinking water source because of high mineral content.

There are no known agricultural wells located on MCAGCC. Surface water and stormwater are used for irrigation purposes. The surface water that accumulates in Deadman Lake generally evaporates.

There are no groundwater discharge locations near the range which could result in lead migration from groundwater to surface water.

RANGE 113A
MCAGCC TWENTYNINE PALMS

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	15
Surface Water / Sediment Receptors	4	4
Sum of Surface Water / Sediment Element Scores *Minimum: 0 Maximum: 65*		**35**

Groundwater

Element	Table	Score
Range Use and Range Management (Source)	1	16
Groundwater Pathways	3	18
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** ☒ 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	**Moderate**

Notes:

SKEET RANGE
MCAGCC TWENTYNINE PALMS
Twentynine Palms – San Bernardino County, California

Date of SARAP update: 10 September 2014

DESCRIPTION

Range Mission:	Skeet shooting/recreation
Training Start Date:	1970s
Direction of Fire:	Southwest
Firing Positions:	10
Target Range:	300 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)		0
Surface Water / Sediment	***RANK***	Minimal
	Source	8
	Pathway	14
	Receptor	4
	TOTAL SCORE	26
Groundwater	***RANK***	Minimal
	Source	8
	Pathway	16
	Receptor	6
	TOTAL SCORE	30

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.

SKEET RANGE
MCAGCC TWENTYNINE PALMS

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	2
Source Element Score *Minimum: -4 Maximum: 20*			8

Notes:

Installation RFMSS data indicates that only lead-free 12 gauge rounds were used at the Skeet Range during the periodic review period. Therefore, no lead deposition has occurred at the range.

Skeet Range has been in operation since the 1970s (ARCADIS/Malcolm Pirnie, 2012).

The range does not have an impact berm; lead recovery is not conducted at this range.

SKEET RANGE
MCAGCC TWENTYNINE PALMS

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	4
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%	6
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	1
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

SKEET RANGE
MCAGCC TWENTYNINE PALMS

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*			14

Notes:

The average amount of rainfall at Twentynine Palms is between 3 and 4 inches per year (USDA NRCS, 1999).

The range is covered by less than 10% vegetation. The area contains patches of creosote bushes and other scrub.

The average slope from the Skeet Range deposition area to the retention pond directly south of the range is approximately 3.8%.

Based on the USDA soil survey, there is no soil type identified at the Skeet Range (USDA NRCS, 1999). The soil map symbol identification indicates the presence of Miscellaneous water at the Skeet Range. The closest soil type to the range is the Urban land-Cajon complex, which consists of mostly coarse sand and has a slope of 2 to 8 percent. Analytical results for soil samples collected from this range indicate pH ranges from 7.33 to 8.55, representing neutral to slightly alkaline soil conditions (ARCADIS, 2013).

Earthen berms separate the range floor from the closest storm water retention basin; they contain surface water runoff on the range.

SKEET RANGE
MCAGCC TWENTYNINE PALMS

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	1
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	1
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%	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	1
Groundwater Pathway Score *Minimum: 4* *Maximum: 27*			16

Notes:

The average amount of rainfall at Twentynine Palms is between 3 and 4 inches per year (USDA NRCS, 1999).

The Mainside cantonment area, including the Skeet Range, is located in the Mainside subbasin.

SKEET RANGE
MCAGCC TWENTYNINE PALMS

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**
Groundwater has been encountered at 75 feet below ground surface in one well in the Mainside subbasin, though it is more commonly found at more than 200 feet below ground surface (MCAGCC, 2006). The soil type directly underlying the Skeet Range is identified as Miscellaneous water. The closest soil type to the range is the Urban land-Cajon complex, which consists of mostly coarse sand and has a slope of 2 to 8 percent. Analytical results for soil samples collected from this range indicate pH ranges from 7.33 to 8.55, representing neutral to slightly alkaline soil conditions (ARCADIS, 2013). The range is covered by less than 10% vegetation. The area contains patches of creosote bushes and other scrub. The average slope from the Skeet Range deposition area to the retention pond directly south of the range is approximately 3.8%.			

SKEET RANGE
MCAGCC TWENTYNINE PALMS

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	0
Surface Water Receptor Score *Minimum: 0 Maximum: 16*			4

Notes:

According to the USGS National Hydrography Map, the closest downgradient surface water body to the Skeet Range is the Mesquite Lake located approximately 2,700 feet to the south (USGS, 2014).

Surface water is not used as a drinking water source at the installation, and there is no surface water bodies used as drinking water sources within six miles of this range.

The installation boundary is located to the southwest approximately 0.33 miles downgradient of the Skeet Range. However, surface water from this range is discharged into the waste water treatment facility ponds directly south of the Skeet Range less than 50 yards from the range boundary. Based on this, it is unlikely for the drainage pathway from the Skeet Range to reach the installation boundary.

SKEET RANGE
MCAGCC TWENTYNINE PALMS

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	6
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:

Drinking water at MCAGCC Twentynine Palms is provided by 11 groundwater production wells in the Surprise Springs subbasin, which currently is the sole source of potable water within MCAGCC Twentynine Palms. These wells are located in an isolated and restricted area of the installation, approximately 12 miles upgradient of the Skeet Range. All wells draw water from the unconfined portions of the upper and middle aquifers. There are no active water supply wells near the Skeet Range.

SKEET RANGE
MCAGCC TWENTYNINE PALMS

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	8
Surface Water / Sediment Pathways	2	14
Surface Water / Sediment Receptors	4	4
Sum of Surface Water / Sediment Element Scores *Minimum: 0 Maximum: 65*		**26**

Groundwater

Element	Table	Score
Range Use and Range Management (Source)	1	8
Groundwater Pathways	3	16
Groundwater Receptors	5	6
Sum of Groundwater Element Scores *Minimum: 0 Maximum: 62*		**30**

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	**Minimal**
Groundwater Evaluation Ranking	**Minimal**

Notes: