6. Conceptual Site Model

CSMs were developed for the operational ranges at MCAGCC Twentynine Palms. A CSM is a summary of the conditions of an operational range, including the environmental setting, MC loading estimates, and a discussion of potential pathways and receptors. For the REVA, each operational range CSM includes the following:

- MC loading estimates (detailed in **Section 3**)
- Geography, topography, and climate
- Surface water features
- Soil characteristics and land cover
- Erosion potential
- Hydrogeology and groundwater characteristics
- Potential surface water and groundwater pathways
- Potential receptors

Key information sources used in the development of the operational range CSMs included the following:

- Military munitions expenditure data
- MCAGCC FMD GIS data
- IRP site data
- USGS topographic maps and regional groundwater resources report
- USDA NRCS soil survey
- Marine Corps ASR
- Marine Corps PRA

Where detailed information of site-specific characteristics and information did not exist, available regional information was used to estimate local characteristics.

Predicting off-range migration of MC requires the evaluation of potential exposure pathways, such as surface water and groundwater flow characteristics, and possible receptors (human and ecological) that might be affected. To this end, the REVA assessment team developed a CSM to characterize the dynamics at MCAGCC Twentynine Palms that can affect MC migration. The primary components of this CSM include:

- delineation of the MC loading areas;
- identification of REVA indicator MC at individual MC loading areas;
- identification of additional environmental data needs to adequately characterize affected areas; and
- a synthesis of hydrogeologic, geologic, and geomorphologic data, which will assist the identification of potential MC migration pathways and receptors.

Information about the MC loading areas was combined with other environmental data in the screening-level analyses, as necessary, to predict MC migration via surface water and groundwater pathways.

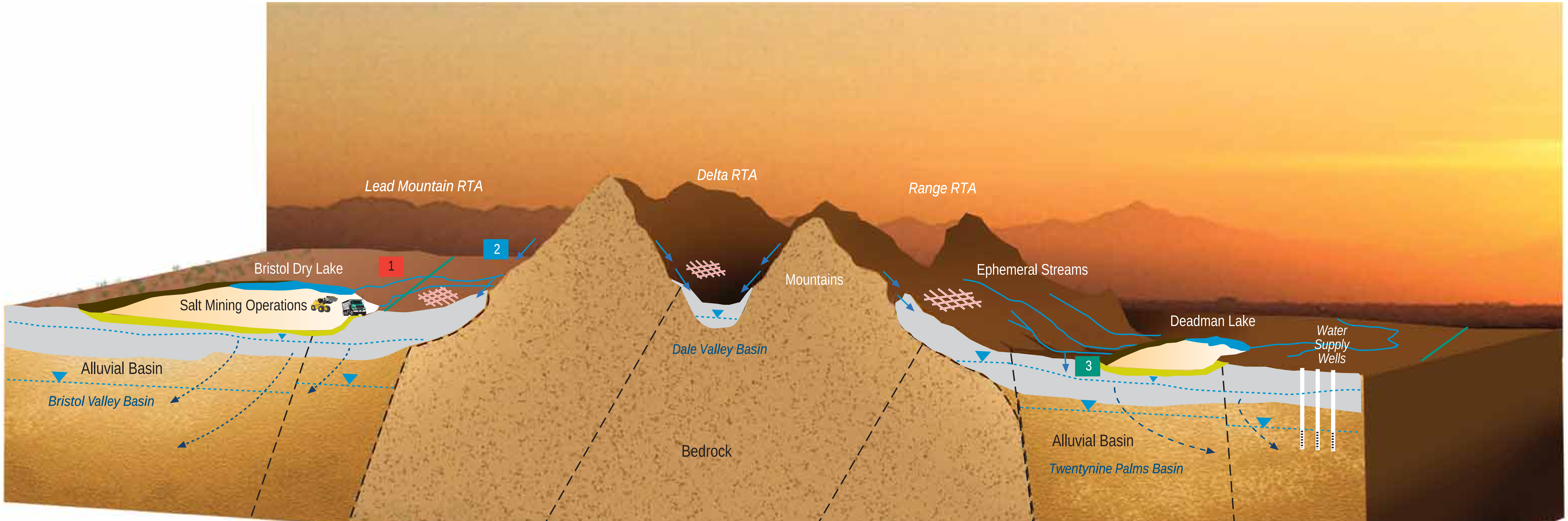
The CSM was developed using information obtained during a site visit, environmental documents obtained from MCAGCC Twentynine Palms, and references on local geologic field studies. Documents obtained from the NREA Division and the installation EOD unit included reports on the installation IRP, site geology and hydrogeology, the water supply system, EOD Ordnance Destroyed Reports, and Range Compatible Use Zone studies.

A schematic diagram depicting the site conditions addressed in the CSM is presented in Figure 6.1-1. The geomorphology of the installation is shown relative to several generalized MC loading areas, the range boundary, and potential receptors (e.g., drinking water wells, ecological receptors) in the alluvial plain. The following sections describe the site characteristics reviewed for the development of the CSM. The site-specific CSMs for the RTAs and primary MC loading areas are provided in **Section 7**.

6.1. Installation Description

MCAGCC Twentynine Palms is located in southern San Bernardino County in the Morongo basin of the Mojave Desert. The installation is approximately 130 miles east of Los Angeles and 54 miles northeast of Palm Springs. The installation is bounded by Interstate 40 to the north and Highway 62 to the south. The areas along the northern, eastern, and western boundaries are undeveloped or sparsely developed. The majority of this land is under the control of the Bureau of Land Management (BLM), including the Johnson Valley Off-Highway Vehicle Area on the western edge of the installation. The southern boundary of the installation is adjacent to the city of Twentynine Palms. Other communities in the vicinity of MCAGCC Twentynine Palms include Joshua Tree, Yucca Valley, and Landers. Other neighboring federal land uses include the Joshua Tree National Park to the south and the Cleghorn Lakes BLM Wilderness Area adjacent to the southeastern corner of the base.

The installation is located in the high desert region of the Mojave Desert and is characterized by rugged terrain consisting of desert, mountains, and a few seasonally wet lake beds (playas). Approximately 99% of the installation area is undeveloped or



NOTES:

1 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. The drinking water wells are depicted to show a potential pathway, but does not represent any exact water well location.

2 This figure illustrates migration pathways that are conceptually possible but there is currently no data documenting actual transport of MC along these pathways.

Three major processes control MC migration:

1 Potential surface water transport from MC loading areas to dry lakes (playas) via ephemeral streams

2 Potential direct groundwater recharge due to washoff into quaternary deposits

3 Potential limited infiltration from ephemeral washes through vadose zone to shallow groundwater

Legend

- Alluvial Basin - Quaternary Deposits
- Alluvial Basin - Tertiary Deposits
- Groundwater Flow Direction
- Primary MC Loading Area
- Ephemeral Streams
- Water Table
- Playa Soil
- Bedrock
- Strike-Slip Faults
- Playa
- Installation Boundary

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

Alluvial Basin-Tertiary Deposits: comprised of poorly sorted medium to coarse 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

MALCOLM PIRNIE

Figure 6.1-1
Conceptual Site Model
Geology and Hydrogeology

MCAGCC Twentynine Palms
Twentynine Palms, CA

unimproved land. The only developed area is at Mainside, located in the southernmost portion of the installation. Mainside contains administration, housing, maintenance, supply and support, and community facilities for the installation.

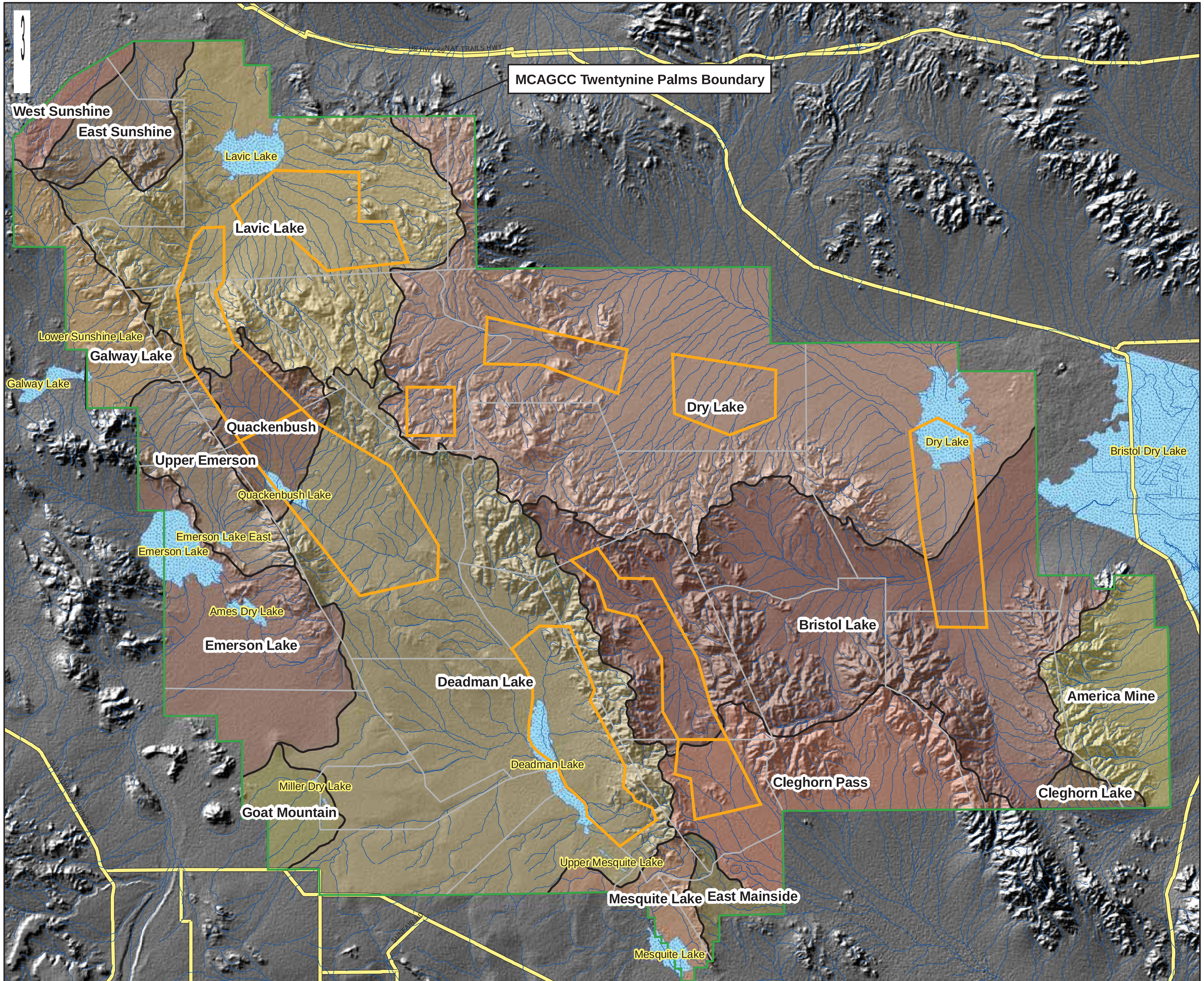
The MCAGCC Twentynine Palms mission is to conduct relevant live-fire combined arms training, urban operations, and joint-/coalition-level integration training that promotes operational forces readiness, as well as to provide the facilities, services, and support responsive to the needs of resident organizations, Marines, Sailors, and their families today and tomorrow (MCAGCC, 2006). MCAGCC Twentynine Palms is the only Marine Corps installation that provides a realistic training environment that allows troops to maneuver through impact areas under conditions simulating combat. MCAGCC Twentynine Palms annually provides training to one-third of the Fleet Marine Force and Reserves units through CAX, Mojave Viper, and numerous other training exercises. The MCAGCC Twentynine Palms training mission is expected to evolve with the development of new weapons systems and tactics (MCAGCC, 2006).

6.2. Geomorphology and Climate

MCAGCC Twentynine Palms is located within the Bullion and Lava Bed mountain ranges, which are part of the Mojave Desert geomorphic province. The majority of the installation lies at elevations ranging between 1,500 and 3,000 feet above mean sea level (amsl). The highest elevation, at 4,699 feet amsl, is in the Bullion Mountains, which trend northwest to southeast across the installation. The lowest elevation, at 604 feet amsl, is in the northeastern corner of the installation near Bristol Dry Lake (USDA NRCS, 1999).

The terrain is characterized by broad alluvial plains, alluvial fans, bedrock uplands, ephemeral washes, playas, lava flows, and sand dunes. The alluvial fans slope from the bedrock highlands into the alluvial plains, with numerous dry washes crossing the alluvial plains toward the playas. During a heavy rainfall event, water flows across the bedrock surface of the mountains into drainage channels and rushes rapidly toward the basin floor. A small amount of the water washing off of the flanks of the mountains infiltrates across the bedrock-alluvial deposit interface, migrating through quaternary deposits (described in **Section 6.3**) to recharge deep aquifers. The ephemeral washes and playas can fill with water after storm events. Some recharge to the groundwater might result from infiltration in these washes, but the infrequency of the storms and the high evaporation rates in the area make this a minor contribution to the total recharge.

At least nine playas are located on the installation (Figure 6.2-1). Volcanic activity is evidenced by Quaternary lava flows in the Lavic Lake and Lava RTAs, as well as several small volcanic craters located in the vicinity of MCAGCC Twentynine Palms. Sand dunes are located throughout the base, but are located primarily along the western flanks of the Bullion and Lava Bed mountains.



REVA
FIGURE 6.2-1
SURFACE WATER FEATURES

MCAGCC TWENTYNINE PALMS
TWENTYNINE PALMS, CA

LEGEND

- MCAGCC TWENTYNINE PALMS
- PRIMARY MC LOADING AREAS
- RTAs
- WATERSHED
- SURFACE WATER (INTERMITTENT)
- WASHES (INTERMITTENT)
- ROAD

Deadman Lake Watershed Boundary Name

Deadman Lake Name of Playa

MCAGCC Twentynine Palms

0 1 2 4 6
Miles

Date: August 2008

Source: MCAGCC/NREA GIS Office 2006
TECOM 2006

The climate at MCAGCC Twentynine Palms is typical of an arid upland desert and is characterized by hot days and cool nights. The yearly mean temperature is 68 degrees Fahrenheit (^{o}F), but temperatures can range from 13^{o}F in January to 118^{o}F in July. Relative humidity ranges from 2% in the summer to 60% in the winter. Across most of the installation area, precipitation averages between 3 and 4 inches per year. At the higher elevations, precipitation may be as high as 7 inches in some years (USDA NRCS, 1999). Winter rainstorms are relatively gentle and occur from November through April. Violent summer thunderstorms occur during July through September and can cause flash flooding throughout the area (The Environmental Company, 2004).

Soils and unconsolidated sediments at MCAGCC Twentynine Palms consist of well-drained sands on the basin floor and excessively drained sandy loams in the mountain valleys. Along the basin floor, a thin veneer of very poorly drained clayey loam (playa soils) covers the playas (NEESA, 1999). Low rainfall combined with high summer temperatures results in accumulation of carbonates, alkali, and other soluble salts from the root zone of desert soils (USDA NRCS, 1999).

6.3. Site Geology

MCAGCC Twentynine Palms is located along the western margins of the Basin and Range physiographic province of southeastern California (USDA NRCS, 1999). This area is characterized by rugged mountain ranges that rise abruptly from broad alluvium-filled desert basins. The mountain ranges are tilted fault blocks that trend northwest to southeast and have been heavily eroded. The mountain ranges are composed mostly of sedimentary rocks, intrusive igneous bodies, metamorphic basement rocks, and/or volcanics (Dibblee, 1967a; Dibblee, 1967b; Dibblee, 1967c; Dibblee, 1968). The alluvium-filled basins commonly are derived from the surrounding bedrock highs and consist of loosely to well consolidated sand, gravel, silt, and clay (Riley and Worts, 1952).

Table 6.3-1 provides the percent distribution of the different geologic units at the installation.

Table 6.3-1: MCAGCC Twentynine Palms Geology

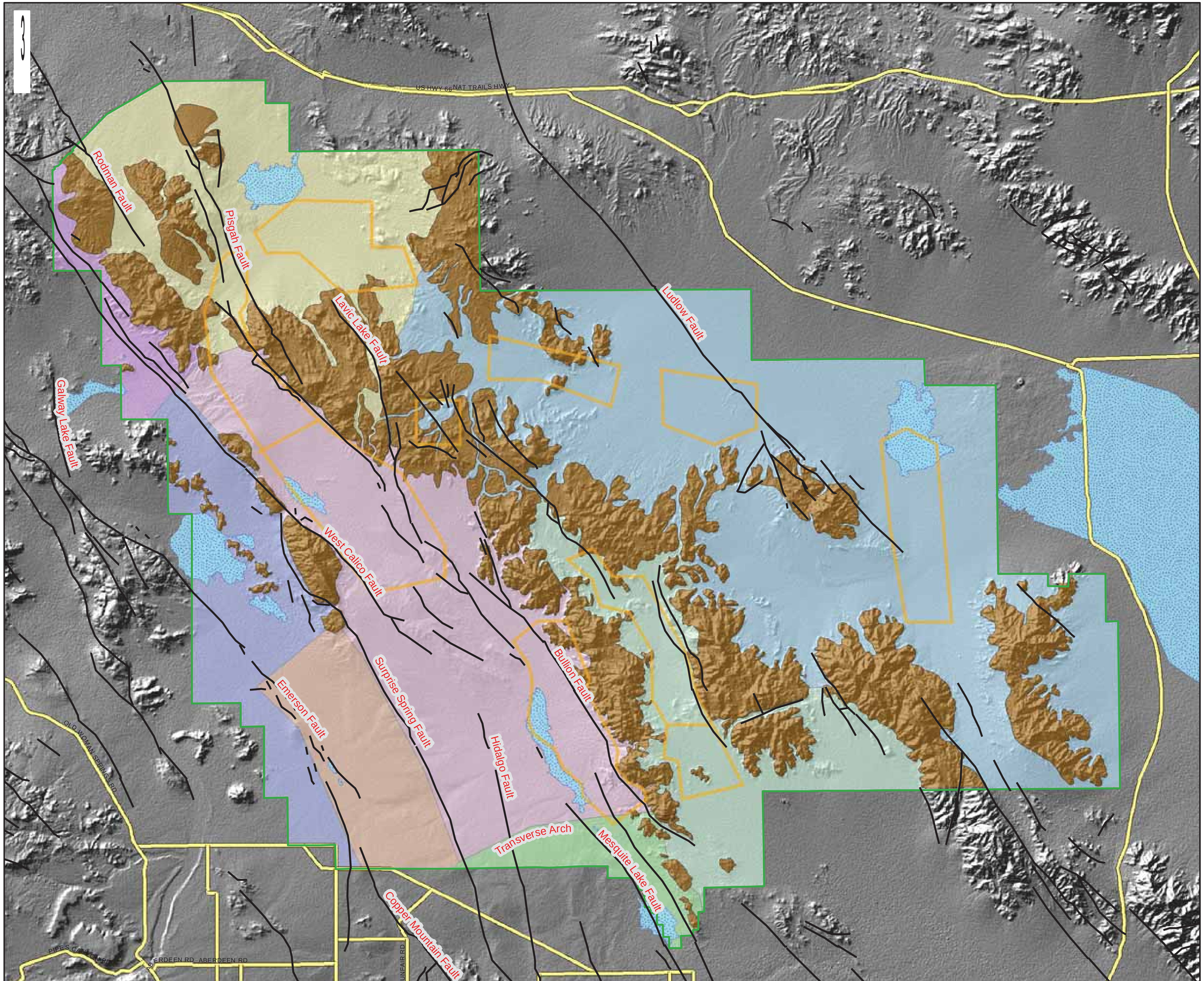
Rock Type	Percent of Installation
Granitic basement	18
Volcanic basement	19
Pleistocene-age nonmarine sediments	15
Holocene-age alluvium	45
Quaternary Dry Lake deposits	3

Source: USDA NRCS, 1999

The Bullion and Lava Bed mountain ranges comprise the majority of the mountainous areas and trend northwest to southeast across the installation (Figure 6.2-1). The mountain ranges consist of crystalline bedrock, which also underlies the basin deposits (Riley et al., 2001). The crystalline bedrock is composed of a Precambrian igneous and metamorphic complex, Jurassic granitic rocks, and Quaternary basalts and related volcanic deposits. The crystalline bedrock is described in greater detail by Riley et al. (2001), Dibblee (1967a, 1967b, 1967c, 1968), and Riley and Worts (1952).

The alluvium-filled basins are located on the flanks of the crystalline bedrock highs and are the dominant surface geologic unit at the installation. The most aerially extensive alluvial basins are located on the northeastern and southwestern flanks of the Bullion and Lava Bed mountains. Smaller sedimentary basins are located within the mountain ranges, such as those found within the Delta and Prospect RTAs (Figure 6.2-1). The basin deposits are a result of two main depositional periods separated by an erosional interval (Riley et al., 2001). The older deposits are Tertiary-aged and compose the bulk of the material within the larger sedimentary basins. The Tertiary deposits can be 2,500 feet (Riley et al., 2001) to 10,500 feet (Akers, 1986) thick in places and are composed of poorly sorted medium to course arkosic sand, silt, and gravel. The younger Quaternary aged deposits lie unconformably on the Tertiary deposits as a zero to 150-foot-thick veneer. The Quaternary deposits are composed primarily of material derived from the uplifted bedrock highs, but also contain reworked sediment from the Tertiary deposits. Additional Quaternary deposits include dune sands, dry wash, and playa deposits. The sedimentary deposits are discussed in greater detail by Riley et al. (2001), Akers (1986), Dibblee (1968), and Riley and Worts (1952).

MCAGCC Twentynine Palms is located in a seismically active area of the Western Mojave Desert known as the Mojave Sheer Zone. The area is characterized by northwest to southeast trending right-lateral strike-slip faults that separate the bedrock highs from basin lows. North- and west-trending faults, as well as a large west trending anticline (Transverse Arch), are observed in the San Bernardino basin to the west of the installation (Riley et al., 2001). These geologic structures divide the basin into several subbasins and can form hydrogeologic barriers to groundwater flow. The most recent seismic event (October 1999) was a rupture along the Lavic fault, which measured 7.1 in magnitude. This event, known as the Hector Mine Earthquake, had a surface rupture of approximately 24 miles long and produced an apparent maximum offset of 12-15 feet. Figure 6.3-1 displays the major faults that are recognized in the area, which include the Bullion, Emerson, Galway Lake, Hidalgo, Ludlow, Mesquite Lake, Pisgah, and West Calico faults (Riley et al., 2001; USDA NRCS, 1999; Riley and Worts, 1952). The Transverse Arch is also labeled in Figure 6.3-1.



REVA
FIGURE 6.3-1
GROUNDWATER BASINS AND GEOLOGIC FAULTS

MCAGCC TWENTYNINE PALMS
TWENTYNINE PALMS, CA

LEGEND

- MCAGCC TWENTYNINE PALMS
- PRIMARY MC LOADING AREAS
- SURFACE WATER (INTERMITTENT)
- EXPOSED BEDROCK
- GEOLOGIC FAULT
- ROAD

GROUNDWATER SUBBASINS

- BESSEMER VALLEY
- BRISTOL VALLEY
- DALE VALLEY
- DEADMAN LAKE
- GIANT ROCK
- LAVIC VALLEY
- SURPRISE SPRING
- TWENTYNINE PALMS VALLEY

MCAGCC Twentynine Palms

0 1 2 4 6
Miles

Date: August 2008

Source: MCAGCC/NREA GIS Office 2006
TECOM 2006
USGS Report 83-4053
CDWR, 2003
Southern California Earthquake Data Center (SCEDC)

6.4. Surface Water

There are no naturally occurring perennial surface water features at MCAGCC Twentynine Palms. Streambeds are dry except after infrequent, heavy rainfall (USDA NRCS, 1999). However, there are several types of hydrologic features that are of particular interest at the installation. These include playas, dry washes, seeps and springs, and man-made water bodies, including storm water retention ponds, golf course ponds, and sewage lagoons (DoN, 2003a). Seasonal seeps are located in the Imperial Lode mining area, the Lead Mountain area, and several mine shafts through the installation (DoN, 2003a and 2003b).

According to data obtained from the MCAGCC Twentynine Palms NREA Division (GIS data that were prepared by NREA staff from USGS sources), 16 subbasins have been delineated within the MCAGCC Twentynine Palms installation boundary. These subbasins mostly consist of ephemeral stream systems that drain to playas within the installation boundary and range in size from 2,819 to 52,178 acres (Figure 6.2-1). The largest playas include Deadman, Dry, Emerson, Lavic, and Mesquite lakes (USDA NRCS, 1999). Drainage is generally in the form of rapid runoff following occasional heavy rainfalls, and the playas can be filled with water for as long as two months a year (USDA NRCS, 1999).

During heavy rainfall events, water runs off the bedrock surfaces of the hills and mountains into deeply incised drainage channels and flows rapidly toward the basin floor. As the water reaches the basin floor, it begins to merge with other flows into the ephemeral playas (USDA NRCS, 1999). Most of this water is lost from the playas and drainage channels to evaporation. Some small amounts of water may infiltrate to recharge the groundwater, but the sporadic nature of the rainfall events and the low hydraulic conductivity of the playa sediments likely prevent significant groundwater recharge in these areas. Interviews with owners of several salt mining operations located off the installation in Bristol Dry Lake and Dale Lake indicate that the playas may partially hold standing water once or twice a year after heavy storms and the water remains in low-lying areas for a period of a few days to a few weeks. Major floods are infrequent, occurring approximately once every ten years. The flooding is seldom severe enough to suspend operations. NREA staff has made similar observations for playas located within MCAGCC Twentynine Palms.

Primary MC loading areas have been identified by Range Control in six of the existing 16 subbasins within MCAGCC Twentynine Palms' installation boundary. These include Dry Lake, Deadman Lake, Bristol Lake, Lavic Lake, Cleghorn Pass, and Quackenbush watersheds (Figure 6.2-1).

The Dry Lake subbasin is the largest drainage area within the MCAGCC Twentynine Palms installation boundary. This 130,000-acre subbasin contains numerous ephemeral stream channels and the Dry Lake playa. Stream channels drain to dry washes and eventually discharge into Dry Lake, a playa located in the northeast portion of the subbasin. The main stream channel of the ephemeral stream network drains in a northeast direction into Dry Lake. A few short channels that originate from a basaltic lava field east of Dry Lake drain westward to Dry Lake. Primary MC loading areas within the Dry Lake subbasin include Black Top I, Black Top II, Rainbow Canyon, and a portion of Lead Mountain.

The Deadman Lake subbasin includes much of the western portion of MCAGCC Twentynine Palms. This 125,000-acre subbasin contains an ephemeral stream network with a parallel drainage pattern that flows into Deadman Lake playa located on the southern side of the installation, approximately 4 miles northwest of Mainside. The branched stream network includes Rainbow Canyon on the northeast side of the watershed and Wood Canyon on the west and flows into Bullion Wash. Bullion Wash, in turn, flows in a southerly direction into Deadman Lake. The southwestern portion of this watershed contains Surprise Spring, which was an important and reliable surface water source, but which no longer flows due to groundwater pumping at the installation.. Primary MC loading areas within the Deadman Lake subbasin include Range and a portion of Quackenbush.

The Bristol Lake subbasin is located in the southeastern portion of MCAGCC Twentynine Palms. This 100,000-acre subbasin contains an ephemeral stream network with a combination of dendritic and parallel drainage patterns that flow into Bristol Lake. Bristol Lake is located east of MCAGCC Twentynine Palms, just outside the installation boundary. The ephemeral stream channels flow in easterly and northerly directions to the Bristol Dry Lake playa. Primary MC loading areas within the Bristol Lake watershed include parts of Delta and Lead Mountain.

The Lavic Lake subbasin is located on the northwest corner of MCAGCC Twentynine Palms. This 76,500-acre subbasin contains an ephemeral stream network that drains to the Lavic Lake playa, which is bordered by the Lava Bed Mountains on the north and west. The ephemeral stream network has a parallel drainage pattern, and the streams flow radially into Lavic Lake. An unnamed active spring exists at the northwest boundary of the Lavic Lake subbasin. The Gays Pass and Lavic Lake primary MC loading areas are located within the Lavic Lake watershed.

The Cleghorn Pass subbasin is located in the southeast corner of MCAGCC Twentynine Palms. This 33,000-acre subbasin contains an ephemeral stream system with a parallel drainage pattern. These streams flow southward and join a stream network that primarily discharges into Dale Lake, which is located 18 miles southeast of the installation boundary. A portion of the stream network branches off and flows eastward into Cleghorn Lake, also located outside the installation boundary. The Prospect primary MC loading area and a small portion of the Delta primary MC loading area are located within the Cleghorn Pass subbasin.

The Quackenbush subbasin is located on the western side of MCAGCC Twentynine Palms. This 12,800-acre subbasin contains an ephemeral stream network with a parallel drainage pattern and the Quackenbush Lake playa. Ephemeral streams within the watershed flow in a southerly direction to Quackenbush Lake. Parts of the Gays Pass and Quackenbush primary MC loading areas are located within the Quackenbush watershed.

Due to the low precipitation and limited natural leaching of soluble materials in soil at MCAGCC Twentynine Palms, MC can potentially accumulate in the soil at MC loading areas. The infrequent rainstorms can be torrential and often result in flash floods. This phenomenon can transport accumulated MC in soil through dissolution in runoff water or erosion of soil and sediments. Thus, flash flood events can be a major transport mechanism of MC in surface water.

The majority of the surface runoff accumulates in ephemeral playas. Playa soils are composed of fine clays that impede infiltration due to their low permeability characteristics. As a result, when playas are flooded with water, evaporation of the ponded water likely predominates over infiltration. However, some recharge to the groundwater is likely to occur; shallow groundwater (10–30 feet below ground surface [bgs]) exists beneath the playas at the installation. Recharge processes from the playa lakes to more permeable quaternary deposits surrounding the playas are not well defined, but could represent a minor MC migration pathway to shallow groundwater. During the period that water accumulates, playas fulfill an important role in supporting ecological habitats for potential ecological receptors, including waterfowl, terrestrial birds, reptiles, and mammals (DoN, 2003b).

6.5. Groundwater

Groundwater at the MCAGCC Twentynine Palms installation is found in the alluvium-filled basins that flank the bedrock uplands. Minor amounts of groundwater may be found within the bedrock units; however, previous investigations have indicated that these units are virtually non-water-bearing (Riley et al., 2001; Koehler, 1983; Riley and Worts, 1952). For the purposes of this report, this groundwater summary focuses on the alluvium-filled basins.

Figure 6.5-1 shows the distribution of the alluvium-filled basins at the MCAGCC Twentynine Palms installation. The primary groundwater basins include:

- the Twentynine Palms basin, southwest of the Bullion Mountains, composed of five subbasins covering parts of MCAGCC Twentynine Palms (Bessemer Valley, Deadman Lake, Giant Rock, Surprise Spring, and Twentynine Palms Valley);
- the Bristol Valley basin on the northeastern side of the Bullion Mountains; and
- several smaller intramountain subbasins that are located in the Bullion and Lava Bed mountains. These basins are separated from the larger basins by bedrock outcrops and/or faults and include portions of the Dale Valley and Lavic Valley subbasins.

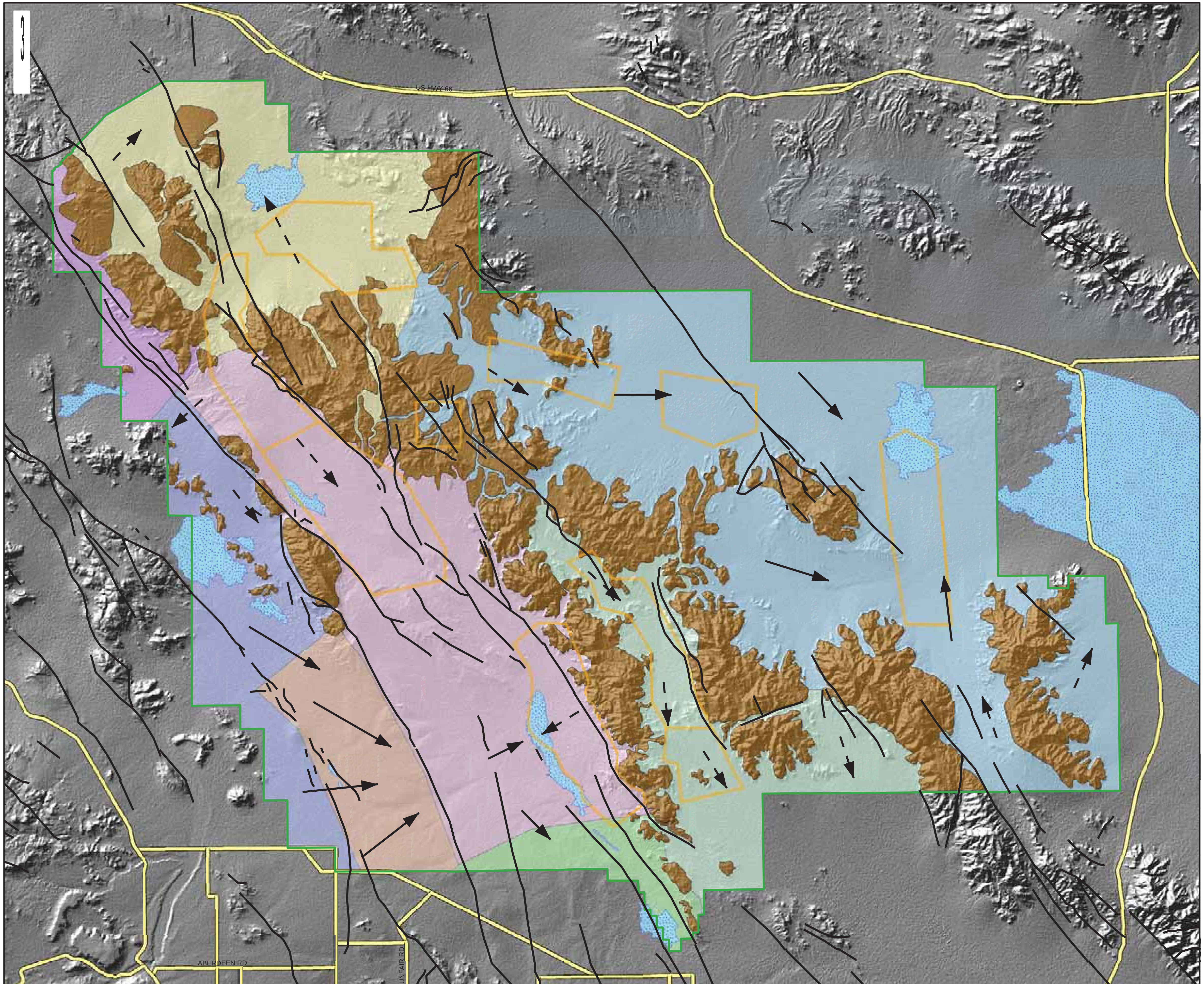
The following subsections describe the groundwater conditions encountered within each of the basins described above.

6.5.1. Twentynine Palms Basin

The best-understood groundwater system at the facility, the Twentynine Palms basin, is found southwest of the Bullion Mountains. This basin is part of a larger aquifer system known as the Morongo groundwater basin, which is characterized by small alluvial subbasins that maintain separate groundwater flow, typically terminating just beneath playas scattered throughout the area (Izbicki and Michel, 2004). The subbasins are divided hydrogeologically by bedrock outcrops, faults, and folds (Riley et al., 2001; Londquist and Martin, 1991; MCAGCC, 2006).

The groundwater bearing units within the basins are composed of unconsolidated to loosely consolidated Tertiary sediments and are divided along structural faults that form very low permeability zones. The Tertiary age sedimentary deposits can be 2,500 to potentially 10,500 feet thick in the depositional centers and are underlain by the bedrock units, which form an effective groundwater barrier (Riley et al., 2001). Londquist and Martin (1991) have reported two interconnected hydrostratigraphic units within the Tertiary deposits of the Surprise Spring subbasin. The upper unit is unconfined and consists of unconsolidated sands of moderately high permeability. The lower unit is confined and consists of consolidated poorly sorted sand, silt, and clay of low permeability. Previous groundwater modeling within this subbasin and surrounding subbasins consistently has defined the upper unconfined unit and lower confined unit as distinct model layers (Riley et al., 2001; Londquist and Martin, 1991; USGS, unpublished data).

Depth to groundwater at the installation ranges from 5 to 400 feet bgs; however, groundwater near the installation’s water supply source and near Mainside is generally encountered at a depth of 185 to 260 feet bgs (RW Beck, 2002; NEESA, 1999). Groundwater for potable use has been derived from the unconfined portions of the aquifer. Thick clay deposits and perched groundwater tables, ranging in depth from 5 to 75 feet, are present beneath areas of the playas (Panacea, 2001a and 2001b; ENSR, 1990). These perched aquifers are assumed to be limited in extent based on the available



REVA
Figure 6.5-1
Primary MC Loading Areas
and Groundwater Basins
MCAGCC Twentynine Palms

MCAGCC Twentynine Palms
Twentynine Palms, CA

Legend

- MCAGCC Twentynine Palms Boundary
- Primary MC Loading Areas
- Dry Lake Beds
- Exposed Bedrock
- Geologic Fault

Groundwater Subbasins

- Bessemer Valley
- Bristol Valley
- Dale Valley
- Deadman Lake
- Giant Rock
- Lavic Valley
- Surprise Spring
- Twentynine Palms Valley
- Road
- Groundwater Flow (Based on Previous Investigations)
- Groundwater Flow (Inferred)

NOTE: Groundwater flow directions based on source information listed below and professional judgement where no data exists.

0 1 2 4 6
Miles

Date: August 2008

Source: MCAGCC/NREA GIS Office 2006
TECOM 2006
USGS Report 83-4053
CDWR, 2003

Groundwater Flow Directions Based on: Schaefer, 1978; Koehler, 1983; Londquist & Martin, 1991; Izbicki & Michel, 2004, Stamos, 2004, Londquist & Martin 1989, and Lewis, 1972.

groundwater data and relatively small aerial extent of the playas. It is uncertain if the perched groundwater recharges the deeper aquifer system.

Groundwater in the deeper aquifer generally flows south to southeastward through the Twentynine Palms alluvial valley; however, local groundwater gradients may have discordant trends and are affected by faulting, folding, and pumping within the subbasins. For example, the Surprise Spring subbasin is recharged by flow across Emerson fault that ultimately comes from the San Bernardino Mountains. This groundwater flows beneath the Surprise Spring area and then flows to the east toward Deadman Lake. Flow then turns south toward Mesquite Lake (Riley et al., 2001; CDWR, 2003). General groundwater flow direction within the Twentynine Palms basin can be inferred from previous investigations and groundwater modeling investigations and is denoted by arrows in Figure 6.5-1 (Izbicki and Michel, 2004; Riley et al., 2001; Londquist and Martin, 1989 and 1991; Schaefer, 1978; Stamos et al., 2004; Lewis, 1972; CDWR, 2003).

Figure 6.5-2 shows groundwater level measurements taken between 2001 and 2006 (USGS, 2006). The head measurements verify the eastward groundwater flow in the southwest portion of the installation. The groundwater level measurement also show the impact of faults on groundwater heads; large drops in head are apparent across several of the faults.

Recharge to groundwater within the Twentynine Palms basin near MCAGCC Twentynine Palms occurs by direct inflow from subbasins to the west and limited infiltration in mountainous areas to the east (NEESA, 1999). Groundwater levels have been declining at the installation since pumping began in 1953 (Schaefer, 1978).

6.5.2. Bristol Valley Groundwater Basin

Limited hydrogeologic information was available for the Bristol Valley basin located to the northeast of the Bullion Mountains. Water level data collected from exploratory drilling and production wells in the towns of Ludlow and Bagdad indicate that groundwater flows away from the Bullion and Bristol Mountains and then southeast down the axis of the basin toward Bristol Dry Lake (Koehler, 1983). The general groundwater flow direction is depicted in Figure 6.5-1. Similar to the Twentynine Palms basin, northwest trending faults within the basin appear to be creating groundwater subbasins. This is evidenced by different water chemistries observed in wells that lie on opposite sides of the Ludlow fault, which trends down the basin axis (Koehler, 1983).

Groundwater levels range from 125 to 300 feet bgs in the Bristol Valley basin. The groundwater occurs in unconsolidated alluvial deposits similar to those described for the Twentynine Palms basin. Perched zones exist near Bristol Dry Lake and Dry Lake, with water levels recorded at 14 to 89 feet bgs (Koehler, 1983). The perched groundwater tables are assumed to be limited in extent based on the available groundwater data and relatively small aerial extent of the playas. It is uncertain if the perched groundwater recharges the deeper aquifer system.

There are no drinking water wells on the portion of the installation covered by the Bristol Valley basin. The groundwater quality does not appear to be suitable for human consumption based on a study conducted by Koehler (1983). Groundwater quality samples collected from exploratory wells report TDS ranges of 1,420 to 252,000 mg/L; chloride ranges of 140 to 11,000 mg/L; and arsenic ranges of 11 to 98 µg/L. Groundwater located to the west of the Ludlow fault appears to have better quality than that on the eastern side of the fault.

6.5.3. Intramountain Basins

Very few subsurface data are available for the intramountain basins found within the Bullion and Lava Bed mountains, including the Dale Valley and Lavic Valley subbasins. The subsurface conditions encountered in these areas are expected to be similar to those described for the Bristol Valley and Twentynine Palms basins, with the following exceptions:

- The water bearing sedimentary deposits are expected to be thinner with proximity to the exposed bedrock outcrops.
- The average grain size that composes the subbasins is expected to be coarser due to the proximal position of the basin with respect to the bedrock source. This might affect the average hydraulic conductivity.
- Average groundwater elevations might be shallower. Limited depth to groundwater information from the Lava RTA indicates a depth to groundwater of 127 feet bgs (Almgren and Koptionak, 1993). Additional evidence for a shallower groundwater elevation includes intermittent seeps (DoN, 2003a).

Groundwater is expected to flow according to surface topography, away from the bedrock uplands and toward the larger flanking basins and playas. Potential groundwater flow directions are indicated with arrows in Figure 6.5-1.

6.6. Water Supplies

Potable water is currently supplied to the installation via water supply wells in the Surprise Spring subbasin of the Twentynine Palms basin (Battelle, 2004a and 2004b). The Surprise Spring subbasin includes parts of the Restricted Area and Sand Hill, Acorn, and Emerson Lake RTAs in the southwestern part of the installation. The subbasin is an isolated, interconnected aquifer system bordered by geologic fault structures that act as full or partial groundwater movement barriers, depending on location. The aquifer is bounded by the Emerson and Copper Mountain faults to the west and the Surprise Spring fault on the east. The northern and southern boundaries are not well defined. The northern extent of the basin is probably an unnamed fault south of the Ames Dry Lake, and the southern boundary lies north of the Transverse Arch, an anticline that traverses the entire subbasin. Limited water, estimated to be 500 acre-feet per year, is recharged to the Surprise Spring subbasin from the San Bernardino Mountains (MCAGCC, 2004). The depth to groundwater in the Surprise Spring subbasin ranges from 150 to over 400 feet bgs (DoN, 2003a and 2003b). Groundwater quality data collected from wells installed within these aquifers show that the groundwater is of a sodium bicarbonate type and meets water quality criteria established under the Safe Drinking Water Act (Law Engineering, 1996).

Water supply wells have also been reported near Deadman Lake and near Emerson Lake (NREA, unpublished GIS data) (Figure 6.5-1). Two of these wells are inactive. Another well is a production well for nonpotable water (Law Engineering, 1996) and reportedly is used by Marines in the field to wash vehicles and field equipment. The well screen is shallow (depth to water is 25 feet) and probably has a high salinity due its proximity to a playa. Potential incidental dermal exposure at this well is not anticipated, as the well is located near two non-live-fire RTAs and is separated from the nearest live-fire RTA by a playa. In addition, incidental dermal exposures are not considered under the REVA program.

Groundwater from the Bristol Valley basin is considered nonpotable because of high mineral content (MCAGCC, 1996). One of the criteria for potable water in California is a TDS concentration less than 3,000 mg/L (California Regional Water Quality Control Board, 2005). Koehler's study (1983) lists the TDS concentrations for several test wells in the northeast portion of the installation. About half of the samples tested above 3,000 mg/L for TDS. All of the samples tested above 500 mg/L, California's secondary standard for aesthetic qualities (Koehler, 1983).

Groundwater near Mainside is primarily of a sodium sulfate type. Fluorides and sulfate concentrations exceed drinking water standards (Panacea, 2001b).

6.6.1. Perchlorate

In accordance with the requirements of the Unregulated Contaminant Monitoring Regulation program, groundwater samples were collected from six water supply wells and the water treatment system equalization tanks in June 2006 and analyzed for perchlorate. The compound was detected in all the samples collected from the system (maximum concentration of 0.44 μg/L) at concentrations below the REVA trigger value (0.98 μg/L) and regulatory compliance criteria (HQMC, 2006).

The detection of this MC leaves open the possibility of MC migration from military munitions use on the ranges into the groundwater system. However, all of the live-fire primary MC loading areas are located down gradient of the drinking water wells (i.e. the groundwater flow direction is from the wells towards the primary MC loading areas). This groundwater flow direction would cause perchlorate and other MC to move away from the drinking water wells. The groundwater intercepted by these drinking water wells is believed to flow from the west, where the only Marine Corps activities are non-live-fire training areas.

As described earlier, the recharge characteristics of the Mojave Desert make it unlikely that perchlorate from base training activities could reach the Twentynine Palms basin in detectable concentrations. Most of the precipitation falls in the mountains and then gathers in small, ephemeral streams, running down the mountain until it reaches the alluvium and begins to infiltrate. There are no MC loading areas that cover the tops of the mountains, although many have their boundaries near the base of the Bullion Mountains where bedrock gives way to alluvium. It is possible that surface water runoff on the west side of the Bullion Mountains could pick up perchlorate from the loading areas at the mountain base before infiltrating to the groundwater. Infrequent flow of water in dry washes east of Deadman Lake could also result in small amounts of MC entering the subsurface. There are some indications that groundwater can locally move west toward Deadman Lake. However, groundwater level data indicate that Deadman Lake is down gradient of the drinking water well locations. Also, Deadman Lake is hydraulically separated from the drinking water wells by faults. Flow from the Bullion Mountains toward Deadman Lake cannot account for contamination in the installation drinking water wells.

Because the perchlorate hits occurred near the western boundary of the site and the groundwater is expected to flow in an easterly direction, there is potentially an off-installation source of perchlorate. The Perchlorate Team of the Interstate Technology & Regulatory Council designated Southern California as one of four regions in the United States with the highest density of perchlorate detections (ITRC, 2005). However, there are no known sources of perchlorate near the western boundary of the installation.

Recent studies by the USGS have indicated possible perchlorate background concentrations in the range of 0.1 to 10 mg/L in the western United States, with some localized areas containing background concentrations that are much greater (Orris, 2006). Although sufficient data are not yet available, it appears that perchlorate can occur naturally, especially in arid environments like that found in the Mojave Desert. The mechanism is not fully understood yet, but it is believed to occur when chloride reacts with ozone in the atmosphere. The resulting perchlorate then dissolves in falling precipitation. There are some indications that lightning also plays a role in the creation of perchlorate. Further, in arid environments where there is less precipitation to remove the perchlorate from the atmosphere, perchlorate can be incorporated into certain geologic formations. A USGS sampling effort to better understand the extent of perchlorate contamination has focused specifically on playas, caliche, and evaporate deposits, all of which are present in the Mojave Desert. Further study is ongoing to better understand the mechanisms behind naturally occurring perchlorate, as well as the geographic range of perchlorate contamination in groundwater (ITRC, 2005; Jackson, 2006).

It is currently unknown whether the perchlorate detected in the installation drinking water wells is natural or from anthropogenic sources. Identification of the source is made challenging by the limited number of wells at the installation and the complex regional hydrogeology. Further study and sampling would be required to make this determination.

6.7. Biota

MCAGCC Twentynine Palms supports a variety of plant and animal life, most of which is adapted to the desert environment. As of 1998, there were 387 native and naturalized vascular plants recorded at the installation, including 66 plant families, 219 genera, and 381 species (Elvin, 2000). The predominant vegetation at the installation is desert annuals and creosote bush. Density and diversity of the vegetation tends to increase at higher elevations in the mountainous areas. The four major vegetation types at the installation are presented in Table 6.7-1 (MCAGCC, 2006).

Table 6.7-1: Predominant Vegetation at MCAGCC Twentynine Palms

Vegetation Type	Dominant Species	Prevalent Location
Mojave creosote bush scrub	Creosote bush, white bursage	Alluvial fans to steep mountain slopes
Desert saltbush scrub	One or more species of saltbush in combination with other halophytes	Basin floors adjacent to playas
Blackbrush scrub	Blackbrush	Mid- to higher mountain slopes
Mojave wash scrub	Smoke tree, desert willow	Ephemeral channels

A comprehensive survey conducted as part of the INRMP to identify special status plants did not identify any federally threatened or endangered plant species. However, a current study reports 11 sensitive plant species and 13 plant species in the “low-moderate potential-to-find” category (MCAGCC, 2006).

A variety of reptile, bird, and mammal wildlife species are found at MCAGCC Twentynine Palms, including bats, bighorn sheep, coyote, bobcat, and desert tortoise. The wildlife species present at the installation are typical of Mojave Desert fauna, with the exception of a wide variety of non-desert-adapted species inhabiting Mainside, particularly in man-made water areas. The availability of water is a key factor limiting the distribution of some species. Springs, seeps, and riparian areas support higher species diversity and constitute critical habitat for several resident and migratory birds, as well as bat species. Rocky terrain provides habitat for many reptile, rodent, and bird species. Table 6.7-2 presents a summary of ecosystems found at MCAGCC Twentynine Palms.

Table 6.7-2: Ecosystems Present at MCAGCC Twentynine Palms

Ecosystem	Area of Base (%)	Number of Species[a]	Comments
CREOSOTE/BURSAGE SCRUB SERIES			
Valleys, gentle bajadas	50	142	Dominant species: creosote bush and white bursage
Disturbed	10	68	Valley, gentle bajadas areas subjected to extensive military training activities
Mountains	24	149	Possess moderate to high diversity of woody perennials
Sand dunes	3	63	Located in the southwestern and northern portions of the installation
Lava flows	5.4	71	Exist as solid basalt pavements, rocky and coarse-gravel substrates
OTHER VEGETATION SERIES			
Yucca woodlands; Joshua trees and/or Mojave yucca	0.4	184	Located in southwestern and northwestern corners of installation
Saltbush scrub; playa and uplands	6	50	Consists of the alkaline margins of the playas
Blackbrush scrub	0.7	154	Located primarily in northwestern corner on upper bajadas and rocky alluvial mountain slopes
RIPARIAN, WET AREAS, and AQUATIC			
Desert riparian	< 0.5	178	Tree-dominated, desert wash with ephemeral surface waters
Desert wash with ephemeral flows	2–4	146	Similar to desert riparian but dominated by shrubs
Springs and seeps	< 0.1	221 (possible)	Intermittent springs at Sunshine Peak and north of Lead Mountain
Dry lake beds (playas)	1.9	50 bird species; 5 shrimp species	Fourteen playas located on installation
Wet areas / ponds / riparian; perennial	< 0.1	Unknown	Man-made; used by migratory birds
Caves, mines, and rock crevices	< 1	Unknown	Critical habitat for bats; used by other species for water, shelter, and protection

Source: MCAGCC, 2006

[a] Number of vertebrate species supported by ecosystem

Sixteen resident and 19 nonresident species present at the installation are considered to have special status according to federal or state regulations. Birds represent the largest number of sensitive species at MCAGCC Twentynine Palms. Twenty-eight sensitive species have been observed, primarily near Mainside, due to the wet areas created by the golf course, sewage treatment systems, and the evaporation ponds. Sensitive birds have also been observed throughout the other RTAs. Deadman Lake, a playa located along the western edge of the Range RTA fills with surface water following precipitation events (MCAGCC, 2006). Avian, reptilian, and mammalian populations are found in proximity to this playa and include several California special concern species. In addition, the playa provides habitat for the Mojave fringe-toed lizard (MFTL), also a California special concern species. The MFTL is restricted to areas with fine, wind-blown sand, including large and small dunes, margins of dry lake beds and washes, and isolated pockets against hillsides (Hollingsworth and Beaman, n.d.). Potential and existing MFTL habitat is depicted in Figure 6.7-1. Other playas found within the installation probably also serve the same habitat roles.

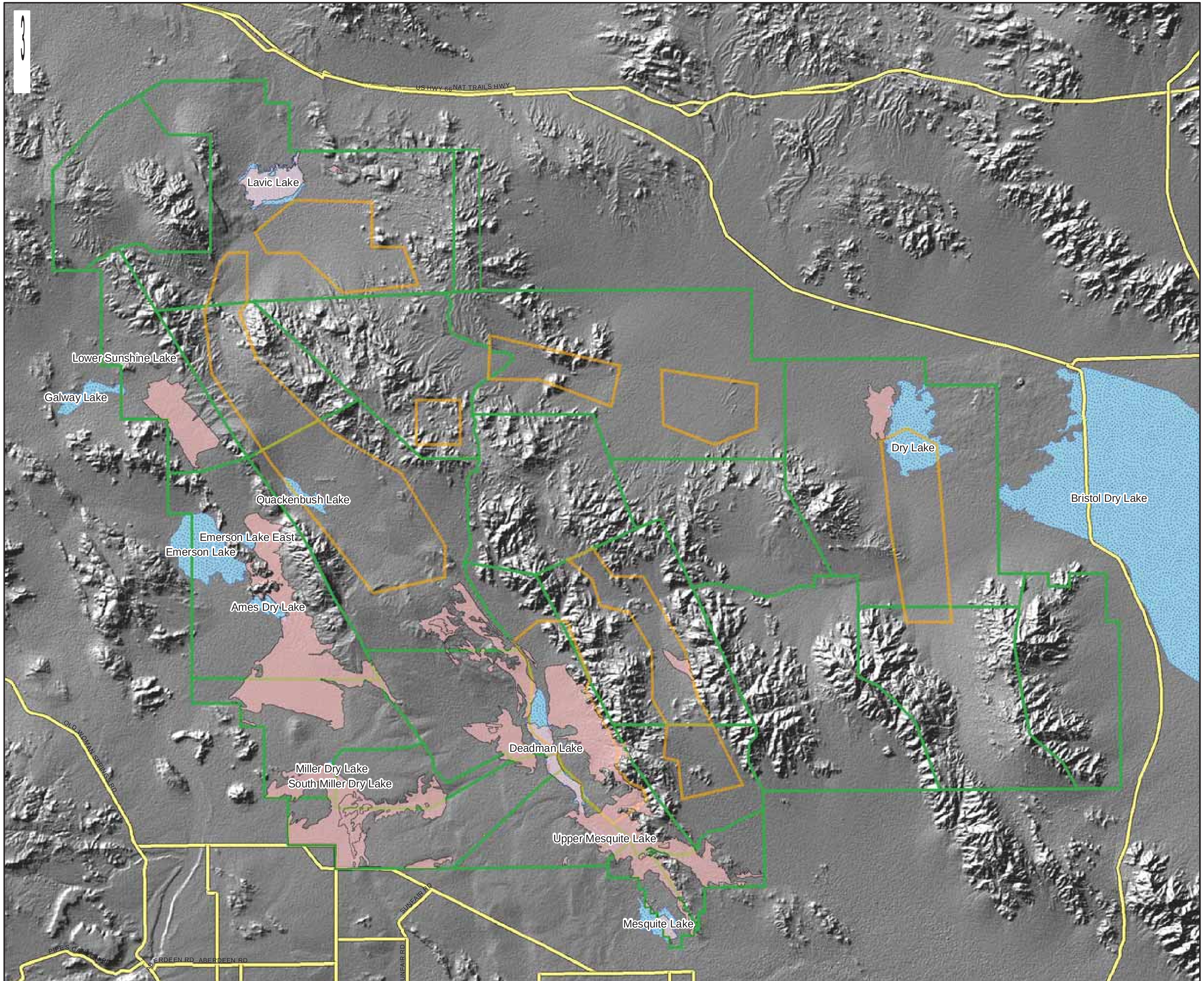
In April 1990, the desert tortoise was listed as a federally threatened species under provisions of the Endangered Species Act of 1973. The desert tortoise is an herbivore found throughout the Mojave Desert. The desert tortoise spends much of the year underground in burrows to avoid the extreme desert temperatures. There may be several of the burrows within an individual tortoise's home range (MCAGCC, 2006). The tortoise is most active aboveground during the spring, summer, and fall when the daytime temperature is below 90^{o}F. MCAGCC Twentynine Palms is within the southern Mojave subdivision of the Western Recovery Unit for the desert tortoise. Specifically designated critical habitat is not found on the installation; however, critical habitats are located near the installation. Table 6.7-3 summarizes one of the numerous surveys that have been conducted at MCAGCC Twentynine Palms to document the distribution and relative densities of the tortoise population throughout the installation. Potential and documented habitat for the desert tortoise is depicted in Figure 6.7-2.

Table 6.7-3: Desert Tortoise Population Densities at MCAGCC Twentynine Palms

Number of Tortoises per Square Mile	Associated Area (acres)
> 50	5,779
21–50	40,985
6–20	103,078
< 6	283,530

Source: MCAGCC, 2006

The presence of soil suitable for digging burrows is a limiting factor to their distribution. As such, fewer tortoises are found in the northeastern portion of the installation. The Marine Corps has conservation measures to reduce or minimize death and injury of desert tortoises and to reduce or minimize disturbance of their habitat to the greatest extent

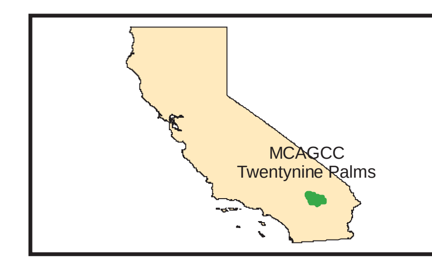


REVA
FIGURE 6.7-1
MOJAVE FRINGE-TOED LIZARD HABITAT

MCAGCC TWENTYNINE PALMS
TWENTYNINE PALMS, CA

LEGEND

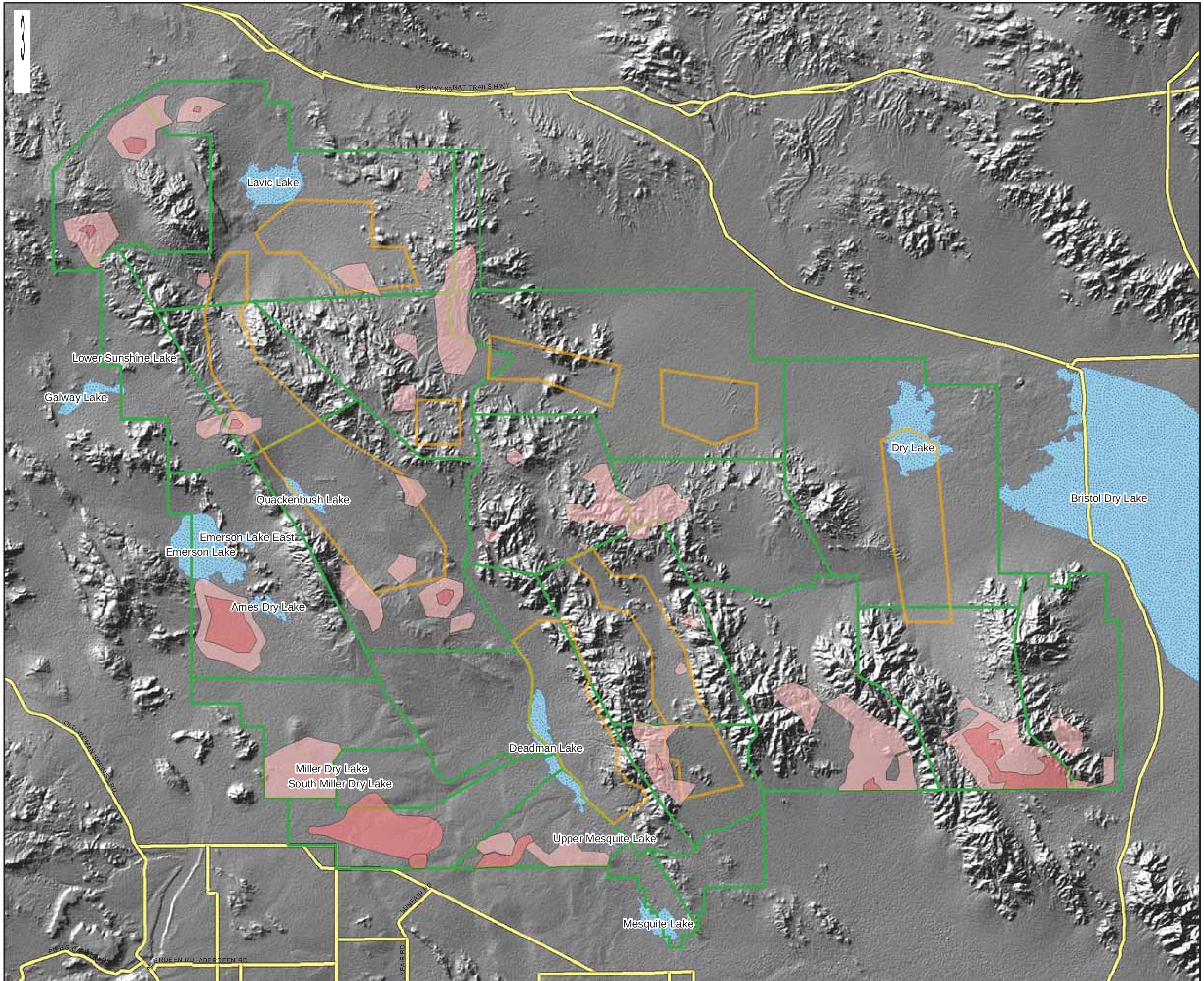
- MCAGCC TWENTYNINE PALMS
- PRIMARY MC LOADING AREAS
- RANGE TRAINING AREAS
- SURFACE WATER (INTERMITTENT)
- ROAD
- FRINGE-TOED LIZARD HABITAT



0 1 2 4 6
Miles

Date: August 2008

Source: MCAGCC/NREA GIS Office 2006
TECOM 2006



REVA
FIGURE 6.7-2
DESERT TORTOISE HABITAT

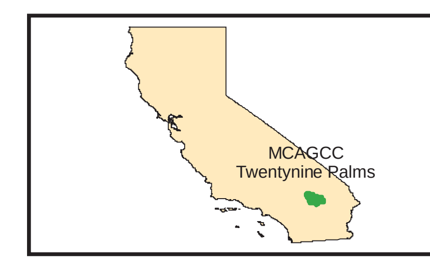
MCAGCC TWENTYNINE PALMS
TWENTYNINE PALMS, CA

LEGEND

- MCAGCC TWENTYNINE PALMS
- PRIMARY MC LOADING AREAS
- RANGE TRAINING AREAS
- SURFACE WATER (INTERMITTENT)
- ROAD

DESERT TORTOISE HABITAT
DENSITY (TORTOISE/MI^2)

- 21-50
- 51-100



0 1.25 2.5 5 7.5
Miles

Date: August 2008

Source: MCAGCC/NREA GIS Office 2006
TECOM 2006

possible while maintaining the training use and mission (U. S. Department of the Interior, 2002).

Description of the habitat, activities, and potential exposure to MC in surface water for the MFTL and the desert tortoise are provided in Appendix A.

6.8. Potential Pathways and Receptors

MC accumulated in the MC loading areas can migrate to potential receptors via the following exposure pathways:

- Surface water runoff
- Leaching to groundwater and subsequent groundwater flow

Exposure pathways considered in the REVA process include consumption of surface water and groundwater for off-range human and ecological receptors, as described in the *REVA Reference Manual* (HQMC, 2006). Other off-range exposures scenarios (e.g., soil ingestion, incidental dermal contact, bioaccumulation and food chain exposure) are not currently considered in the REVA process. The potential points of exposure for receptors of MC at the MCAGCC Twentynine Palms installation include the following:

- The installation's active drinking water supply wells
- Special status ecological receptors, such as the desert tortoise and the MFTL that live near playas
- Salt mining activities east of the installation that pump groundwater down gradient of the RTAs or can be flooded by surface runoff following storm events

6.8.1. Surface Water Pathway

Surface water runoff can mobilize and transport accumulated MC in soil through dissolution or erosion of soil and sediments. The majority of the surface runoff drains to the interior of the installation and accumulates in playas. The fate of surface water in the playas is typically evaporation, although a small amount of infiltration can occur. The playas can be filled with storm water runoff for two months to a year. In an ecosystem where water is a limiting factor, playas and washes filled with storm water runoff can provide habitat for wildlife. For this reason, surface water in the playas and washes presents a potential exposure pathway for resident and migratory wildlife.

A potential exposure pathway for human health has been identified in the salt mining activities in Bristol Dry Lake and Dale Lake, located down gradient of the Lead Mountain and Prospect primary MC loading areas, respectively. However, interviews with the owners of some of these operations indicated that small sections of standing water form once or twice a year, but the water is not used in the salt mining operations and they usually recede within a few days or weeks. Occasionally, flooding may be substantial enough to close operations, but this has not happened in several years. Thus, MC from the installation have negligible effect on the mined salt and are not expected to affect workers.

Primary MC loading areas are located in six of the existing 16 subwatershed areas within the MCAGCC Twentynine Palms installation boundary. These include Dry Lake, Deadman Lake, Bristol Lake, Lavic Lake, Cleghorn Pass, and Quackenbush and watersheds. Locations of watersheds, streams, and impact areas that potentially may receive MC loading are shown in Figure 6.2-1 and are summarized in Table 6.8-1.

Table 6.8-1: Subwatersheds within Primary MC Loading Areas

Subwatershed	Size (acres)	Associated Primary MC Loading Area	Drainage Information
Dry Lake	130,000	Black Top I	Washes drain in a northeast direction into Dry Lake; several short channels that originate from an ancient basaltic lava field east of Dry Lake also drain westward into Dry Lake.
		Black Top II	
		Rainbow Canyon	
		Lead Mountain (also in Bristol Lake subwatershed)	
Deadman Lake	125,000	Range	Washes with a parallel drainage pattern flow into Deadman Lake; the branched stream network includes Rainbow Canyon (northeast side of the watershed) and Wood Canyon (west side) that flow into Bullion Wash, which flows in a southerly direction into Deadman Lake; the southwestern portion of watershed contains Surprise Spring (no longer flows).
		Quackenbush (also in Quackenbush subwatershed)	
Bristol Lake	100,000	Delta (also in Cleghorn Pass subwatershed)	Washes with a combination of dendritic and parallel drainage patterns flow into Bristol Dry Lake, located directly east of the installation boundary.
		Lead Mountain (also in Dry Lake subwatershed)	
Lavic Lake	76,500	Gays Pass (also in Quackenbush subwatershed)	Washes with parallel drainage pattern flow radially into Lavic Lake, which is bordered by the Lava Bed Mountains on the north and west; an unnamed active spring exists at the northwest boundary.
		Lavic Lake	
Cleghorn Pass	33,000	Delta (also in Bristol Lake subwatershed)	Washes with a parallel drainage pattern flow southward and join a stream network that primarily discharges into Dale Lake (located 18 miles southeast of the installation boundary); portion of the stream network branches off and flows eastward into Cleghorn Lake (also located outside the installation boundary).
		Prospect	

Subwatershed	Size (acres)	Associated Primary MC Loading Area	Drainage Information
Quackenbush	12,800	Gays Pass (also in Lavic Lake subwatershed)	Washes with a parallel drainage pattern flow in southerly direction to Quackenbush Lake.
		Quackenbush (also in Deadman Lake subwatershed)	

6.8.2. Groundwater Pathway

Several potential migration pathways to groundwater exist at the installation. MC in surface runoff washing from the flanks of the mountains can infiltrate into the Quaternary alluvial deposits along the alluvium-bedrock interface (Figure 6.1-1). Water entering the vadose zone could then migrate vertically into the phreatic zone. However, this MC migration pathway is likely to be very limited because most training activities at the installation are not focused on the upper and middle slopes of the mountain ranges, but rather the bases of the mountains below the alluvium-bedrock interface. Further, the high temperatures and low humidity in this climate result in little infiltration; most of the water is removed by evaporation.

The potential exists for surface water accumulating in the playas to recharge shallow, perched groundwater (Figure 6.1-1) either by limited infiltration through the playa soils or by more rapid infiltration through more permeable alluvial soils surrounding the playas during flood events. Recharge directly through playa deposits is generally minimal given the reduced permeability of these soils; however, during certain seasonal periods in which precipitation occurs, some limited communication between shallow groundwater and surface water retained in playas is potentially possible. As described in **Section 6.4**, the quantity of recharge to Quaternary deposits surrounding the playas is not well characterized. Additionally, the potential exists for surface water to percolate through the alluvial deposits within surface water drainages. However, because most surface runoff occurs as high-energy flash floods and the high temperatures drive high evaporation rates, the transport of surface water into the subsurface is considered minimal and unlikely to recharge the deep groundwater.

The MC loading areas described in **Section 3** are located within or drain toward the groundwater basins located at the installation. Groundwater basins that can receive MC loading are shown in Figure 6.5-1 and are summarized in Table 6.8-2.

Table 6.8-2: Groundwater Basins and Associated Primary MC Loading Areas

Groundwater Basin	Associated Primary MC Loading Area	MC Transport Information
Twentynine Palms basin	Range	Minimal MC transport may occur to the west toward Deadman Lake.
	Quackenbush	Minimal MC transport may occur to the southeast toward Deadman Lake.
	Portions of Gays Pass	
Bristol Valley basin	Lead Mountain	Minimal MC transport may occur to the north toward Dry Lake or east toward Bristol Lake.
	Black Top I	Minimal MC transport may occur eastward toward Dry Lake and Bristol Dry Lake.
	Black Top II	
Intramountain basins	Rainbow Canyon	Based on topography, this appears to be a closed basin with no MC transport likely to other basins.
	Delta	Minimal MC transport may occur to the south off installation toward Dale Lake.
	Prospect	
	Portions of Gays Pass	Minimal MC transport may occur to the north toward Lavic Lake.
	Lavic Lake	

The groundwater pathway is not expected to result in contamination at any of the receptors with REVA indicator MC from training activities for several reasons. First, MC migration to groundwater is expected to be very low for the reasons stated above. Secondly, groundwater containing MC is unlikely to reach any of the receptors. Training activities do not impact drinking water wells; all of the live-fire loading areas are located either in unconnected groundwater basins or down gradient of the wells. Groundwater from those wells likely originates to the west of the installation in the San Bernardino Mountains. The perchlorate concentration detected in these wells is well below the Environmental Protection Agency recommended drinking water equivalent level of 24.5 μg/L and the state of California's promulgated level of 6 μg/L and is probably either naturally occurring or derived from an anthropogenic source other than active ranges.

The salt mining operations in nearby Bristol Dry Lake and Dale Lake are not likely to be impacted by MC loading at MCAGCC Twentynine Palms. Many of the wells at the mining operations are screened in the deep groundwater zones and are not used for potable water. Although some pump shallow groundwater, they are unlikely to encounter high levels of MC due to limited MC groundwater transport potential, as described in this section.

7. Operational Range Training Areas

The operational ranges assessed in REVA include live-fire maneuver areas, fixed ranges, SARs, and training areas where military munitions are known or suspected to have been used. The areas were selected for assessment based upon discussions with Range Control and NREA personnel at MCAGCC Twentynine Palms and the data presented in the Training Range Sustainment Planning and Training Range Inventory, 2004 National Defense Authorization Act Section 366 Report (TECOM, 2004).

Although SDZs could be delineated, these features were only used to assist in the determination of MC loading areas for fixed ranges because the majority of fired military munitions are believed to have impacted at or near the target areas of the operational range. Because there are few specifically designated impact areas at MCAGCC Twentynine Palms and firing of military munitions is approved anywhere within the live-fire RTAs, the MC loading areas were more accurately defined based on GIS layers (including target emplacements), input from Range Control, aerial photography, direction of fire, flight patterns, and any additional information available on the operational range and its use.

MCAGCC Twentynine Palms maintains ranges throughout the military complex. The current and historical uses of these operational ranges were assessed under REVA. The operational ranges at MCAGCC Twentynine Palms consist of both RTAs and fixed ranges located within the RTAs. There are currently 22 RTAs at MCAGCC Twentynine Palms (Figure 3.5-3). Five RTAs (located in the southwest corner of the base) are designated as non-live-fire maneuver areas.. The remaining 17 RTAs permit live-fire training anywhere within the training area, except for a 1,000 m buffer area inside the installation boundary. The boundaries of each RTA are defined by training requirements, topography, and other constraints. The current RTAs and their MC loading area are presented in Table 7-1.

The assessments for the operational range areas, both current and historical, are presented in the following sections:

- Pre-1969 Historical Training Use (**Section 7.1**)
- 1969 – 1979 Historical RTAs (**Sections 7.2 – 7.9**)
- Current RTAs (**Sections 7.10 – 7.31**)

The section for each operational area contains discussions on the operational range background, the CSM, MC loading areas and totals, screening-level modeling results (if applicable), and additional range information.

Table 7-1: Current RTAs and MC Loading Areas

RTA[a,b]		Size of RTA (acres)	Size of RTA (1,000 m^2)	Size of MC Loading Area (1,000 m^2)
PRIMARY MC LOADING AREAS WITHIN RTAs	Lead Mountain	53,572	216,792	44,585
	Prospect	13,152	53,222	17,518
	Delta	29,761	120,435	32,124
	Lavic Lake	54,786	221,704	40,939
	Quackenbush	42,435	171,721	73,836
	Range	21,749	88,013	51,785
	Black Top	50,871	205,861	21,943 (Black Top I) 25,156 (Black Top II)
	Gays Pass	15,316	74,118	41,047
	Rainbow Canyon	25,578	103,508	9,000
OTHER MC LOADING AREAS WITHIN RTAs	America Mine	20,920	84,656	8,466 [c]
	Bullion	28,874	116,843	11,684 [c]
	Cleghorn Pass	36,318	146,969	14,697 [c]
	Lava	22,785	92,205	9,220 [c]
	Noble Pass	24,040	97,282	9,728 [c]
	Sunshine Peak	22,902	92,678	9,268 [c]
	Emerson Lake	32,155	130,124	13,012 [c]
	Maumee Mine	16,110	65,194	6,519 [c]
	Acorn[d]	17,471	70,699	7,070 [c]
	East[d]	6,893	27,894	2,789 [c]
	Gypsum Ridge[d]	17,554	71,036	7,104 [c]
	Sand Hill[d]	16,794	67,959	6,796 [c]
	West[d]	10,626	43,000	4,300 [c]

[a] Each RTA is considered an MC loading area. However, per discussions with Range Control, 9 primary MC loading areas were identified as receiving the greatest amount of munitions usage.

[b] Historical use ranges and RTAs (those established prior to 1979) were much larger than existing RTAs and typically encompassed more than one current RTA / MC loading area. MC loading on historical ranges was conducted separately for former RTAs and estimated using extrapolations of current military munitions expenditure data with the MC Loading Calculator.

[c] For current and historical RTAs at which a primary MC loading area has not been designated, it is assumed that the MC loading occurs on 10% of the total RTA area.

[d] These operational RTAs are designated as maneuver area / non-live-fire only.

Groundwater Analysis Summary

A qualitative groundwater analysis was performed by analyzing the source media, migration mechanisms, and exposure pathways documented in the MCAGCC Twentynine Palms CSM. Based on the results of the qualitative analysis of the groundwater information, limited potential exists for MC migration to groundwater, and no groundwater receptors associated with the indicator MC are present. Therefore, a groundwater screening-level analysis was not conducted. Discussions of the qualitative analysis and screening-level analysis are presented in **Section 4**.

Surface Water Analysis Summary

Surface water fate and transport modeling through screening-level analysis was conducted for primary MC loading areas within two RTAs: Lead Mountain and Prospect. In addition to the two RTAs and their loading areas, the associated upstream RTAs and their loading areas were included in the screening-level transport analysis for accuracy and completeness. For Lead Mountain, this included portions of the Bullion, Cleghorn Pass, Delta, and Lava RTAs, with very limited contribution from the Prospect RTA. Upstream contributors to the Prospect analysis included Cleghorn Pass and limited contributions from the Delta and Bullion RTAs. The results of the surface water screening-level modeling are discussed in detail in **Section 7.10.3** and **Section 7.11.3**. Brief screening-level analysis summaries are also presented in the upstream MC loading area sections.

7.1. Historical Training Use (1941–1969)

Prior to the establishment of Marine Corps Training Center (MCTC) Twentynine Palms in 1952, the U.S. Army and U.S. Navy used the area that is currently MCAGCC Twentynine Palms for various military training. The following information is summarized from the ASR and PRA report for the installation for the period between 1941 and 1969 (USACE, 2001a and 2001b).

7.1.1. Twentynine Palms Air Academy (1941–1944)

Use of the MCAGCC Twentynine Palms property for military training began in late 1941 when the U.S. Army West Coast Air Corps Training Center formed the Twentynine Palms Air Academy. The mission was to train and instruct military personnel on the operation and flying of gliders. The school consisted of a main airfield and three auxiliary airfields. The main airfield, called Condor Field #1, was located on Mesquite Dry Lake, which is located within Mainside. Condor Field #2 was located on Deadman Lake, along the border of the current West and Sand Hill RTAs. Two other auxiliary airfields were located outside the property boundary of MCAGCC Twentynine Palms and are considered Formerly Used Defense Sites. In March 1943, the base transitioned to a Flying Training Detachment pilot school to train pilots in powered flight. The academy was active until April 1944, when the Western Flying Training Command discontinued training.

Historical information on military training at the facilities does not document the use of ordnance, and glider and training aircraft did not normally carry ordnance (USACE, 2001a). No ranges were documented at the facility during this time. Therefore, MC loading was not performed for this historical use area.

7.1.2. California-Arizona Maneuver Area (1942–1944)

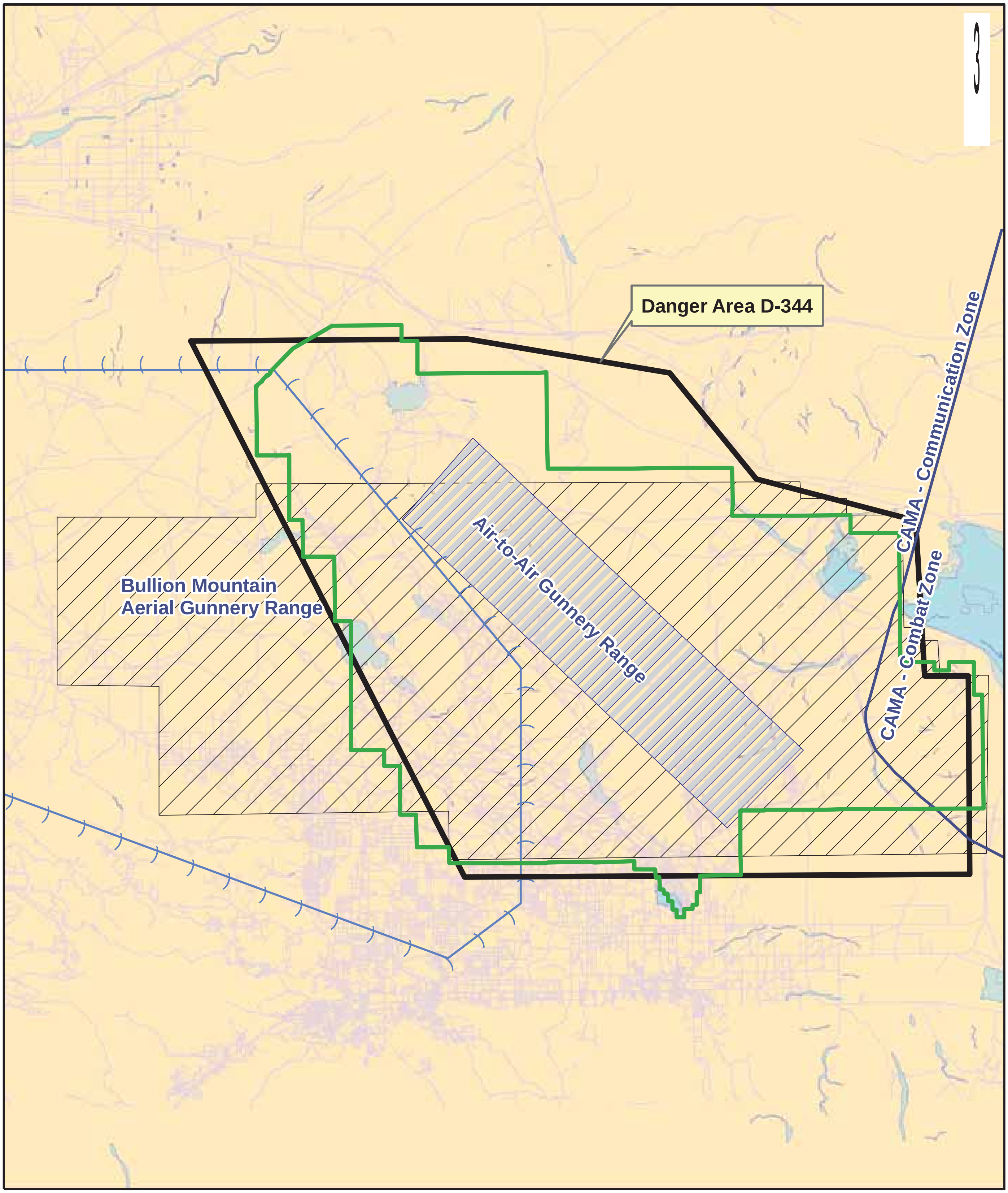
In March 1942, the U.S. Army established the Desert Training Center (DTC) for training mechanized units in desert warfare in preparation for conflict in North Africa. The DTC grew to encompass many camps, airfields, depots, ranges, and maneuver areas, covering approximately 18,000 square miles. It stretched from Pomona, California, eastward to within 50 miles of Phoenix, Arizona, southward to Yuma, Arizona, and northward to the southern tip of Nevada. The boundaries of the combat zone included all of MCAGCC Twentynine Palms; however, the vast majority of the base was within the Communication Zone, which was occupied by service units and used for simulated theater of operations for training, administration, and logistical support. Approximately 62 square miles on the eastern portion of MCAGCC Twentynine Palms were within the Combat Zone, where combat troops were stationed and conducted live-fire training and maneuvers (USACE, 2001a). The Combat Zone of the California-Arizona Maneuver Area (CAMA) overlies the current America Mine, Lead Mountain, and Bullion RTAs (Figure 7.1-1) (USACE, 2001b). The CAMA was disestablished in 1944, when the allies were victorious in North Africa.

Historical documents do not identify any specific ordnance use of range areas within MCAGCC Twentynine Palms, nor do they identify the degree or frequency of training operations there. However, given its use as a live-fire maneuver area located in an unrestricted fire zone, MC loading was performed for the Combat Zone in the area that overlaps with the installation. Existing expenditure data, adjusted for the munitions types likely to have been used during the WWII timeframe, were used to estimate MC loading for this area.

7.1.3. Victorville Bombing Range (1942–1949)

After the closure of the Twentynine Palms Air Academy, Victorville Army Air Field was established in 1942. Condor Field #1 was redesignated Victorville Auxiliary Air Field A-6 in 1944, and several bombing targets were established on the western boundary of the current MCAGCC Twentynine Palms. Two bombing targets were located within MCAGCC Twentynine Palms: Victorville Precision Bombing Ranges #17 and #18. The bombing ranges were used until 1945, at which time both ranges were declared excess (USACE, 2001a).

The Army used practice bombs on Victorville Precision Bombing Range #18. In 1947, the USACE issued a certificate of decontamination for Bombing Range #18. Range clearance personnel did not consider scrap or debris from practice bombs as UXO; therefore, the practice bombs were left in place.



LEGEND

- INSTALLATION BOUNDARY
- SURFACE WATER (INTERMITTENT)
- CAMA
- DANGER AREA D-344
- AIR-TO-AIR GUNNERY RANGE
- BULLION MNTS AERIAL GUNNERY RANGE
- VICTORVILLE BOMBING RANGE

4 2 0 4 Miles

SOURCE: MCAGCC/NREA GIS OFFICE 2006; TECOM 2006; USACE, 2001

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MALCOLM PIRNIE	MCAGCC TWENTYNINE PALMS, CALIFORNIA RANGE ENVIRONMENTAL VULNERABILITY ASSESSMENT	PRE-1952 RANGE TRAINING USE	MALCOLM PIRNIE, INC. AUGUST 2008 FIGURE 7.1-1

Between October 1947 and January 1948, 2,860 practice bombs and 32 parachute flares were removed from Precision Bombing Range #17. Due to the relative short period of time of range use and lack of high explosives used on the targets, MC loading was not estimated for these ranges (USACE, 2001a).

7.1.4. Naval Auxiliary Air Station Twentynine Palms (1944–1946)

The U.S. Navy took over Condor Field #1 and the associated auxiliary fields from the U.S. Army in 1944. The Navy established Naval Auxiliary Air Station (NAAS) Twentynine Palms in 1944 to serve as a fleet fighter and bomber aircraft base. Aviators completed gunnery, rocketry, and bombing training (USACE, 2001a). Three different bombing targets, 11th Naval District Targets #98 through #100, were established. Only Targets #98 and #99 were present within the current boundaries of MCAGCC Twentynine Palms. The installation also included a six-position rifle range. NAAS Twentynine Palms was formally disestablished on February 1, 1946, though the ASR indicates that the facility was closed prior to that date.

Historical documents reviewed for the ASR do not contain information on all of the specific types of ordnance used for rocketry, gunnery, and bombing training at NAAS Twentynine Palms. Records document the use of only a few types of high explosive munitions at the targets (USACE, 2001a). However, magazines at NAAS Twentynine Palms included space for additional high explosive munitions and small arms. Given the short period of time for range use, MC loading was not estimated for these ranges.

7.1.5. Bullion Mountain Aerial Gunnery Range (1946)

MCAGCC Twentynine Palms included portions of the Bullion Mountain Aerial Gunnery Range, which was set up by the U.S. Army. Aeronautical charts show the range established in July 1946 and then removed from the charts in August 1946. The range, if it was ever used, was operational for approximately one month and consisted of an estimated 705,920 acres trending northwest to southeast across the center of MCAGCC Twentynine Palms (USACE, 2001a) (Figure 7.1-1). The historical documents do not identify targets or the types of munitions used at the range. MC loading was not estimated for this range.

7.1.6. MCTC / Marine Corps Base Twentynine Palms

The Marine Corps began operating at Twentynine Palms in 1952, when Camp Pendleton established the Camp Detachment MCTC Twentynine Palms. In 1953, the site was redesignated as the MCTC Twentynine Palms. By 1956, most of the base construction was completed, and the Marine Corps staged several training exercises during the winter of 1956. In February 1957, MCAGCC Twentynine Palms began to administer itself and was redesignated Marine Corps Base Twentynine Palms. Based on the historical information reviewed for the ASR and PRA, no specific live-fire maneuver areas or RTAs were established during this timeframe (USACE, 2001a and 2001b). Similarly, the documents only discuss the general munitions types used during this timeframe and do not indicate volumes of munitions fired or frequency of training operations. Thus, a large data gap regarding the location, degree, and frequency of training activities exists between 1952 and 1969.

Interviews conducted with Range Control personnel indicated that training activities at MCAGCC Twentynine Palms were conducted at a reduced rate (compared to the current training tempo) in the years leading up to and including the Vietnam War. CAXs, which currently constitute the largest use of munitions during training operations, were not instituted at the installation until 1975. In 1969, the installation was administratively subdivided into eight RTAs for training purposes. Therefore, given the lack of available data on the location and degree of munitions use at the installation, as well as the anecdotal data indicating a lower level of munitions use during this timeframe as compared to current levels, MC loading was not estimated for the period between 1952 and 1969.

The following section describing military munitions and MC loading is focused solely on the CAMA Combat Zone.

Military Munitions

The types of military munitions used at the CAMA prior to the establishment of MCAGCC Twentynine Palms are mostly undocumented. The limited types of munitions documented include practive and live high explosive munitions (USACE, 2001a). Actual military munitions data for this area were not available to the REVA assessment team.

Estimated MC Loading

MC loading assumptions for the military establishments prior to the establishment of MCAGCC Twentynine Palms are described in **Section 3.6**. The MC Loading Rate Calculator was used to estimate the amount of MC loaded by military operations conducted at the CAMA. The MC loading amounts were calculated and distributed across the approximately 62 square miles of the former CAMA Combat Zone that overlap the installation boundary on the America Mine RTA and portions of the Bullion and Lead Mountain RTAs (USACE, 2001a). The MC loading amounts calculated for the CAMA during Time Period C (1938–1976) are contained in Table 7.1-1. MC loading during this period was estimated only for the period of operation of this live-fire maneuver area (1942–1944). Estimated MC loading of RDX and TNT were calculated for CAMA, extrapolating from existing munitions data. The types of munitions used at this location likely did not include items containing HMX, and perchlorate-containing munitions were not introduced until after 1962; therefore, no loading rates for these constituents were calculated. No MC loading occurred prior to 1942, when the use of military munitions at MCAGCC Twentynine Palms began.

Table 7.1-1: Estimated Annual MC Loading for the CAMA Combat Zone

MC Loading Area	Period	Begin Use	End Use	HMX (kg/m^2)	RDX (kg/m^2)	TNT (kg/m^2)	Perchlorate[a] (kg/m^2)
CAMA Combat Zone	C (1938-1976)	1942	1944	n/a	4.07E-07	2.89E-10	n/a

[a] Perchlorate has only been used in military munitions since 1962.

7.2. Alpha (1969–1979)

This RTA was part of the western boundary of MCAGCC Twentynine Palms and covered approximately 62,000 acres, which include the current Emerson Lake, Maumee Mine, and Acorn RTAs (Figure 7.2-1) (USACE, 2001a). The RTA was used primarily for combat troop maneuvers, with firing out of the range permissible to impact areas in Bravo I, Bravo II, Charlie, Delta, Echo, and Foxtrot (USACE, 2001b). The Alpha RTA was used from 1969 through 1979, at which time MCAGCC Twentynine Palms' RTAs were reconfigured.

There were no fixed firing points or fixed ranges within the Alpha RTA. One area within Alpha was designated an impact area for helicopter air-to-ground ordnance; however, the location of this impact area was not determined (USACE, 2001b).

Military Munitions

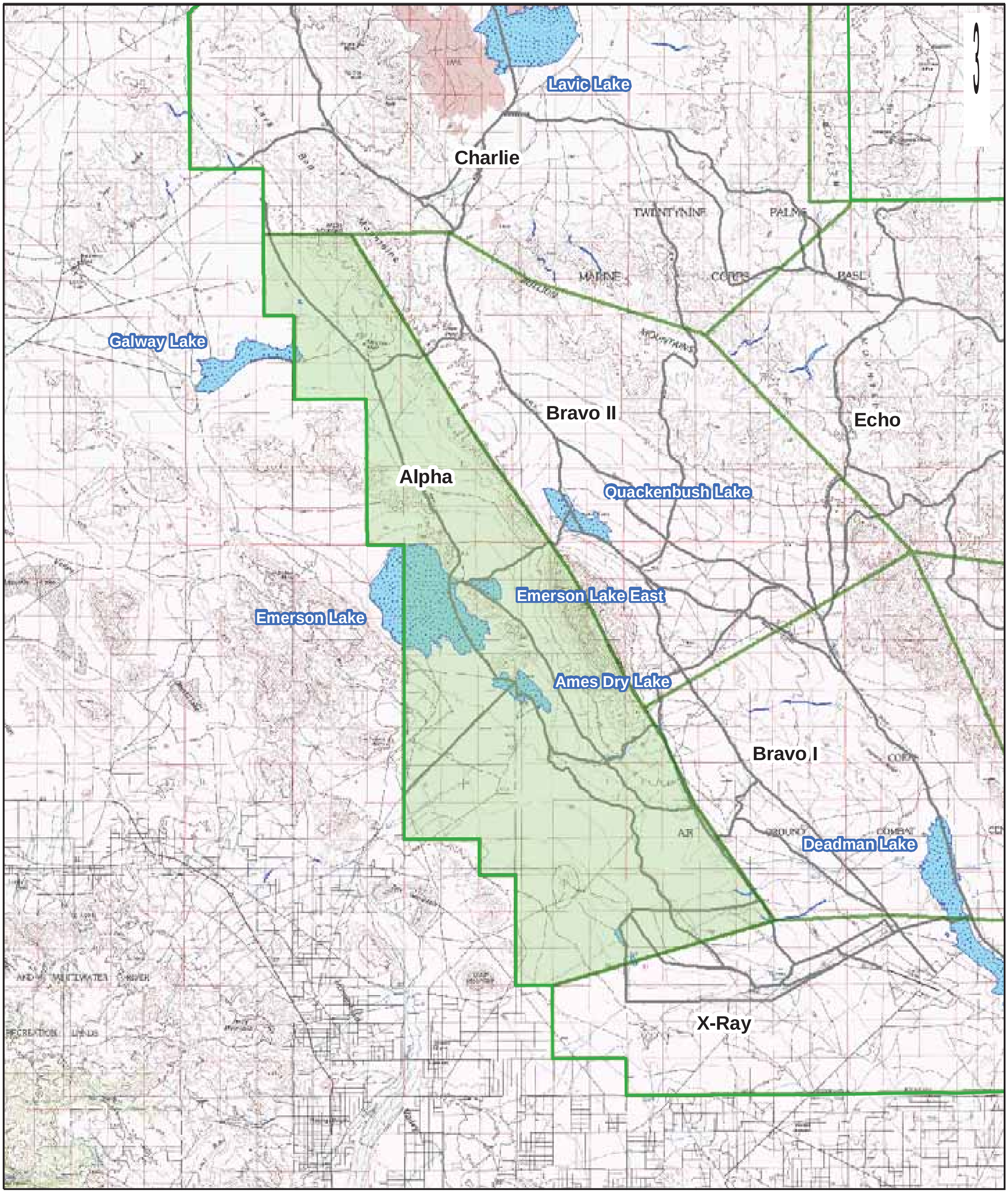
The general types of military munitions expended in this RTA include small arms ammunition, practice munitions, and live high explosive munitions. Detailed military munitions for the Alpha RTA are documented in the PRA for MCAGCC Twentynine Palms (USACE, 2001b).

7.2.1. CSM

The CSM elements for the Alpha RTA are summarized in the corresponding CSM sections for the Emerson Lake, Maumee Mine, and Acorn RTAs.

Estimated MC Loading

Due to a lack of available expenditure data for the time period of use of this historical RTA, current military munitions expenditures recorded for the Emerson Lake and Maumee Mine RTAs were used to estimate MC loading for the Alpha RTA. Only a small portion of the southern part of the Alpha RTA overlapped the current Acorn RTA, a non-live-fire range; therefore, MC associated with historical loading from Alpha were not added to the Acorn RTA. This assumption increases the estimated mass of MC loaded onto the Emerson Lake and Maumee Mine RTAs.



LEGEND

- MCAGCC TWENTYNINE PALMS
- ALPHA HISTORICAL USE RTA
- HISTORICAL USE RTA
- SURFACE WATER (INTERMITTENT)
- MAIN SUPPLY ROUTE

2 1 0 2 Miles

SOURCE: MCAGCC/NREA GIS OFFICE 2006; TECOM 2006; USGS, VARIOUS DATES;
COORDINATE SYSTEM: UTM ZONE: 11N DATUM: NAD83 UNITS: METERS

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MALCOLM PIRNIE	MCAGCC TWENTYNINE PALMS, CALIFORNIA RANGE ENVIRONMENTAL VULNERABILITY ASSESSMENT	ALPHA RTA (1969 - 1979)	MALCOLM PIRNIE, INC. SEPTEMBER 2007 FIGURE 7.2-1

There are no current primary MC loading areas identified at the installation that overlap with the Alpha RTA. As such, and due to the lack of fixed firing positions or impact areas, it was assumed that 10% of the total historical RTA area was loaded with MC. The MC Loading Rate Calculator was used to estimate the amount of MC loaded to the Alpha RTA between 1969 and 1979.

The MC loading amounts calculated for the Alpha RTA during Time Periods C (1938–1976) and D (1977–1988) are presented in Table 7.2-1. The estimated masses of HMX, RDX, TNT, and perchlorate were calculated using the MC Loading Rate Calculator. Loading was not estimated for this historical RTA prior to 1969 and was not estimated for this area following 1979. Loading for this area after 1979 is broken out separately for the Emerson Lake, Maumee Mine, and Acorn RTAs.

Table 7.2-1: Estimated Annual MC Loading for the Alpha RTA

MC Loading Area	Period	Begin Use	End Use	HMX (kg/m^2)	RDX (kg/m^2)	TNT (kg/m^2)	Perchlorate (kg/m^2)
Alpha	C (1938-1976)	1969	1976	1.06E-10	4.73E-08	2.15E-10	7.68E-09
	D (1977-1988)	1977	1979	8.46E-11	3.79E-08	1.72E-10	6.14E-09

7.3. Bravo I (1969–1979)

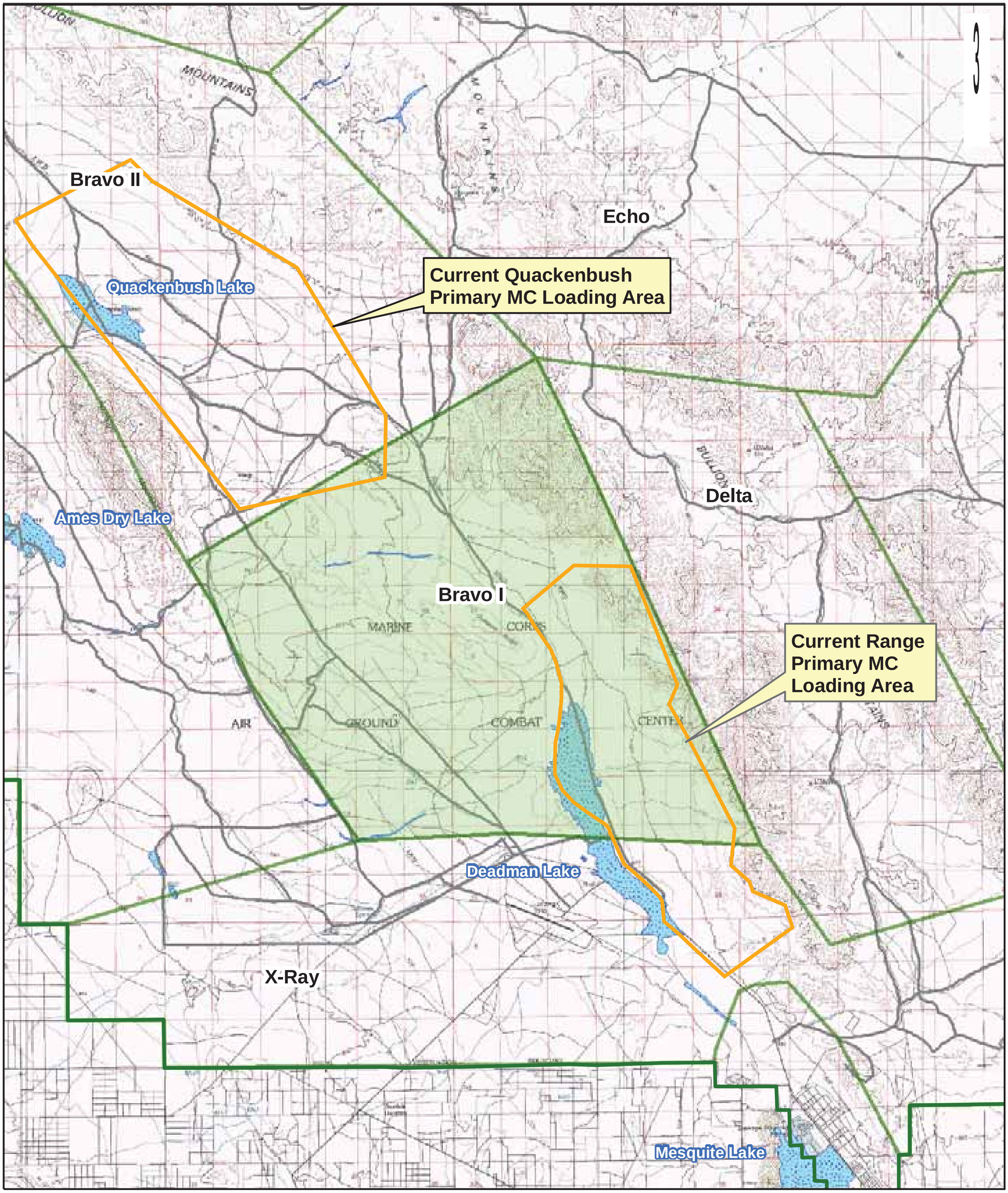
The Bravo I RTA was located east of the Alpha RTA and north of the X-Ray RTA in what are currently the Range, Noble Pass, and Gypsum Ridge RTAs (Figure 7.3-1) (USACE, 2001a). The Bravo I RTA was approximately 45,000 acres and was designated a primary impact and firing area for conventional ground weapons and troop maneuvers. Bravo I was used from 1969 through 1979, at which time MCAGCC Twentynine Palms' RTAs were reconfigured.

There were no fixed firing points within the RTA. Munitions impacts were concentrated on the western slope of the Bullion Mountains, located between the Bravo I RTA and the historical Delta RTA (USACE, 2001b).

One impact area, the Super Critical Fuze Impact Area #2, was designated for use with high explosive munitions. Based on historical documents reviewed during the ASR, this impact area was located on the western slopes of the Bullion Mountains from 1973 to 1975, between the Bravo I and historical Delta RTAs and within the current Range RTA. This range is now known as Range 110 (USACE, 2001b).

Military Munitions

The general types of military munitions expended in this RTA include small arms ammunition and high explosive munitions. A detailed summary of military munitions



LEGEND

- MCAGCC TWENTYNINE PALMS
- BRAVO I HISTORICAL USE RTA
- CURRENT MC LOADING AREA
- HISTORICAL USE RTA
- SURFACE WATER (INTERMITTENT)
- MAIN SUPPLY ROUTE

2 1 0 2 Miles

SOURCE: MCAGCC/NREA GIS OFFICE 2006; TECOM 2006; USGS, VARIOUS DATES;

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MALCOLM PIRNIE

MCAGCC TWENTYNINE PALMS, CALIFORNIA
RANGE ENVIRONMENTAL VULNERABILITY ASSESSMENT

BRAVO I RTA
(1969 - 1979)

MALCOLM PIRNIE, INC.

AUGUST 2008

FIGURE 7.3-1

used at the Bravo I RTA is provided in the PRA for MCAGCC Twentynine Palms (USACE, 2001b).

7.3.1. CSM

The CSM elements for the Bravo I RTA are summarized in the corresponding CSM sections for the Range, Noble Pass, and Gypsum Ridge RTAs.

Estimated MC Loading

The Bravo I RTA overlaps the Range primary MC loading area, as well as the Noble Pass and Gypsum Ridge RTAs. The MC Loading Rate Calculator was used to estimate the amount of MC loaded on the Bravo I RTA between 1969 and 1979. Due to a lack of available expenditure data for the time period of use of this historical RTA, current military munitions expenditures recorded for the Range, Noble Pass, and Gypsum Ridge RTAs were used to estimate MC loading for the Bravo I RTA.

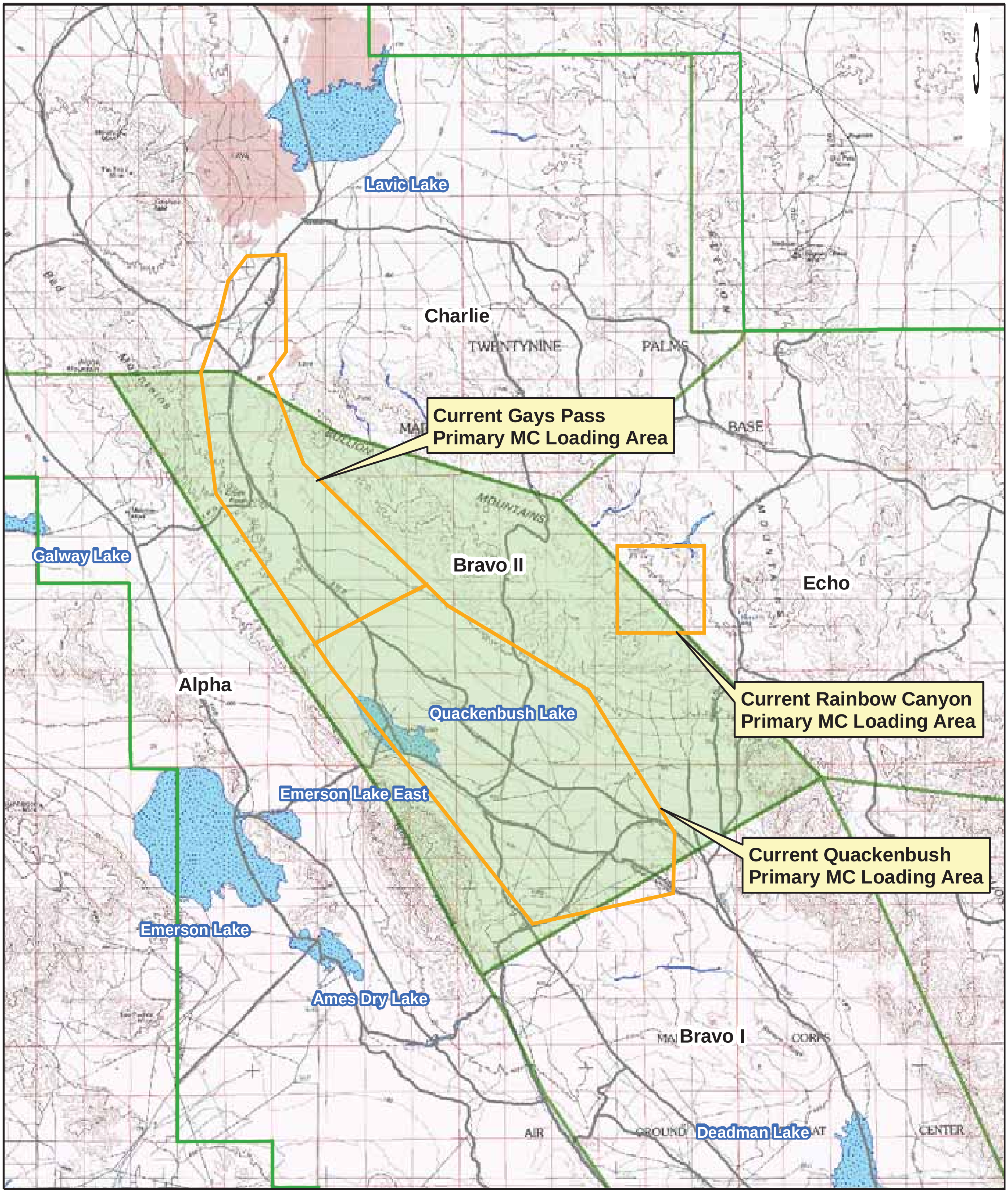
The MC loading amounts calculated for the Bravo I RTA during Time Periods C (1938–1976) and D (1977–1988) are presented in Table 7.3-1. The estimated masses of HMX, RDX, TNT, and perchlorate were calculated using the MC Loading Rate Calculator. Loading was not estimated for this historical RTA prior to 1969 or after 1979. Loading for this area after 1979 is broken out separately for the Range, Noble Pass, and Gypsum Ridge RTAs.

Table 7.3-1: Estimated Annual MC Loading for the Bravo I RTA

MC Loading Area	Period	Begin Use	End Use	HMX (kg/m^2)	RDX (kg/m^2)	TNT (kg/m^2)	Perchlorate (kg/m^2)
Bravo I	C (1938-1976)	1969	1976	2.31E-11	4.41E-08	3.84E-08	6.241E-10
	D (1977-1988)	1977	1979	1.85E-11	3.53E-08	3.07E-08	4.99E-10

7.4. Bravo II (1969–1979)

The Bravo II RTA was located north of Bravo I, between the Alpha and Echo RTAs. This historical RTA is now covered by the current Quackenbush, Gays Pass, Rainbow Canyon, and Noble Pass RTAs (Figure 7.4-1) (USACE, 2001a). The Bravo II RTA served as a primary impact and firing area for conventional ground weapons and inert aircraft ordnance. The entire area was used as an impact area for artillery and mortar ammunition, and the northern half of the RTA was designated for inert aircraft ordnance. The RTA was also used for troop maneuvers. Bravo II was used from 1969 through 1979, at which time MCAGCC Twentynine Palms' RTAs were reconfigured. There were no fixed firing points or impact areas designated within the Bravo II RTA (USACE, 2001b).



LEGEND

- MCAGCC TWENTYNINE PALMS
- BRAVO II HISTORICAL USE RTA
- CURRENT MC LOADING AREA
- HISTORICAL USE RTA
- SURFACE WATER (INTERMITTENT)
- MAIN SUPPLY ROUTE

2 1 0 2 Miles

SOURCE: MCAGCC/NREA GIS OFFICE 2006; TECOM 2006; USGS, VARIOUS DATES;

MALCOLM PIRNIE

MCAGCC TWENTYNINE PALMS, CALIFORNIA
RANGE ENVIRONMENTAL VULNERABILITY ASSESSMENT

BRAVO II RTA
(1969 - 1979)

MALCOLM PIRNIE, INC.

AUGUST 2008

FIGURE 7.4-1

Military Munitions

The general types of military munitions expended in this RTA include small arms ammunitions and high explosive munitions. A detailed summary of military munitions used at the Bravo II RTA is provided in the PRA for MCAGCC Twentynine Palms (USACE, 2001b).

7.4.1. CSM

The CSM elements for the Bravo II RTA are summarized in the corresponding CSM sections for the Quackenbush, Gays Pass, Rainbow Canyon, and Noble Pass RTAs.

Estimated MC Loading

The Bravo II RTA primarily overlaps the current Quackenbush and Gays Pass primary MC loading areas, along with smaller portions of the Noble Pass and Rainbow Canyon RTAs. Due to a lack of available expenditure data for the time period of use of this historical RTA, current military munitions expenditures recorded for the Quackenbush, Gays Pass, Rainbow Canyon, and Noble Pass RTAs were used to estimate MC loading for the Bravo II RTA. MC from historical use military munitions in Bravo II were loaded for the period between 1969 and 1979. The MC Loading Rate Calculator was used to estimate the amount of MC loaded on the Bravo II RTA between 1969 and 1979.

The MC loading amounts calculated for the Bravo II RTA during Time Periods C (1938–1976) and D (1977–1988) are presented in Table 7.4-1. The estimated masses of HMX, RDX, TNT, and perchlorate were calculated using the MC Loading Rate Calculator. Loading was not conducted for this historical RTA prior to 1969 or after 1979. Loading for this area after 1979 is broken out separately for the Quackenbush, Gays Pass, Rainbow Canyon, and Noble Pass RTAs.

Table 7.4-1: Estimated Annual MC Loading for the Bravo II RTA

MC Loading Area	Period	Begin Use	End Use	HMX (kg/m^2)	RDX (kg/m^2)	TNT (kg/m^2)	Perchlorate (kg/m^2)
Bravo II	C (1938-1976)	1969	1976	4.01E-12	3.22E-07	5.56E-07	1.11E-10
	D (1977-1988)	1977	1979	3.21E-12	2.57E-07	4.45E-07	8.88E-11

7.5. Charlie (1969–1979)

The Charlie RTA covered approximately 93,000 acres in the northwest corner of MCAGCC Twentynine Palms, north of the Alpha and Bravo II RTAs (Figure 7.5-1) (USACE, 2001a). Because road access to the RTA was difficult, the area was used primarily as an impact and firing area for conventional ground weapons and aircraft ordnance. A dummy airfield was located in the southern portion of Charlie and was used as a target. Troop maneuvers normally were not permitted in this RTA. The Charlie RTA includes all of the current Sunshine Peak RTA and portions of the Lavic Lake, Gays Pass, Rainbow Canyon, and Maumee Mine RTAs. Charlie was used from 1969 through 1979, at which time MCAGCC Twentynine Palms' RTAs were reconfigured. There were no fixed firing points or designated fixed ranges within the Charlie RTA. The dummy airfield was used as a target; however, the entire RTA potentially could have been used as an impact area during training operations (USACE, 2001b).

Military Munitions

The general types of military munitions expended in this RTA include high explosive munitions. A detailed summary of military munitions used at the Charlie RTA is provided in the PRA for MCAGCC Twentynine Palms (USACE, 2001b).

7.5.1. CSM

The CSM elements for the Charlie RTA are summarized in the corresponding CSM sections for the Lavic Lake, Gays Pass, Rainbow Canyon, Sunshine Peak, and Maumee Mine RTAs.

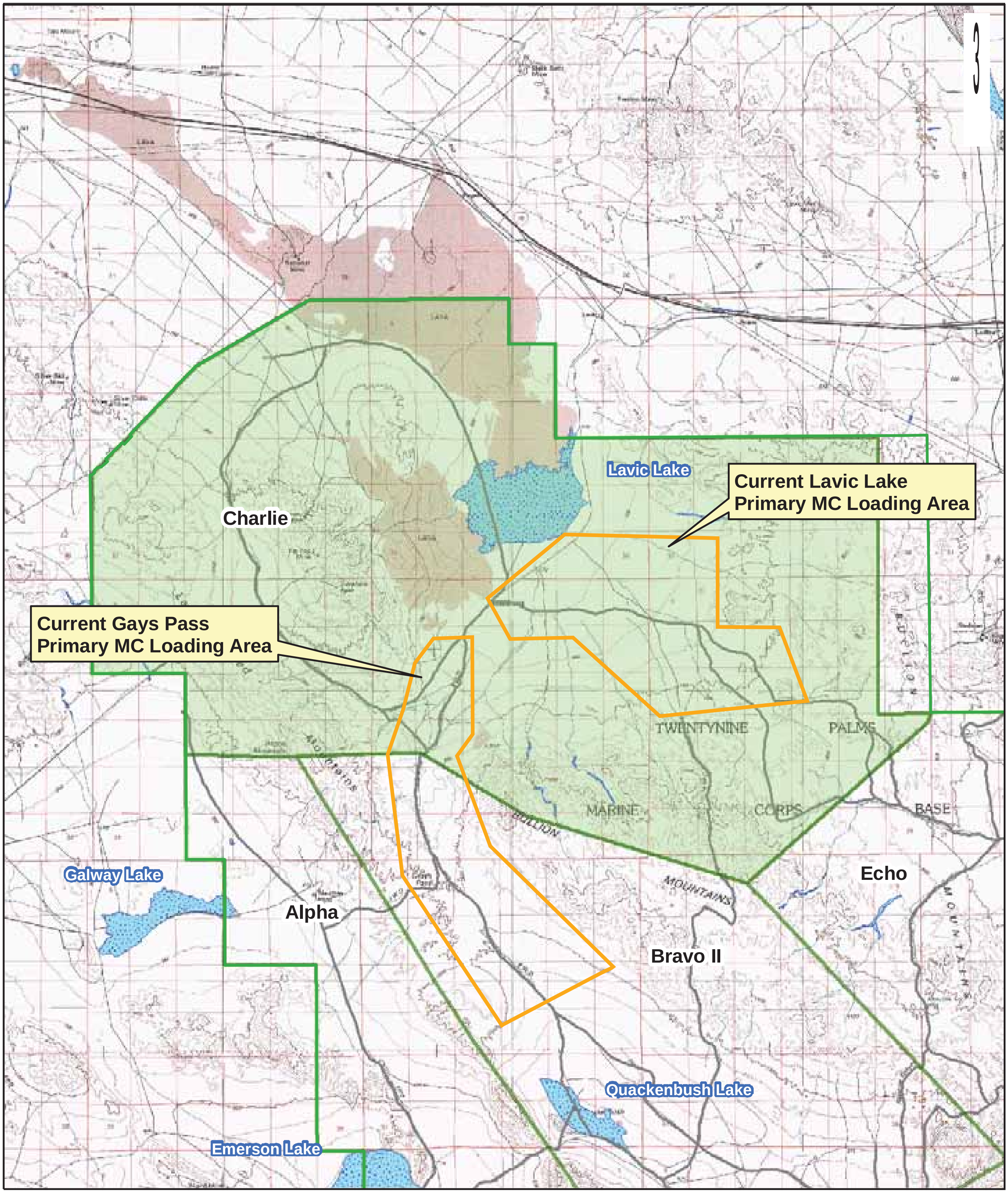
Estimated MC Loading

The Charlie RTA overlaps the Lavic Lake and Gays Pass primary MC loading areas. In addition, this historical use RTA fully overlaps the Sunshine Peak RTA and the northern section of the Maumee Mine RTA as well as portions of the Rainbow Canyon RTA (but not the Rainbow Canyon primary MC loading area). Due to a lack of available expenditure data for the time period of use of this historical RTA, current military munitions expenditures recorded for these RTAs were used to estimate MC loading for the Charlie RTA. The MC Loading Rate Calculator was used to estimate the amount of MC loaded on the Charlie RTA between 1969 and 1979.

The MC loading amounts calculated for the Charlie RTA during Time Periods C (1938–1976) and D (1977–1988) are presented in Table 7.5-1. The estimated masses of HMX, RDX, TNT, and perchlorate were calculated using the MC Loading Rate Calculator. Loading for this historical RTA did not occur prior to 1969 or after 1979. Loading for this area after 1979 is broken out separately for the current RTAs that overlap this historical RTA.

Table 7.5-1: Estimated Annual MC Loading for the Charlie RTA

MC Loading Area	Period	Begin Use	End Use	HMX (kg/m^2)	RDX (kg/m^2)	TNT (kg/m^2)	Perchlorate (kg/m^2)
Charlie	C (1938-1976)	1969	1976	2.82E-11	4.68E-07	7.16E-07	1.81E-10
	D (1977-1988)	1977	1979	2.26E-11	3.75E-07	5.72E-07	1.44E-10



LEGEND

- MCAGCC TWENTYNINE PALMS
- CHARLIE HISTORICAL USE RTA
- CURRENT MC LOADING AREA
- HISTORICAL USE RTA
- SURFACE WATER (INTERMITTENT)
- MAIN SUPPLY ROUTE

2 1 0 2 Miles

SOURCE: MCAGCC/NREA GIS OFFICE 2006; TECOM 2006; USGS, VARIOUS DATES;

MALCOLM PIRNIE

MCAGCC TWENTYNINE PALMS, CALIFORNIA

RANGE ENVIRONMENTAL VULNERABILITY ASSESSMENT

CHARLIE RTA (1969 - 1979)

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FIGURE 7.5-1

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7.6. Delta (1969-1979)

The Delta RTA was located in the central part of MCAGCC Twentynine Palms, covering approximately 38,500 acres. It was approximately 4 miles wide and 12 miles long (Figure 7.6-1). At the time, the Delta RTA was designated a primary impact and firing area for conventional ground weapons and was used infrequently for troop maneuvers. This historical RTA is now designated as the Prospect and Delta (current use) RTAs; portions of the Cleghorn Pass and Noble Pass RTAs are also designated in the former historical footprint. Delta was used from 1969 through 1979, at which time MCAGCC Twentynine Palms' RTAs were reconfigured. There were no fixed firing points or impact areas designated with the Delta RTA; the majority of the RTA was used as an impact area. At the time, an EOD Range was located in the southeast corner of the RTA, in what is now Cleghorn Pass (USACE, 2001b).

Military Munitions

The general types of military munitions expended in this RTA include high explosive munitions. A detailed summary of military munitions used at the Delta RTA is provided in the PRA for MCAGCC Twentynine Palms (USACE, 2001b).

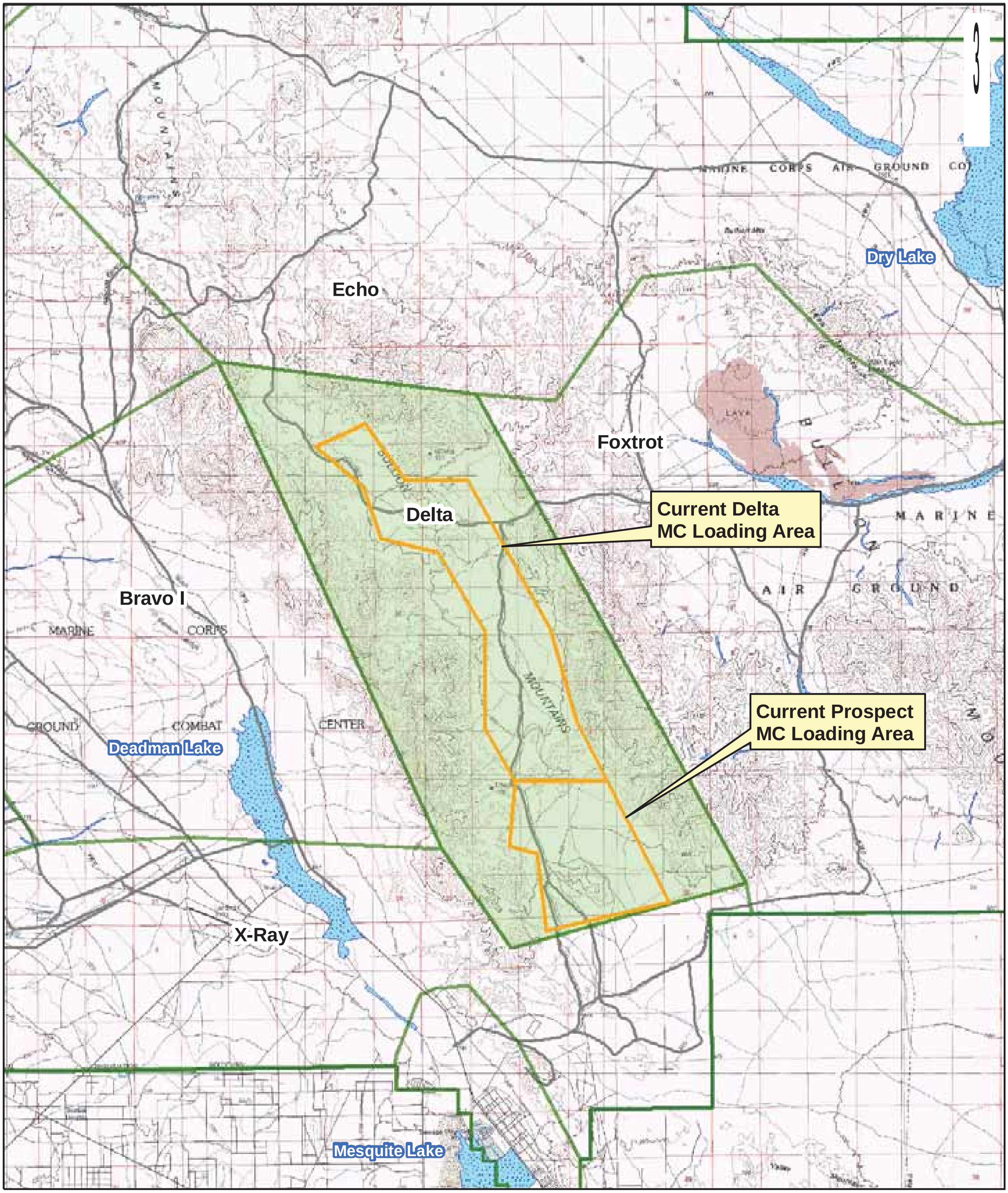
7.6.1. CSM

The CSM elements for the Delta RTA are summarized in the corresponding CSM sections for the Prospect, Delta, Cleghorn Pass, and Noble Pass RTAs.

Estimated MC Loading

The historical Delta RTA fully contains the current Prospect and Delta primary MC loading areas, as well as smaller portions of the Cleghorn Pass and Noble Pass RTAs. Due to a lack of available expenditure data for the time period of use of this historical RTA, current military munitions expenditures recorded for these RTAs were used to estimate MC loading for the historical use Delta RTA. The MC Loading Rate Calculator was used to estimate the amount of MC loaded on the Delta RTA between 1969 and 1979.

The MC loading amounts calculated for the Delta RTA during Time Periods C (1938–1976) and D (1977–1988) are presented in Table 7.6-1. The estimated masses of HMX, RDX, TNT, and perchlorate were calculated using the MC Loading Rate Calculator. Loading for this historical RTA did not occur prior to 1969 or after 1979. Loading for this area after 1979 is broken out separately for the Prospect, Delta (current use), Cleghorn Pass, and Noble Pass RTAs.



LEGEND

- MCAGCC TWENTYNINE PALMS
- DELTA HISTORICAL USE RTA
- CURRENT MC LOADING AREA
- HISTORICAL USE RTA
- SURFACE WATER (INTERMITTENT)
- MAIN SUPPLY ROUTE

2 1 0 2 Miles

SOURCE: MCAGCC/NREA GIS OFFICE 2006; TECOM 2006; USGS, VARIOUS DATES;

MALCOLM PIRNIE

MCAGCC TWENTYNINE PALMS, CALIFORNIA

RANGE ENVIRONMENTAL VULNERABILITY ASSESSMENT

DELTA RTA (1969 - 1979)

MALCOLM PIRNIE, INC.

AUGUST 2008

FIGURE 7.6-1

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Table 7.6-1: Estimated Annual MC Loading for the Delta RTA

MC Loading Area	Period	Begin Use	End Use	HMX (kg/m²)	RDX (kg/m²)	TNT (kg/m²)	Perchlorate (kg/m²)
Delta	C (1938-1976)	1969	1976	2.70E-11	2.09E-07	2.85E-07	3.66E-10
	D (1977-1988)	1977	1979	2.16E-11	1.67E-07	2.28E-07	2.93E-10

7.7. Echo (1969–1979)

The Echo RTA was located in the northeastern section of MCAGCC Twentynine Palms. It was the largest of the historical RTAs during this timeframe, covering approximately 130,500 acres (Figure 7.7-1) (USACE, 2001a). The Echo RTA was an impact and firing area for conventional ground weapons and aircraft ordnance. No fixed firing positions were located within the RTA; however, a dummy airfield was located within this RTA and was used as a target. Troop maneuvers normally were not permitted within the area. The Echo RTA is now incorporated within the Lead Mountain, Black Top, Rainbow Canyon, Lava, and Noble Pass RTAs (USACE, 2001b). The Echo RTA was used from 1969 through 1979, at which time MCAGCC Twentynine Palms' RTAs were reconfigured.

Military Munitions

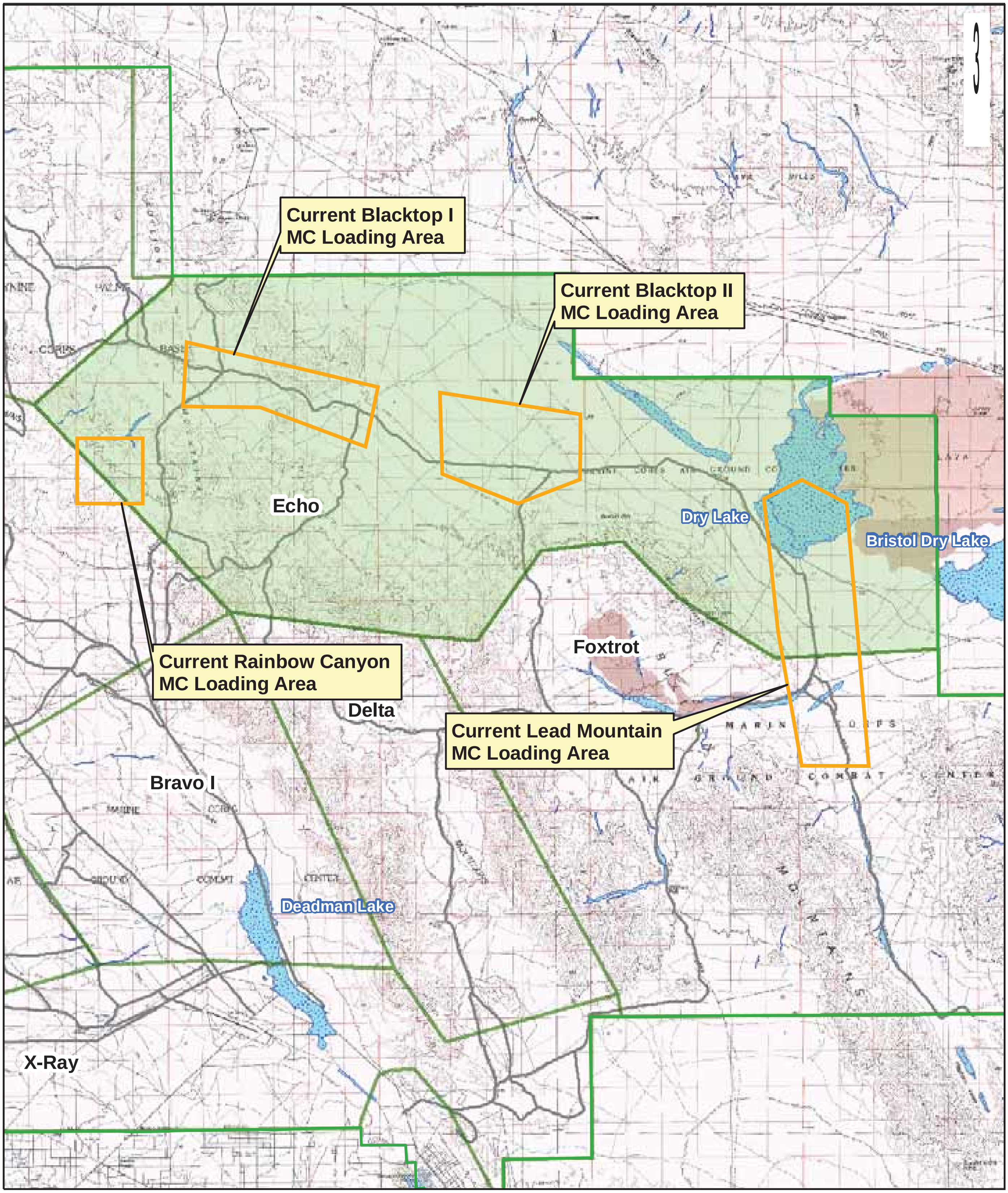
The general types of military munitions expended in this RTA include high explosive munitions. A detailed summary of military munitions used at the Echo RTA is provided in the PRA for MCAGCC Twentynine Palms (USACE, 2001b).

7.7.1. CSM

The CSM elements for the Echo RTA are summarized in the corresponding CSM sections for the Lead Mountain, Black Top, Rainbow Canyon, Lava, and Noble Pass RTAs.

Estimated MC Loading

The Echo RTA overlaps primary MC loading areas within Black Top, Rainbow Canyon and the northern half of Lead Mountain. Portions of the Lava and Noble Pass RTAs also overlap this former RTA. Due to a lack of available expenditure data for the time period of use of this historical RTA, current military munitions expenditures recorded for these RTAs were used to estimate MC loading for the historical use Echo RTA. The MC Loading Rate Calculator was used to estimate the amount of MC loaded on the Echo RTA between 1969 and 1979.



LEGEND

- MCAGCC TWENTYNINE PALMS
- ECHO HISTORICAL USE RTA
- CURRENT MC LOADING AREA
- HISTORICAL USE RTA
- SURFACE WATER (INTERMITTENT)
- MAIN SUPPLY ROUTE

2 1 0 2 Miles

SOURCE: MCAGCC/NREA GIS OFFICE 2006; TECOM 2006; USGS, VARIOUS DATES.

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MCAGCC TWENTYNINE PALMS, CALIFORNIA
RANGE ENVIRONMENTAL VULNERABILITY ASSESSMENT

ECHO RTA
(1969 - 1979)

MALCOLM PIRNIE, INC.
AUGUST 2008
FIGURE 7.7-1

The MC loading amounts calculated for the Echo RTA during Time Periods C (1938–1976) and D (1977–1988) are presented in Table 7.7-1. The estimated masses of HMX, RDX, TNT, and perchlorate were calculated using the MC Loading Rate Calculator. Loading for this historical RTA did not occur prior to 1969 or after 1979. Loading for this area after 1979 is broken out separately for the Lead Mountain, Black Top, Rainbow Canyon, Lava, and Noble Pass RTAs.

Table 7.7-1: Estimated Annual MC Loading for the Echo RTA

MC Loading Area	Period	Begin Use	End Use	HMX (kg/m^2)	RDX (kg/m^2)	TNT (kg/m^2)	Perchlorate (kg/m^2)
Echo	C (1938-1976)	1969	1976	1.76E-11	2.79E-07	4.03E-07	1.54E-10
	D (1977-1988)	1977	1979	1.41E-11	2.23E-07	3.22E-07	1.23E-10

7.8. Foxtrot (1969–1979)

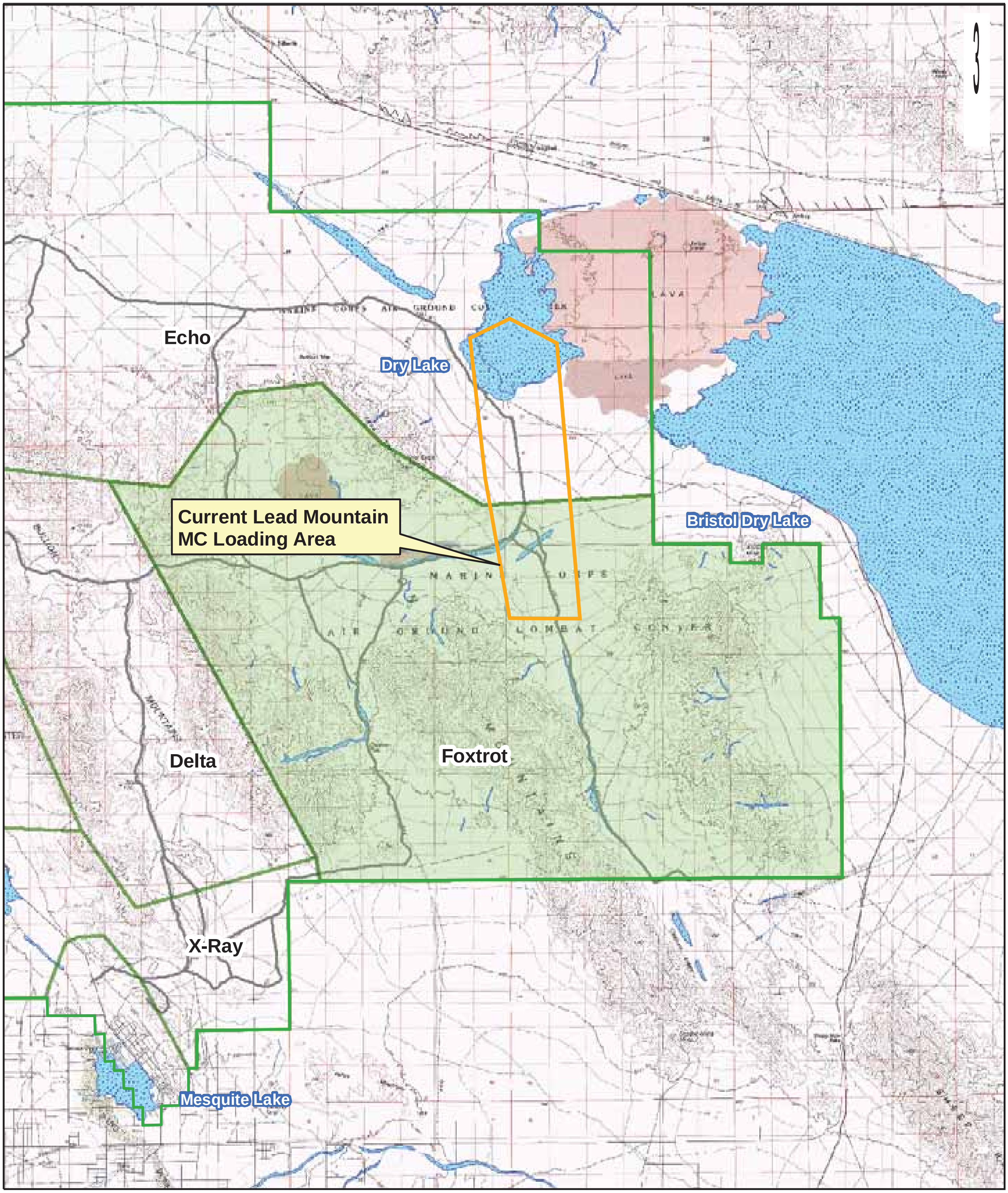
The Foxtrot RTA was located on the southeastern portion of MCAGCC Twentynine Palms, east of the historical Delta RTA and south of the Echo RTA (Figure 7.8-1) (USACE, 2001a). Foxtrot covered approximately 115,700 acres and was used as a primary impact and firing area for conventional ground weapons and an impact area for aircraft ordnance. The Foxtrot RTA now consists of the Lead Mountain, America Mine, Bullion, Cleghorn Pass, and Lava RTAs. There were no fixed firing positions or designated impact areas within Foxtrot except for Super Critical Fuze Area #1. Located along the western slopes of mountains that divide current RTAs Cleghorn Pass and Bullion, Super Critical Fuze Area #1 is now part of the Cleghorn Pass RTA. Super Critical Fuze Area #1 most likely was used as an impact area for certain types of high explosive munitions in this timeframe. The RTA normally was not used for troop maneuvers; however, a fixed range, Missile Range 3, was located in the north part of the area. Missile Range 3 was used for missile firings. The direction of fire was to the west toward the Delta RTA (USACE, 2001b).

Military Munitions

The general types of military munitions expended in this RTA include high explosive munitions. A detailed summary of military munitions used at the Foxtrot RTA is provided in the PRA for MCAGCC Twentynine Palms (USACE, 2001b).

7.8.1. CSM

The CSM elements for the Foxtrot RTA are summarized in the corresponding CSM sections for the Lead Mountain, America Mine, Bullion, Cleghorn Pass, and Lava RTAs.



LEGEND

- MCAGCC TWENTYNINE PALMS
- FOXTROT HISTORICAL USE RTA
- CURRENT MC LOADING AREA
- HISTORICAL USE RTA
- SURFACE WATER (INTERMITTENT)
- MAIN SUPPLY ROUTE

2 1 0 2 Miles

SOURCE: MCAGCC/NREA GIS OFFICE 2006; TECOM 2006; USGS, VARIOUS DATES;

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RANGE ENVIRONMENTAL VULNERABILITY ASSESSMENT

FOXTROT RTA (1969 - 1979)

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AUGUST 2008

FIGURE 7.8-1

Estimated MC Loading

The Foxtrot RTA overlaps the southern half of the Lead Mountain primary MC loading area. This historical use RTA also fully contains the America Mine and Bullion RTAs and the majority of the Cleghorn Pass and Lava RTAs. Due to a lack of available expenditure data for the time period of use of this historical RTA, current military munitions expenditures recorded for these RTAs were used to estimate MC loading for the historical use Foxtrot RTA. The MC Loading Rate Calculator was used to estimate the amount of MC loaded on the Foxtrot RTA between 1969 and 1979.

The MC loading amounts calculated for the Foxtrot RTA during Time Periods C (1938–1976) and D (1977–1988) are presented in Table 7.8-1. The estimated masses of HMX, RDX, TNT, and perchlorate were calculated using the MC Loading Rate Calculator. Loading for this historical RTA did not occur prior to 1969 or after 1979. Loading for this area after 1979 is broken out separately for the Lead Mountain, America Mine, Bullion, Cleghorn Pass, and Lava RTAs.

Table 7.8-1: Estimated Annual MC Loading for the Foxtrot RTA

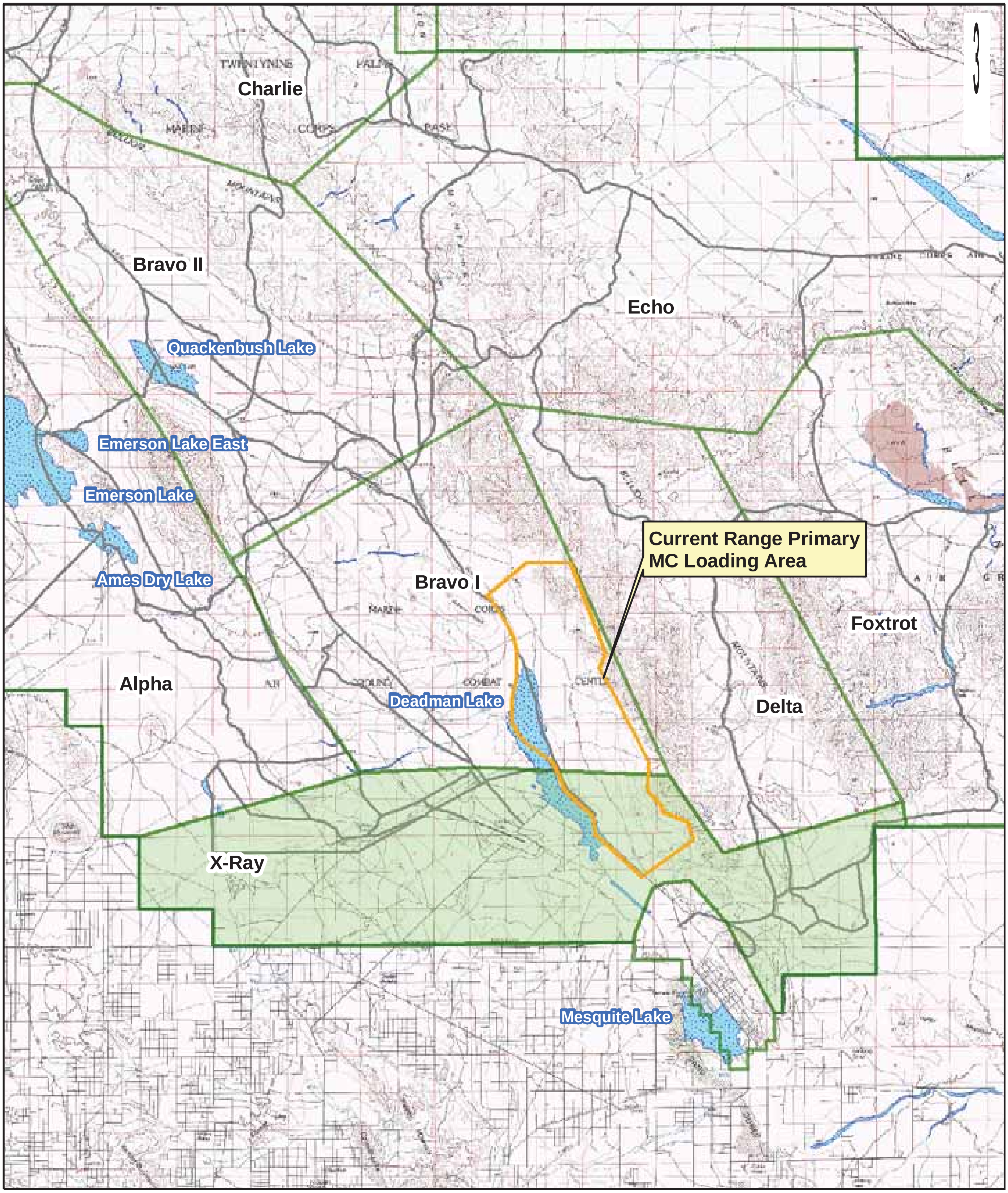
MC Loading Area	Period	Begin Use	End Use	HMX (kg/m^2)	RDX (kg/m^2)	TNT (kg/m^2)	Perchlorate (kg/m^2)
Foxtrot	C (1938-1976)	1969	1976	5.86E-11	5.67E-07	7.00E-07	8.98E-10
	D (1977-1988)	1977	1979	4.69E-11	4.53E-07	5.60E-07	7.19E-10

7.9. X-Ray (1969–1979)

The X-Ray RTA formed the southern boundary of MCAGCC Twentynine Palms, covering approximately 51,000 acres (Figure 7.9-1) (USACE, 2001a). The X-Ray RTA currently is composed of the Prospect, Range, East, Gypsum Ridge, Sand Hill, andWest RTAs. It was designated a nonimpact area and designed as a maneuver area for crew served weapons. Only blank ammunition was authorized for use within the RTA. High explosive munition firing was allowed from the area for official demonstrations only, as it was located closest to the cantonment area (Mainside). Missile Ranges 1 and 2 were located within the X-Ray RTA. Additional fixed ranges were contained within the RTA, in what are now the Range and East RTAs (USACE, 2001b).

Military Munitions

The general types of military munitions expended in this RTA include blank small arms and pyrotechnic items. A detailed summary of military munitions used at the X-Ray RTA is provided in the PRA for MCAGCC Twentynine Palms (USACE, 2001b).



LEGEND

- MCAGCC TWENTYNINE PALMS
- X-RAY HISTORICAL USE RTA
- CURRENT MC LOADING AREA
- HISTORICAL USE RTA
- SURFACE WATER (INTERMITTENT)
- MAIN SUPPLY ROUTE

2 1 0 2 Miles

SOURCE: MCAGCC/NREA GIS OFFICE 2006; TECOM 2006; USGS, VARIOUS DATES;

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RANGE ENVIRONMENTAL VULNERABILITY ASSESSMENT

X-RAY RTA (1969 - 1979)

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FIGURE 7.9-1

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7.9.1. CSM

The CSM elements for the X-Ray RTA are summarized in the corresponding CSM sections for the Prospect, Range, East, Gypsum Ridge, Sand Hill, and West RTAs.

Estimated MC Loading

The X-Ray RTA overlaps the southern portion of the Range primary MC loading area. The former RTA consists mostly of current non-live-fire RTAs. Due to a lack of available expenditure data for the time period of use of this historical RTA, current military munitions expenditures recorded for these RTAs were used to estimate MC

loading for the historical use X-Ray RTA. The X-Ray RTA was designated a troop maneuver area; therefore, there is limited MC loading associated with military activities on this area. The MC Loading Rate Calculator was used to estimate the amount of MC loaded on the RTA between 1969 and 1979.

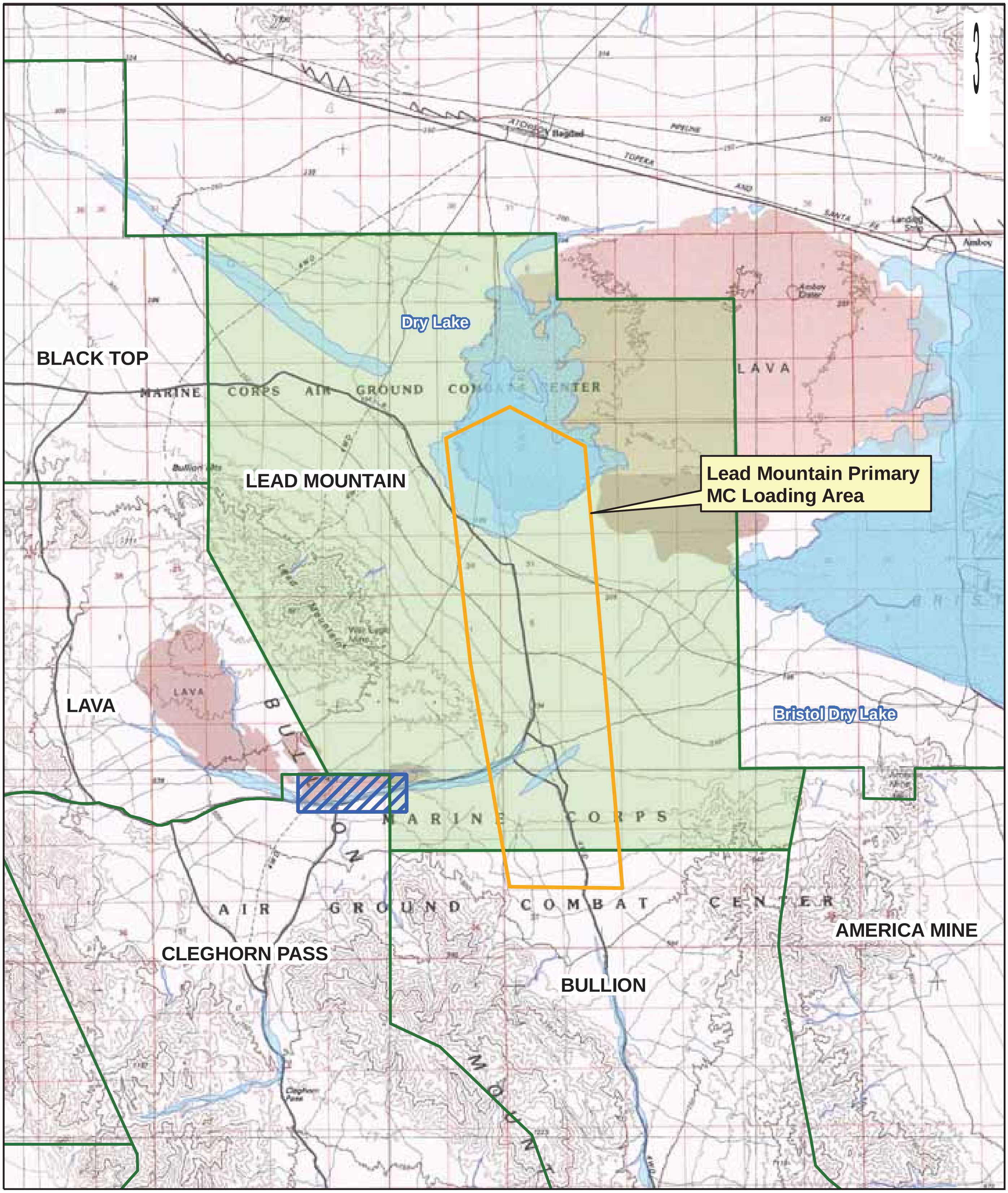
The MC loading amounts calculated for the X-Ray RTA during Time Periods C (1938–1976) and D (1977–1988) are presented in Table 7.9-1. The estimated masses of HMX, RDX, TNT, and perchlorate were calculated using the MC Loading Rate Calculator. Loading for this historical RTA did not occur prior to 1969 or after 1979. Loading for this area after 1979 is broken out separately for the Prospect, Range, East, Gypsum Ridge, Sand Hill, and West RTAs.

Table 7.9-1: Estimated Annual MC Loading for the X-Ray RTA

MC Loading Area	Period	Begin Use	End Use	HMX (kg/m^2)	RDX (kg/m^2)	TNT (kg/m^2)	Perchlorate (kg/m^2)
X-Ray	C (1938-1976)	1969	1976	n/a	4.15E-10	2.94E-13	5.00E-10
	D (1977-1988)	1977	1979	n/a	3.32E-10	2.35E-13	4.00E-10

7.10. Lead Mountain

The Lead Mountain RTA is located in the northeast portion of MCAGCC Twentynine Palms (Figure 7.10-1) and covers 53,572 acres (USACE, 2001a). The northern and eastern boundaries of the RTA make up the installation boundary. Lead Mountain is currently used for aerial bombardment, combined ground-based and aviation-based training, and ground-based live fire. Located within the Lead Mountain RTA is a CAX target system, an automated target system consisting of stationary pop-up armor targets. The targets are radio-controlled to support training of tank gunnery personnel and aid anti-tank Marines in identifying and firing on hostile targets. In addition to the CAX targets within the RTA, six Laser Target Areas (LTAs) for laser ground-to-ground or air-



LEGEND

- LEAD MOUNTAIN RTA
- RANGE TRAINING AREA
- PRIMARY MC LOADING AREA
- SURFACE WATER (INTERMITTENT)
- MAIN SUPPLY ROUTE
- RESTRICTED AREA

2 1 0 2 Miles

SOURCE: MCAGCC/NREA GIS OFFICE 2006; TECOM 2006; USGS, VARIOUS

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RANGE ENVIRONMENTAL VULNERABILITY ASSESSMENT

LEAD MOUNTAIN RTA

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AUGUST 2008

FIGURE 7.10-1

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to-ground firing are present. Three C.C. courses are located within the Lead Mountain RTA (Table 7.10-1) (USACE, 2001b).

Table 7.10-1: Fixed Ranges within the Lead Mountain RTA

Fixed Range	Range Type	Area (1,000 m^2)
LIVE-FIRE RANGES		
C.C. Course Station 1	C.C. Course	329.76
C.C. Course Station 2	C.C. Course	621.80
C.C. Course Station 3	C.C. Course	775.09

The Lead Mountain RTA was established in 1979, following the reassignment of new RTAs and their associated boundaries and training purposes. Slight changes were made to the RTA boundaries in 1997. Prior to the designation of Lead Mountain, the area was part of the Echo and Foxtrot RTAs from 1969 through 1979. The Echo and Foxtrot RTAs were used for similar training operations as Lead Mountain; additional information regarding the Foxtrot RTA is in **Section 7.8** (USACE, 2001b).

A restricted area is located on the far southwestern corner of the Lead Mountain RTA, along the boundary with the Cleghorn Pass RTA. This area is considered a no-fire zone (MCAGCC, 2006).

A primary MC loading area was identified within the Lead Mountain RTA based on interviews with Range Control and the fixed target location (MCAGCC FMD, 2006). The interviews and locations of the target emplacements indicate the highest density of military munitions firing exists at the center of the Lead Mountain RTA and follows southward through the valley to the northern end of the Bullion RTA. The Lead Mountain MC loading area is 44,585,000 m^2 in size and is approximately 3,500 m wide by 12,000 m long.

Military Munitions

The general classes of military munitions fired in this RTA include small arms ammunition and high explosive munitions. Detailed military munitions use data are presented in the PRA (USACE, 2001b), and detailed assumptions for the determination of MC loading rates are provided in the *REVA Reference Manual* (HQMC, 2006).

7.10.1. CSM

7.10.1.1. Estimated MC Loading

The primary MC loading area for the Lead Mountain RTA is shown in Figure 7.10-1. The MC Loading Rate Calculator was used to estimate the amount of MC loaded to this primary MC loading area over time (Table 7.10-2). It was conservatively assumed that all military munitions expenditures for the Lead Mountain RTA were performed within the boundaries of the primary loading area, rather than across the entire RTA. Therefore, the MC loading amounts estimated for each identified time period during which the RTA was used, Time Periods D and E, were assumed to occur only within the primary loading area for the purposes of the modeling effort (**Section 7.10.3**). There are no SARs located within the Lead Mountain RTA; therefore, qualitative assessments to determine the fate and transport of lead were not conducted for this RTA. Expenditure data were extrapolated for time periods when expenditure data were not available.

Table 7.10-2: Estimated Annual MC Loading for the Lead Mountain Primary MC Loading Area

MC Loading Area	Period	Begin Use	End Use	HMX (kg/m^2)	RDX (kg/m^2)	TNT (kg/m^2)	Perchlorate (kg/m^2)
Lead Mountain	D (1977-1988)	1979	1988	1.13E-12	1.09E-07	1.47E-07	4.70E-11
	E (1989-Present)	1989	2005	1.42E-12	1.36E-07	1.84E-07	5.88E-11

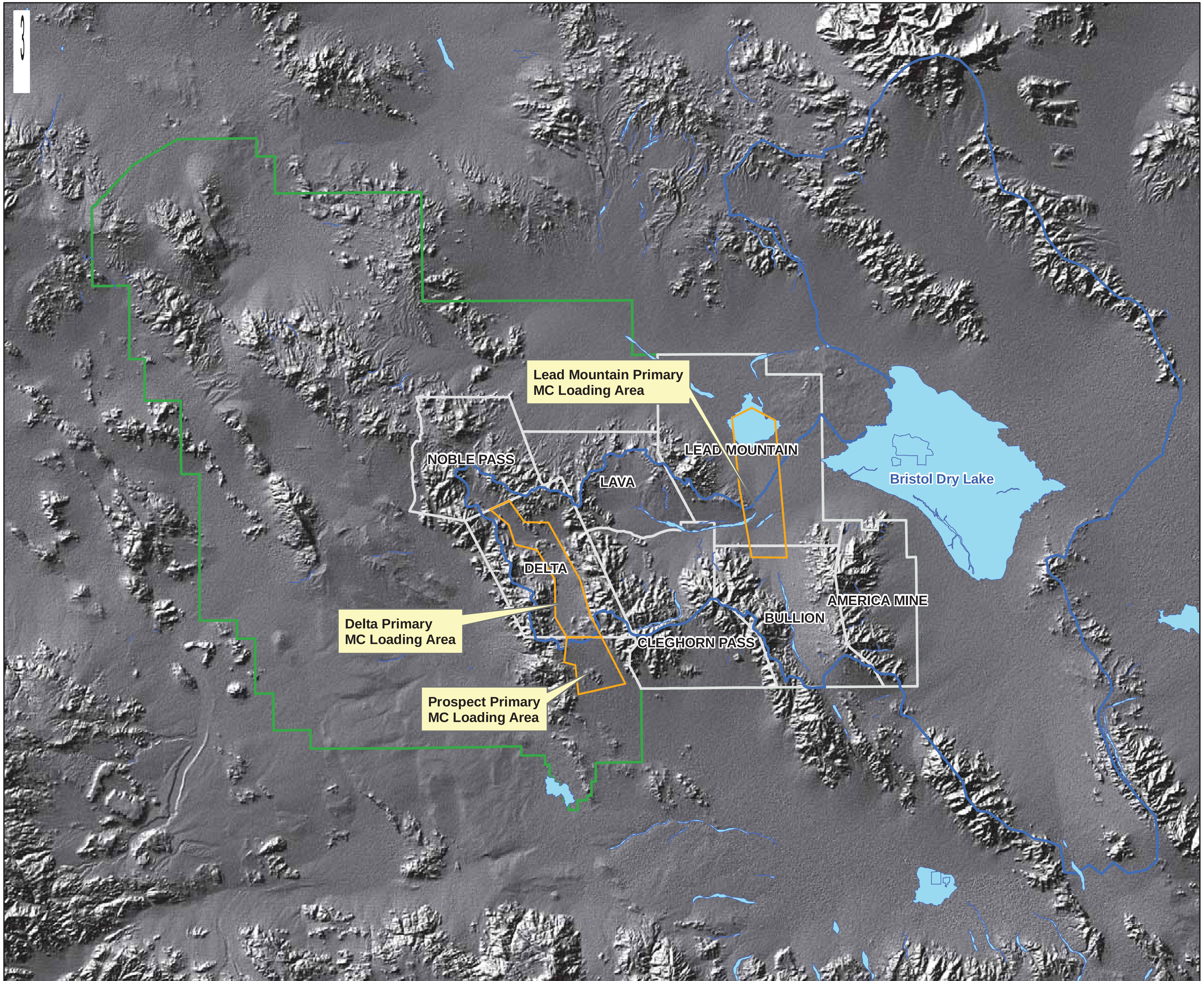
7.10.1.2. Geography and Topography

The Lead Mountain RTA is part of the high desert region of the Mojave Desert, which is characterized by rugged terrain consisting of desert, mountains, and playas (MCAGCC, 2006). The Lead Mountain RTA is composed mostly of level land surface, with Dry Lake playa located in the northern portion of the RTA and mountains on the western side (USACE, 2001a; MCAGCC FMD, 2006). Bristol Dry Lake borders the eastern side of the RTA and the installation boundary. The lowest elevation on the installation, 604 feet amsl, is found near Bristol Dry Lake. Based on data contained in the 30-m digital elevation model of the region, the elevation at the Lead Mountain RTA ranges from 604 to 2,762 feet amsl (MCAGCC FMD, 2006). The terrain generally slopes from southwest to northeast, with broad alluvial plains and fans, ephemeral washes, dry lake beds, and lava flows all found within the Lead Mountain RTA.

The primary MC loading area is located on largely level land surface within the interior of the RTA, with Dry Lake making up the northern portion of the loading area. The MC loading area slopes from southwest to northeast with an average slope of 2.3%.

7.10.1.3. Surface Water Features

There are no perennial surface water features within the Lead Mountain RTA. Streambeds are dry except after infrequent, heavy rainfall (USDA NRCS, 1999). The Lead Mountain RTA is located within two surface water basins: Dry Lake basin and Bristol Dry Lake basin (Figure 7.10-2). Dry Lake, located within the Lead Mountain RTA, receives drainage from approximately 67% of the RTA surface area. Bristol Dry Lake, located just east of the installation boundary, receives drainage from approximately 33% of the RTA surface area. The Lead Mountain primary MC loading area has similar

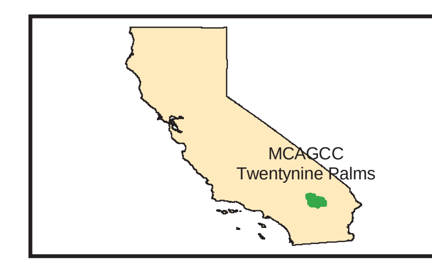


REVA
FIGURE 7.10-2
LEAD MOUNTAIN PRIMARY MC LOADING AREA AND DRAINAGE AREA

MCAGCC TWENTYNINE PALMS
TWENTYNINE PALMS, CA

LEGEND

- MCAGCC TWENTYNINE PALMS
- RANGE TRAINING AREAS
- PRIMARY MC LOADING AREAS
- BRISTOL DRY LAKE WATERSHED
- SURFACE WATER (INTERMITTENT)



0 1.5 3 6 9
Miles

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

Date: August 2007

Source: MCAGCC/NREA GIS Office 2006
TECOM 2006

surface water characteristics as the overall RTA. Fifty-eight percent of the area drains toward Dry Lake, and 42% drains toward Bristol Dry Lake.

7.10.1.4. Soil Characteristics and Land Cover

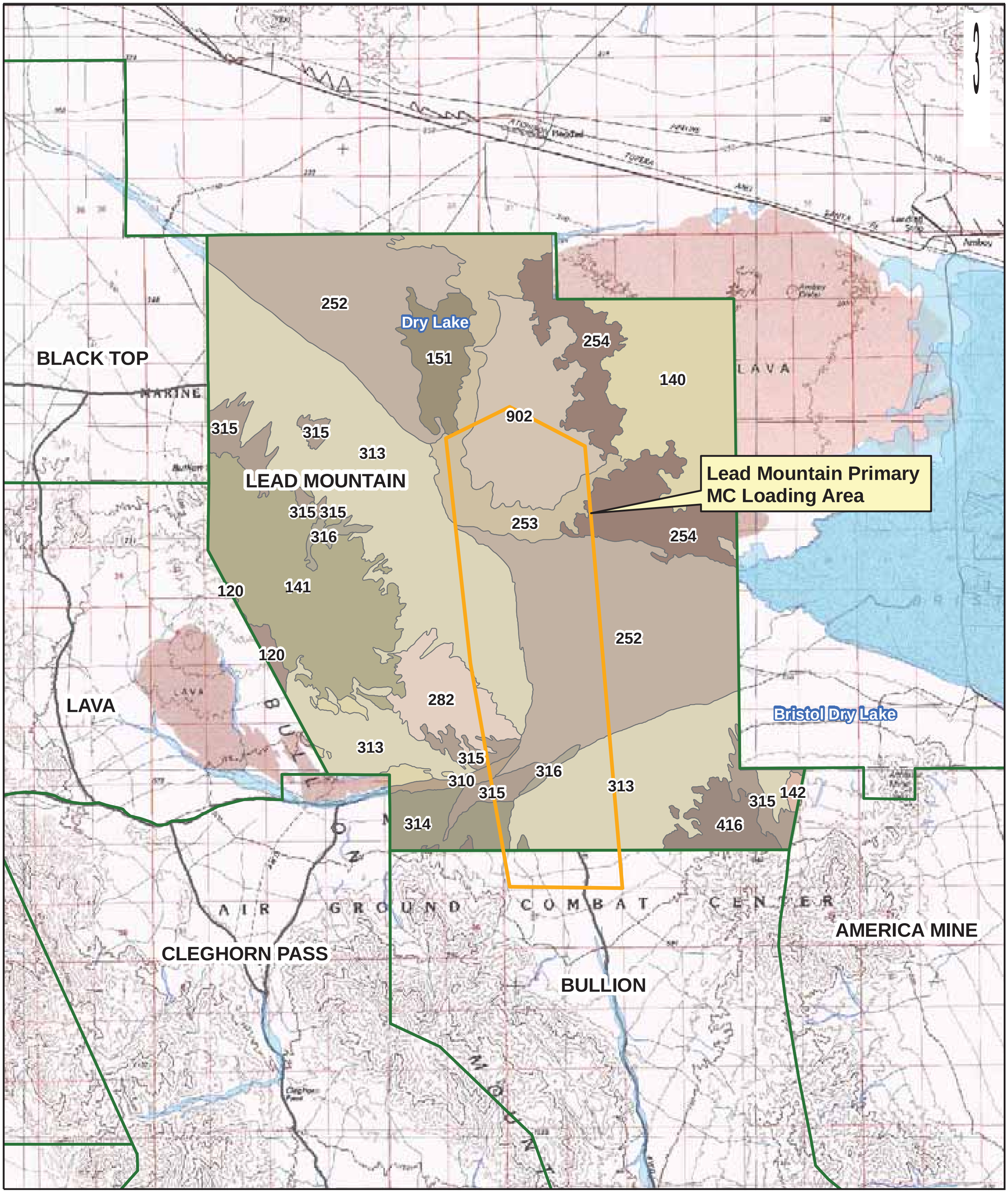
The NRCS identified numerous soil types within the Lead Mountain RTA (Figure 7.10-3 and Table 7.10-3). The soil types include mainly Bristolake-Carrizo association and Carrizo complex soils, which vary from sand to extremely gravelly coarse sand. Bristolake and Carrizo series soils are generally excessively drained with very low runoff potential. Bristolake series soils are described as having rapid permeability, whereas Carrizo series soils are described as having rapid or very rapid permeability. The permeability of the soils is decreased by the presence of loam or sandy loam in the surface soils (USDA NRCS, 1999).

The high permeability of the soils and the smaller slopes decrease the amount of surface water that would run off the area and increase the amount of water that would infiltrate. However, the intense rainfall events that occur at MCAGCC Twentynine Palms often generate flash flood conditions, causing MC transport by runoff to exceed the limited infiltration that may occur through these soils. These soils support a variety of plant life, mainly desert plants such as creosote bushes and salt scrub; however, the area includes a large percentage of bare ground (MCAGCC, 2006).

Table 7.10-3: NRCS Map Unit Soil Descriptions for the Lead Mountain RTA

NRCS Map Unit	Soil Description
282	Mask extremely gravelly fine sandy loam
313	Carrizo complex
141	Sunrock-Haleburu-Lava flows association
140	Sunrock-Lava flows complex
310	Carrizo association
315	Carrizo-Clegorpass association
316	Carrizo-Carrizo
416	Goldroad-Dalvord-Rock outcrop association
142	Sunrock-Pacific Mesa association
314	Carrizo complex
252	Bristolake-Carrizo association
253	Amboy crater-Gypboy association
254	Amboy crater-Lava flows complex
151	Rositas sand
902	Typic Haplosalids-Gypboy association
120	Eastrange gravelly sandy loam

Note: Shaded cells represent the major soil units found within the Lead Mountain RTA.



LEGEND

- RANGE TRAINING AREA
- PRIMARY MC LOADING AREA
- SURFACE WATER (INTERMITTENT)
- MAIN SUPPLY ROUTE

NRCS Soil

120	151	310	416
140	252	313	902
141	253	314	
142	254	315	
	282	316	

2 1 0 2 Miles

SOURCE: MCAGCC/NREA GIS OFFICE 2006; TECOM 2006; USGS, VARIOUS DATES.

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RANGE ENVIRONMENTAL VULNERABILITY ASSESSMENT

SOIL TYPES WITHIN LEAD MOUNTAIN RTA

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AUGUST 2008

FIGURE 7.10-3

7.10.1.5. Erosion Potential

The erodibility of the Lead Mountain primary MC loading area is moderate, mainly due to the slightly sloping topography (approximately 2.3%) within the MC loading area. A low to moderate soil erodibility factor of 0.03 was selected for the Lead Mountain primary MC loading area for use in the surface water transport analysis (**Section 7.10.3**).

7.10.1.6. Groundwater Characteristics

The Lead Mountain RTA lies in the Bristol Valley groundwater basin, for which limited hydrogeologic information exists. In the past, portions of the basin near the Black Top RTA, located west of the Lead Mountain RTA, have been referred to as the West Ludlow subbasin (Law Environmental, 1996). Water level data collected from exploratory drilling, as well as production wells in the towns of Ludlow and Bagdad, show groundwater flow away from the Bullion and Bristol Mountains and then southeast down the axis of the basin toward Bristol Dry Lake (Koehler, 1983). The general groundwater flow direction in Lead Mountain is to the southeast, west of Dry Lake, and to the north, south of Dry Lake. As in the Twentynine Palms basin, northwest-trending faults within the basin appear to be creating groundwater subbasins. This is evidenced by different water chemistries observed in wells that lie on opposite sides of the Ludlow fault, which trends down the basin axis.

Depth to groundwater ranges from 125 to 300 feet bgs within the aquifer. The groundwater occurs in unconsolidated alluvial deposits. Perched groundwater zones exist near Bristol Dry Lake and Dry Lake, with water levels recorded at 14 to 89 feet bgs (Koehler, 1983). The perched groundwater tables are assumed to be limited in extent based on the available groundwater data and the relatively small aerial extent of the playas. It is uncertain if the perched groundwater spills over into the deeper aquifer system.

7.10.1.7. Potential Groundwater and Surface Water Pathways

Groundwater Pathways

MC deposited on the RTA have the potential to migrate toward the water table at Lead Mountain by dissolution into precipitation and subsequent infiltration into the subsurface. The presence of coarse soils, such as sands and gravel, aid vertical migration; however, due to the high evaporation rate in the region, the wetted front in surface soil eventually decreases and minerals in the water precipitate as solids. There is limited potential for vertical migration of MC due to the infrequent nature of rainfall in the area (less than 5 inches per year), the high evaporation rate, and the depth to the groundwater. For areas with shallow groundwater, such as playas, the soils are generally made up of finer grained soils, which limit the rate of vertical migration of MC to groundwater. The potential concentration of any MC reaching the saturated zone would be dependent on many factors, such as its mass loading at the surface, aqueous solubility, and retardation of the MC due to soil characteristics.

Surface Water Pathways

Surface water runoff is the dominant pathway for MC transport at MCAGCC Twentynine Palms. The intense rainfall events produce large volumes of water that rapidly run off the bedrock in mountainous areas and travel downstream through the ephemeral streams and dry washes to the playas. The sparse vegetation on the installation does not dissipate the kinetic energy of the surface water as it travels downstream, increasing the potential for MC migration in surface water. During these intense rainfall events, MC have the potential to migrate downstream via two pathways: (1) transportation of MC adhered to soil particles within the surface water and (2) dissolution of MC into surface water runoff. Surface water runoff collects within two playas: Dry Lake (on MCAGCC Twentynine Palms) and Bristol Dry Lake (located outside the installation boundaries).

7.10.1.8. Potential Groundwater and Surface Water Receptors

Groundwater Receptors

Potential groundwater receptors from the Lead Mountain RTA consist of the salt mining operations located within Bristol Dry Lake, located east of the MC loading area and the installation boundary. Based on telephone interviews with representatives from the salt mines, salt is extracted from two possible groundwater sources: (1) shallow or perched groundwater located 10 to 20 feet bgs below Bristol Dry Lake and (2) from deeper groundwater bearing zones, approximately 100 feet bgs. The largest salt mining operation within Bristol Dry Lake, Tetra Tech, pumps water from the deeper groundwater bearing unit for use in its solar evaporation ponds. As water evaporates from the ponds, salts precipitate out of solution and crystallize in the ponds. The salt is dried and shipped via railcar to food manufacturers and well drilling companies for commercial use. However, MC deposited on Lead Mountain are unlikely to migrate to groundwater and travel with the subsurface flow where they could be recovered by the salt mining activities. Infiltration of MC into the subsurface is limited by evaporation, and groundwater beneath the southern end of the primary MC loading area is generally deep. Infiltration of MC in surface water within the playa is also unlikely to infiltrate due to the low permeability of soils underlying the playa.

No drinking water wells were identified within the Lead Mountain RTA or primary MC loading area boundaries, and no drinking water wells were identified down gradient of the primary MC loading area. The groundwater quality in the Lead Mountain region is generally too poor for use as a potable water source.

Surface Water Receptors

Playas, such as Dry Lake and Bristol Dry Lake, are important ecosystems supporting waterfowl, terrestrial birds, and mammals when ponding of runoff occurs or when adequate vegetation exists (DoN, 2003a). Identified MFTL habitat is located west of Dry Lake, within the Lead Mountain RTA. The desert tortoise can also be found among the alluvial plains surrounding the playas (MCAGCC, 2006).

Potential human receptors are the salt mine workers that work within Bristol Dry Lake. Salt mine workers operate within the playa, but are unlikely to come into contact with surface water. Based on interviews with salt mine employees, Bristol Dry Lake rarely floods, less than once every 10 years. Therefore, the potential interaction between human receptors and surface water is negligible.

Potential ecological receptors of surface water from Lead Mountain are the MFTL and the desert tortoise. An exposure and toxicity assessment for MC in surface water entering playas at MCAGCC Twentynine Palms was conducted to address the potential impacts to ecological receptors (Appendix A).

The MFTL typically obtains all of its water from its omnivorous diet, and the likelihood of this species consuming surface water from a playa is considered negligible. The desert tortoise does need to directly consume water, but normally obtains water that collects in natural or tortoise-constructed depressions in the soil following summer thunderstorms. The saline nature of the surface water in the playa lakes would deter tortoises from drinking the water because of the electrolyte imbalance it could cause. Therefore, Bristol Dry Lake is unsuitable habitat for the MFTL and desert tortoise.

Until recently, toxicity studies for RDX and TNT exposures to reptiles had not been conducted. The U.S. Army Center for Health Promotion and Preventive Medicine (USACHPPM) is in the process of evaluating the toxicity of MC to reptiles, specifically using the western fence lizard (*Sceloporus occidentalis*). Unpublished results for TNT exposures note high survival rates. Adverse effects (i.e., growth and food intake) were noted at the 35 milligrams per kilogram per day (mg/kg/d) dose, but not at the 25 mg/kg/d dose. The 25 mg/kg/d reptilian no observed adverse effects level is greater than the mammalian (0.2 mg/kg/d) and avian (0.07 mg/kg/d) toxicity values developed by the USACHPPM (2000 and 2002), indicating that reptiles are at least two orders of magnitude less sensitive to TNT than mammals and birds. Previous studies (as described in the ecotoxicity paper provided in Appendix A) indicate that mammals and birds will not be adversely affected by drinking lake waters containing TNT. As such, it can be safely concluded that the MFTL and desert tortoise would not be adversely affected (Malcolm Pirnie, 2007).

USACHPPM has not yet completed reptilian ecotoxicity assessments for RDX exposure. However, since the toxicity of TNT and RDX to birds and mammals is similar, the assumption that the sensitivity of reptiles to RDX is similar to TNT is reasonable. Hence, even if the MFTL and desert tortoise drink water from these playas, neither TNT nor RDX are expected to cause adverse effects at the predicted surface water concentrations.

7.10.2. Groundwater Analysis Results

A qualitative groundwater analysis was performed by analyzing the source media, migration mechanisms, and exposure pathways documented in the MCAGCC Twentynine Palms CSM. Based on the results of the qualitative analysis of the groundwater information, limited potential exists for MC migration to groundwater and no groundwater receptors associated with the indicator MC are present. Therefore, a groundwater screening-level analysis was not conducted. Discussions of the qualitative analysis and screening-level analysis are presented in **Section 4**.

7.10.3. Surface Water Analysis Results

A screening-level analysis of MC concentrations in surface water was conducted for the Lead Mountain primary MC loading area and its upstream drainages, based on the high level of MC loading, the presence of surface drainages that extend off the installation boundary, and the proximity of a potential surface water exposure point with documented human and ecological presence (Bristol Dry Lake). The screening-level analysis for surface water was conducted as described in **Section 5**.

Drainages within the southern half of the Lead Mountain MC loading area drain eastward into Bristol Dry Lake. Drainages in the center and northern sections of this primary MC loading area discharge to the Dry Lake playa, which is fully contained within the installation boundary. Therefore, only a portion of the MC loaded at Lead Mountain was used in the surface water transport analysis to Bristol Dry Lake. In addition to Lead Mountain, portions of the Prospect, Delta, America Mine, Bullion, Cleghorn Pass, Lava, and Noble Pass MC loading areas contribute surface water runoff to Bristol Dry Lake (MCAGCC FMD, 2006). Approximately 42% of Lead Mountain, 4% of Prospect, 99% of Delta, 98% of America Mine, 82% of Bullion, 53% of Cleghorn Pass, 59% of Lava, and 12% of Noble Pass MC loading areas drain into Bristol Dry Lake. MC loading from these RTAs was incorporated into the screening-level analysis.

The surface water screening-level analysis was carried out for a time period ranging from 1969 to 2005. Historical MC loading areas within the drainage area of Bristol Dry Lake include the Foxtrot, Echo, and Delta RTAs. MC loading at these historical areas was estimated to occur for a time period ranging from 1969 to 1979. MC concentrations estimated in surface water runoff at the edge of MC loading areas from these historical MC loading areas were predicted to be negligible by year 2005.

Table 7.10-4 presents the estimated percentage of MC mass contributed by individual loading areas to Bristol Dry Lake. The Delta MC loading area was predicted to contribute over half of the total RDX and TNT mass draining into Bristol Dry Lake. The America Mine MC loading area was predicted to contribute more than 80% of the total HMX load, whereas the Cleghorn Pass MC loading area was predicted to contribute a significant portion of the total perchlorate load (approximately 70%) into Bristol Dry Lake.

Table 7.10-4: Screening-Level Estimates of Percentage MC Mass Contributed by Individual MC Loading Areas into Bristol Dry Lake

MC	From Lead Mountain	From Prospect	From Delta	From America Mine	From Bullion	From Cleghorn Pass	From Lava	From Noble Pass
RDX	21.0	0.8	54.0	0.3	4.9	9.9	8.4	1.0
TNT	17.7	0.5	67.9	0.2	3.0	4.1	5.7	0.8
HMX	0.5	0.1	7.9	80.5	0.05	10.7	0.2	0.1
Perchlorate	3.0	0.8	8.9	7.0	7.3	69.9	0.02	3.2

Note: Data are provided in percent mass.

Table 7.10-5 presents the estimated average annual edge-of-loading-area concentrations in surface water runoff from the Lead Mountain primary MC loading area, as well as upstream MC loading areas, that drain Bristol Dry Lake. Based on surface water screening-level calculations, concentrations of RDX and TNT leaving the respective MC loading areas were estimated to be above the REVA trigger values. The HMX and perchlorate concentrations were estimated to be below the REVA trigger values at the edge of all of the MC loading areas.

Table 7.10-5: Screening-Level Estimates of Annual Average Edge-of-Loading-Area MC Concentrations in Runoff

MC	From Lead Mountain	From Prospect	From Delta	From America Mine	From Bullion	From Cleghorn Pass	From Lava	From Noble Pass
RDX	**4.0**	**3.8**	**6.1**	**0.16**	**1.2**	**4.6**	**5.6**	**0.41**
TNT	**4.5**	**3.4**	**10**	**0.13**	**1.0**	**2.5**	**5.0**	**0.44**
HMX	4.1E-05	2.4E-04	4.0E-04	0.02	5.6E-06	2.2E-03	4.8E-05	1.6E-05
Perchlorate	1.6E-03	0.011	2.9E-03	9.9E-03	5.4E-03	0.094	4.1E-05	3.9E-03

Notes: Concentrations provided in μg/L.
Shading and bold indicate that the predicted concentration exceeds the REVA trigger value.

Table 7.10-6 presents the estimated MC concentrations in surface water entering Bristol Dry Lake, following downstream mixing. Concentrations of RDX and TNT in surface water runoff entering Bristol Dry Lake, after downstream mixing, were estimated to be slightly above the REVA trigger values. The post-mixing HMX and perchlorate concentrations were estimated to be below the REVA trigger values.

Table 7.10-6: Screening-Level Estimates of Annual Average MC Concentrations in Runoff Entering Bristol Dry Lake

MC	Post-Mixing Concentration Entering Bristol Dry Lake (µg/L)
RDX	**0.19**
TNT	**0.25**
HMX	9.6E-05
Perchlorate	5.4E-04

Note: **Shading and bold** indicate that the predicted concentration exceeds the REVA trigger value

The evaporative concentration and accumulation method described in **Section 5** was used to estimate aqueous phase concentrations of MC in playas that account for evaporation and deposition. The maximum estimated concentrations in Bristol Dry Lake after evaporation and concentration at the end of the simulation period were estimated (Table 7.10-7). Accounting for evaporation and multiyear accumulation of MC, the estimated surface water concentrations of RDX and TNT in Bristol Dry Lake were predicted to exceed the REVA trigger values.

Actual concentrations in runoff and playas might be significantly less than predicted, due to the highly conservative nature of the analysis employed. For example, the evaporative concentration and accumulation method used does not account for MC loss terms, such as decay, groundwater recharge, and sediment deposition, which are likely to be encountered in the washes and playas.

Table 7.10-7: Screening-Level Estimates of MC Concentrations in Playas, Accounting for Evaporation and Multiyear Accumulation

MC	Concentration in Bristol Dry Lake (µg/L)
RDX	**47**
TNT	**63**
HMX	2.4E-02
Perchlorate	0.14

Note: **Shading and bold** indicate that the predicted concentration exceeds the REVA trigger value.

Although the post-mixing and evaporative concentration / accumulation concentrations of RDX and TNT are estimated to reach Bristol Dry Lake above the REVA trigger values, there are no regulatory criteria established in the Colorado River Basin Plan for the MC associated with military munitions for surface waters (California Regional Water Quality Control Board, 2005). In addition, as discussed in preceding sections, there are no potential receptors (human or ecological) of MC in surface water. Based upon the results of the exposure and toxicity assessment, concentrations of MC predicted to occur in Bristol Dry Lake are unlikely to pose a threat to the MFTL or desert tortoise. The complete exposure and toxicity assessment is provided as Appendix A.

7.11. Prospect

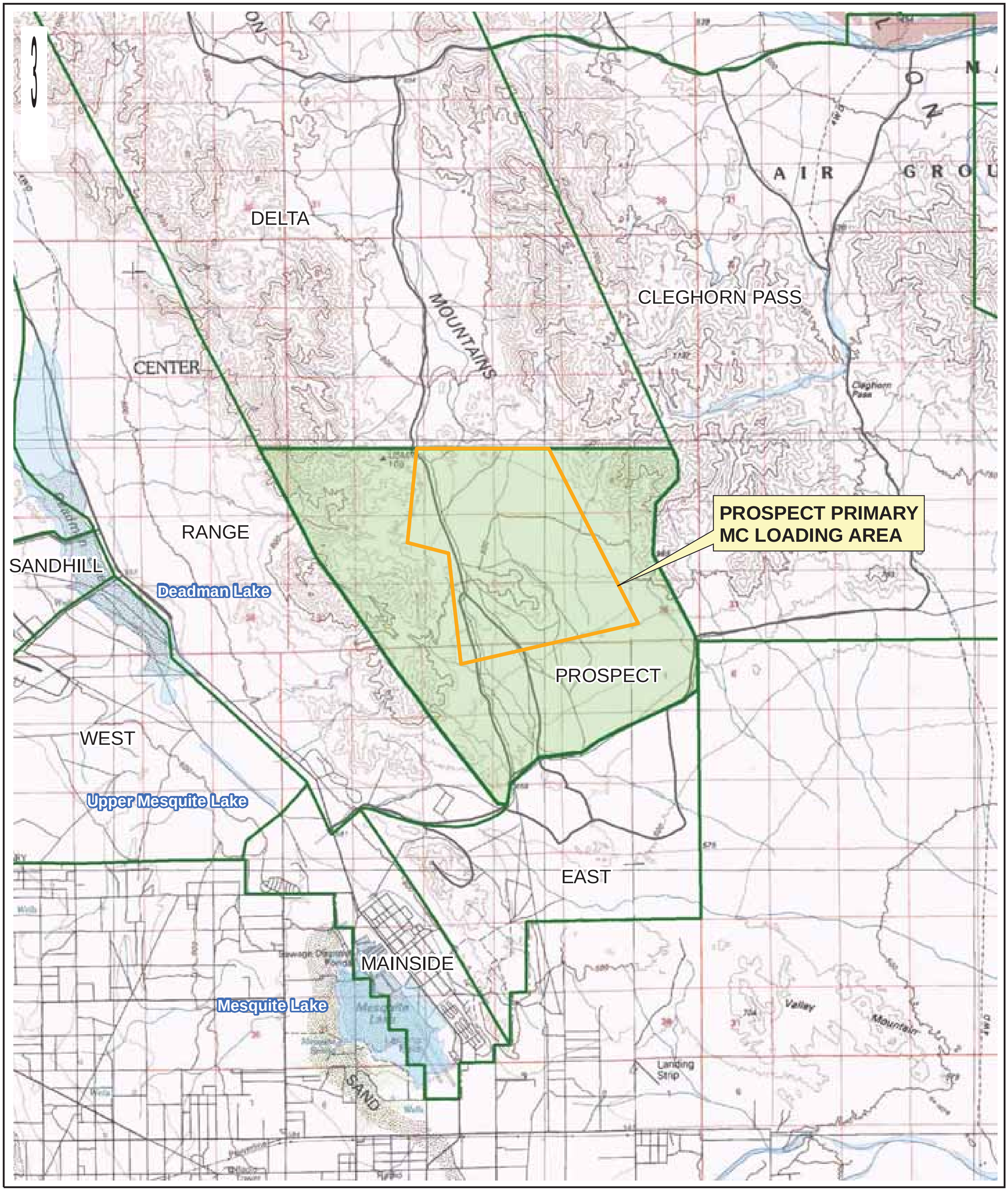
The Prospect RTA is located in the south-central section of MCAGCC Twentynine Palms (Figure 7.11-1). It is located south of the Delta RTA and was part of the Delta RTA from the 1950s through 1997 (USACE, 2001a). In January 1998, the MCAGCC Twentynine Palms RTAs were reorganized, and Prospect was designated as a separate RTA. The Prospect RTA covers 13,152 acres, most of which are designated as impact areas. This RTA contains CAX target systems and an LTA for laser ground-to-ground and air-to-ground firing (USACE, 2001b). Two fixed ranges, Convoy Course Stations 1 and 2, are located within the RTA.

Fixed Range 201 was previously located within the Prospect RTA. The range was designated the Combat Engineer Demolition and Field Fortification Range. It was designed to accommodate mine and countermine operations at the company level and could be used for sweeping, breaching, and clearance operation. Range 201 was used from the 1980s to the mid-1990s, when the former Range 114 was constructed in the East RTA. Range 420, the Company Live-Fire Illuminated Night Attack Range, was also located in what is now the Prospect RTA; the range was used in the mid-1980s and is no longer in use (USACE, 2001b).

A primary MC loading area was identified within the Prospect RTA based on interviews with Range Control and a review of the fixed target locations (MCAGCC FMD, 2006). The interviews and locations of the target emplacements indicate that the highest potential density of military munitions firing exists in the center of the RTA along the valley floor. The Prospect primary MC loading area is 17,518,000 m^2 and is approximately 4,750 m in length along the valley floor, with an average width of approximately 3,500 m between bedrock outcrops.

Military Munitions

The general classes of military munitions expected in this MC loading area include small arms ammunition and high explosive munitions. Detailed military munitions use data are presented in the PRA (USACE, 2001b), and detailed assumptions for the determination of MC loading rates are provided in the *REVA Reference Manual* (HQMC, 2006).



LEGEND

- PROSPECT RTA
- RANGE TRAINING AREA
- PRIMARY MC LOADING AREA
- SURFACE WATER (INTERMITTENT)
- MAIN SUPPLY ROUTE

2 1 0 2 Miles

SOURCE: MCAGCC/NREA GIS OFFICE 2006; TECOM 2006; USGS, VARIOUS DATES.

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MALCOLM PIRNIE

MCAGCC TWENTYNINE PALMS, CALIFORNIA

RANGE ENVIRONMENTAL VULNERABILITY ASSESSMENT

PROSPECT RTA

MALCOLM PIRNIE, INC.

AUGUST 2008

FIGURE 7.11-1

7.11.1. CSM

7.11.1.1. Estimated MC Loading

The primary MC loading area of the Prospect RTA is depicted in Figure 7.11-1. The MC Loading Rate Calculator was used to estimate the amount of MC loaded to this primary MC loading area over time (Table 7.11-1). It was conservatively assumed that all military munitions expenditures for the Prospect RTA were performed within the boundaries of the primary loading area, rather than across the entire RTA. Therefore, the MC loading amounts estimated for each identified time period during which the RTA was used, Time Periods D and E, were assumed to occur only within the primary loading area for the purposes of the screening-level transport analysis effort (**Section 7.11.3**). There are no SARs located within the Prospect RTA; therefore, qualitative assessments to determine the fate and transport of lead were not conducted for this RTA. Expenditure data were extrapolated for time periods when expenditure data were not available.

Table 7.11-1: Estimated Annual MC Loading for the Prospect RTA

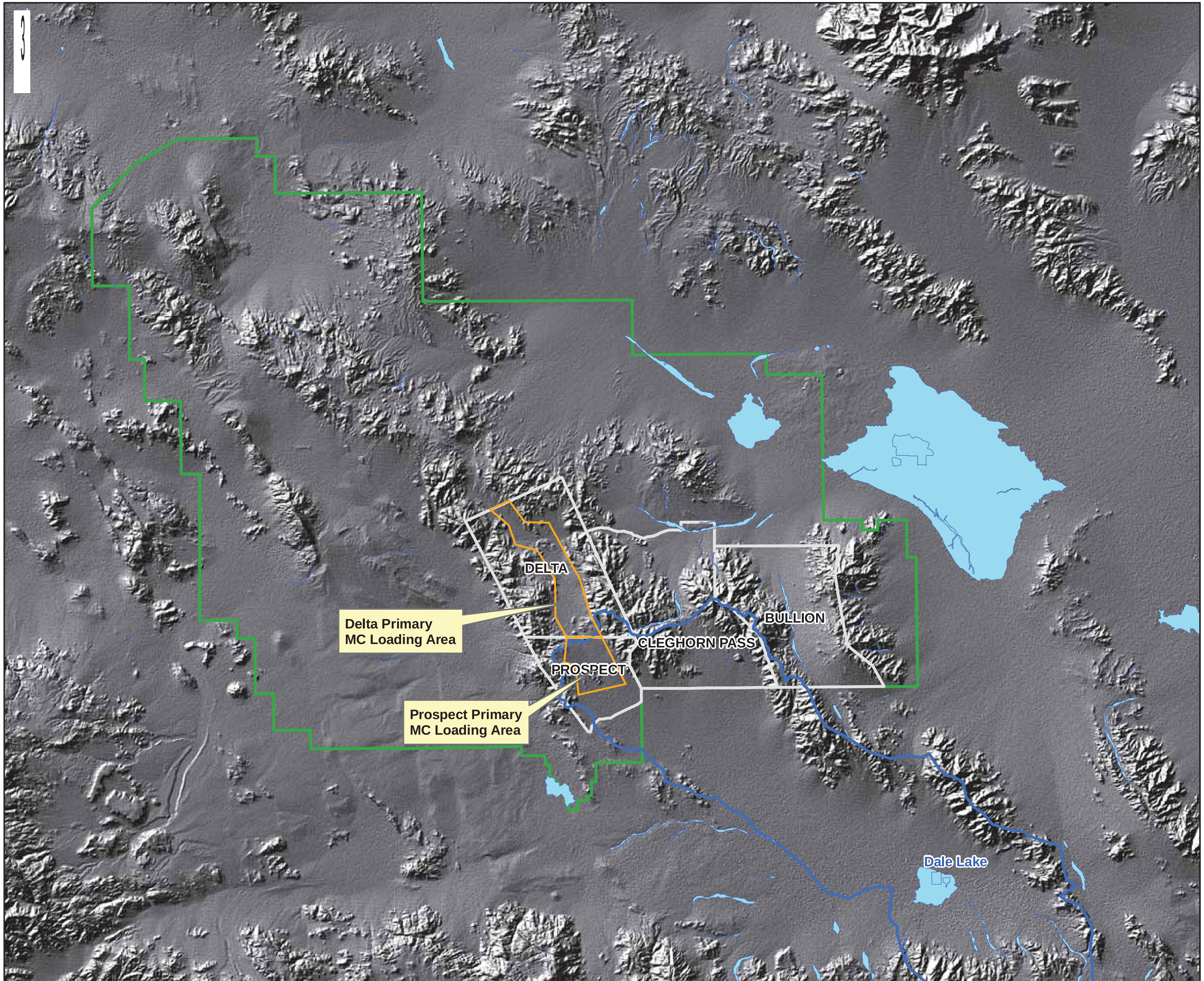
MC Loading Area	Period	Begin Use	End Use	HMX (kg/m^2)	RDX (kg/m^2)	TNT (kg/m^2)	Perchlorate (kg/m^2)
Prospect	D (1977-1988)	1979	1988	6.58E-12	1.02E-07	9.66E-08	3.10E-10
	E (1989-Present)	1989	2005	8.22E-12	1.28E-07	1.21E-07	3.87E-10

7.11.1.2. Geography and Topography

The Prospect RTA is located in a valley between the Bullion Mountains, which flank the area along the eastern and western boundaries of the RTA. A rocky outcrop in the valley floor represents the divide between the Prospect RTA and the Delta RTA to the north. The installation boundary is the southern boundary of the Prospect RTA. The elevation in the Prospect RTA ranges from 1,985 to 3,865 feet amsl (MCAGCC FMD, 2006). The terrain generally slopes from northwest to southeast, with the mountainous region sloping toward the valley floor. The primary MC loading area is generally defined as the valley floor, with the floor sloping from the east and west boundaries of the MC loading area toward the center of the MC loading area and then sloping to the southeast, across the installation boundary.

7.11.1.3. Surface Water Features

There are no perennial surface water features within the Prospect RTA or primary MC loading area. Streambeds are dry, except after infrequent, heavy rainfall (USDA NRCS, 1999). Portions of the Prospect RTA are contained within four different surface water basins: Bristol Dry Lake, Cleghorn Pass, Deadman Lake, and East Mainside (Figure 7.11-2). Seventy-eight percent of the Prospect RTA is within the Cleghorn Pass surface water basin. The Cleghorn Pass basin drains into ephemeral streams, which flow south off the installation boundary and discharge into Dale Lake, located approximately 18

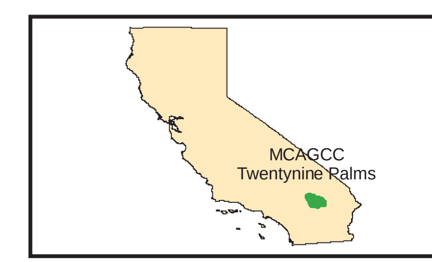


REVA
FIGURE 7.11-2
PROSPECT PRIMARY MC LOADING AREA AND DRAINAGE AREA

MCAGCC TWENTYNINE PALMS
TWENTYNINE PALMS, CA

LEGEND

- MCAGCC TWENTYNINE PALMS
- RANGE TRAINING AREAS
- PRIMARY MC LOADING AREAS
- SURFACE WATER (INTERMITTENT)



0 1.5 3 6 9
Miles

Date: August 2008

Source: MCAGCC/NREA GIS Office 2006
TECOM 2006

miles downstream of the Prospect primary MC loading area. Thirteen percent of the Prospect RTA, primarily the western slopes of the Bullion Mountains, drains toward Deadman Lake, a playa located within the installation boundary. Five percent of the RTA is in the East Mainside drainage basin, which drains off the installation. Four percent of the RTA drains northward toward the Delta RTA.

The majority of the Prospect primary MC loading area (96%) drains toward Dale Lake. The remaining four percent of the primary MC loading area drains to Bristol Dry Lake, located east of the MCAGCC Twentynine Palms boundary. No drainages within the primary MC loading area drain to either Deadman Lake or Mesquite Dry Lake (MCAGCC FMD, 2006).

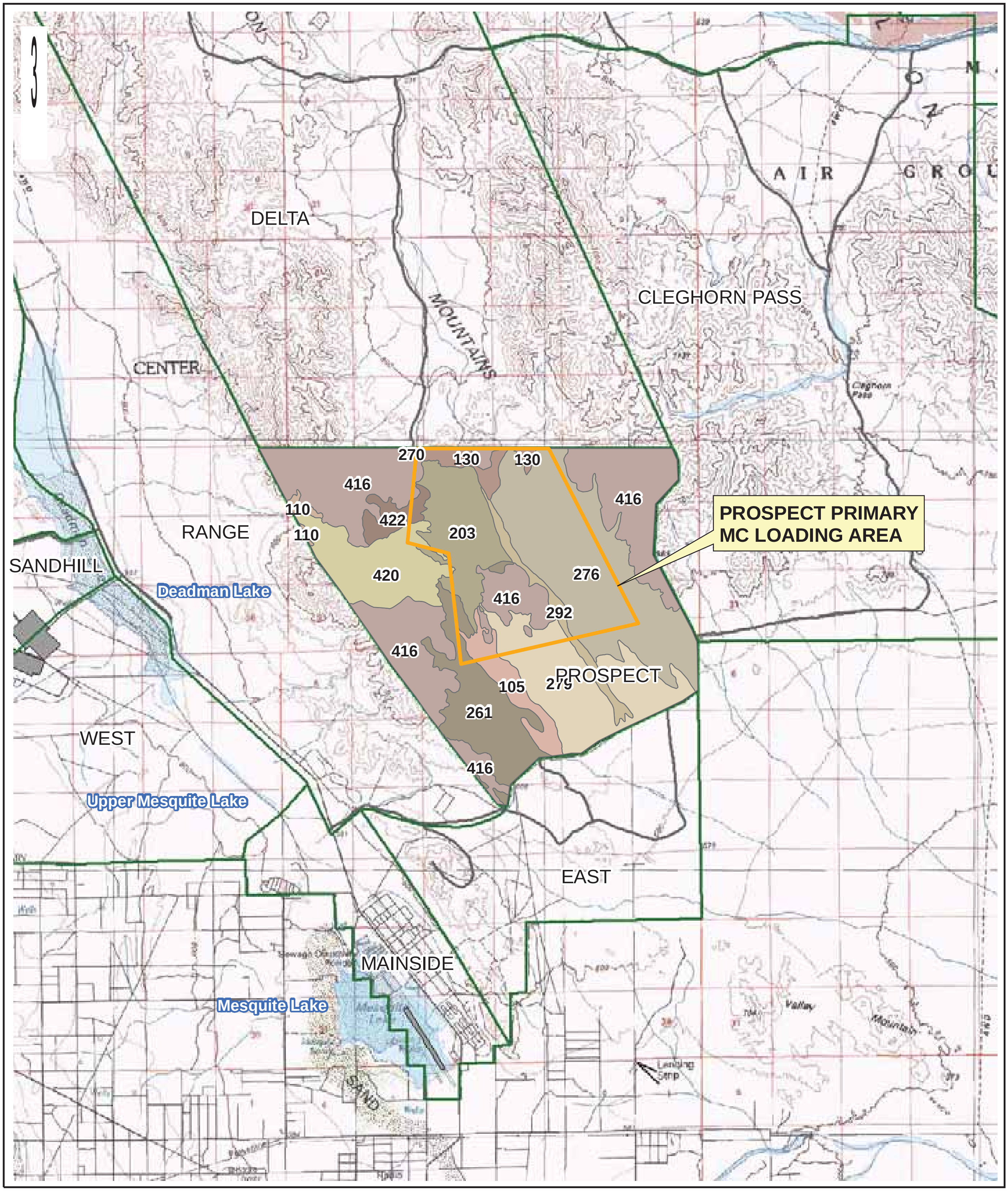
7.11.1.4. Soil Characteristics and Land Cover

The Prospect RTA is composed mainly of gravelly and coarse sandy soils (Figure 7.11-3 and Table 7.11-2) in the valley, with bedrock outcrops in the mountains. The soil types are primarily Narea-Desfirex-Edalph complex, Goldroad-Dalvord-Rock outcrop association, and Arizo extremely gravelly loamy sand. Narea, Goldroad, and Arizo series soils are generally described as excessively drained soils. However, the ground slope varies from zero to 75% depending on the soil type; the runoff potential varies from negligible on low slopes to very high on high slopes (USDA NRCS, 1999). Higher rates of runoff will occur during intense rainfall events. Creosote bush scrub is the main vegetative type within Prospect, with bare ground common, especially on the bedrock outcrops.

Table 7.11-2: NRCS Map Unit Soil Descriptions for the Prospect RTA

NRCS Map Unit	Soil Description
416	Goldroad-Dalvord-Rock outcrop association
270	Arizo extremely gravelly loamy sand
110	Bluepoint sand
130	Owlshead association
276	Arizo
203	Narea-Desfirex-Edalph complex
422	Dalvord-Rock outcrop association
292	Arizo association
420	Dalvord-Goldroad-Rock outcrop association
261	Twobitter-Cajon-Arizo complex
279	Arizo sand
105	Cajon-Arizo-Bluepoint complex

Note: Shaded cells represent the major soil units found within the Prospect RTA.



SOURCE: MCAGCC/NREA GIS OFFICE 2006; TECOM 2006; USGS, VARIOUS DATES;

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RANGE ENVIRONMENTAL VULNERABILITY ASSESSMENT

SOIL TYPES WITHIN PROSPECT RTA

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AUGUST 2008

FIGURE 7.11-3

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7.11.1.5. Erosion Potential

The erodibility of the Prospect primary MC loading area is moderate, based on the coarse soil types present. The soils at Prospect are generally gravelly coarse sands to loamy sands. A low to moderate soil erodibility factor of 0.06 was selected for the Prospect primary MC loading area for use in the surface water transport analysis (**Section 7.11.3**).

7.11.1.6. Groundwater Characteristics

The Prospect RTA is located within the Dale Valley intramountain groundwater basin at MCAGCC Twentynine Palms. Subsurface data are not available for the intramountain basins found within the Bullion Mountains. The subsurface conditions in these areas are expected to be similar to the Bristol Valley groundwater basin in the northeast portion of the installation and the Twentynine Palms basin in the southwest portion of the installation, with the following exceptions:

- The water bearing sedimentary deposits are expected to be thinner due to the proximity of the exposed bedrock outcrop.
- The average groundwater elevations may be closer to the surface; limited depth to groundwater from the Lava RTA suggests a depth to groundwater of 127 feet bgs (Almgren and Koptionak, 1993).

The groundwater basins underlying Prospect may be part of a single groundwater basin, along with the East RTA, that eventually flows into or is part of the Twentynine Palms basin.

7.11.1.7. Potential Groundwater and Surface Water Pathways

Groundwater Pathways

MC deposited on the RTA have the potential to migrate toward the water table at Prospect by dissolution into precipitation and subsequent infiltration into the subsurface. The presence of coarse soils, such as sands and gravel, aid vertical migration; however, due to the high evaporation rate in the region, the wetted front in surface soil eventually decreases and minerals in the water precipitate out, decreasing the vertical migration rate. The vertical migration of MC to groundwater has limited potential based on the infrequent nature of rainfall in the area (less than 5 inches per year), the high evaporation rate, and the depth to the groundwater. For areas with shallow groundwater, such as playas, the soils are generally finer-grained, which limits the vertical migration rate of MC. The potential concentration of any MC reaching the saturated zone would be dependent on many factors, such as its mass loading at the surface, aqueous solubility, and retardation of the MC due to soil characteristics.

Surface Water Pathways

Surface water runoff is the dominant pathway for MC transport at MCAGCC Twentynine Palms compared to MC transport via groundwater infiltration. The intense rainfall events produce large volumes of water that rapidly run off the bedrock in mountainous areas and travel downstream through the ephemeral streams and dry washes to the playas. The sparse vegetation on the installation does not dissipate the kinetic energy of the surface water as it travels downstream, increasing the potential for MC migration in surface water. During these intense rainfall events, MC have the potential to migrate downstream, away from the MC loading areas, either adhered to suspended particles or dissolved in surface water. Three playas receive drainage from the Prospect RTA and the primary MC loading area: Dale Lake located south the installation, Bristol Dry Lake located east of the installation, and Deadman Lake located on the installation, north of Mainside. Dale Lake receives the bulk of the runoff from this primary MC loading area.

7.11.1.8. Potential Groundwater and Surface Water Receptors

Groundwater Receptors

The only potential groundwater receptor of MC from the Prospect RTA is the salt mining operation located within Dale Lake, 18 miles southeast of the Prospect primary MC loading area and across the installation boundary. Based on telephone interviews with the salt mine owner, saline water is extracted from two groundwater sources: (1) shallow or perched groundwater located 20 feet bgs within the dry lake and (2) from deeper groundwater bearing zones, approximately 200 feet bgs. The salt mining operation within Dale Lake, Superior Salt, pumps water from both groundwater bearing units. In addition, the operation accepts brine from water treatment plants for use in evaporation ponds. As water evaporates from the source water, salts precipitate out of solution and crystallize in the evaporation ponds.

No drinking water wells were identified within the Prospect RTA or MC loading area or the MCAGCC Twentynine Palms boundaries down gradient of the MC loading area.

Similar to the situation at Lead Mountain, MC deposited on Prospect are unlikely to migrate to groundwater and travel with the subsurface flow over 18 miles in distance where it could be recovered by the salt mining activities. Infiltration of MC into the subsurface is limited by evaporation, and groundwater beneath the southern end of the primary MC loading area is generally deep. Infiltration of MC in surface water within the playa is also unlikely to infiltrate due to the low permeability soils underlying the playa.

Surface Water Receptors

Surface water runoff travels through ephemeral streams and into the Dale Lake playa. Within the Prospect RTA, potential desert tortoise habitat is located on the eastern slopes of the Bullion Mountains. Downstream of the Prospect MC loading area are Dale Lake, Bristol Dry Lake, and Deadman Lake. The drainage area of Deadman Lake does not overlap the MC loading area; thus, this playa is not estimated to receive MC loading. Ninety-six percent of the MC loading area drains toward Dale Lake, with the remaining four percent of the Prospect MC loading area draining, through Lead Mountain, Delta, and Cleghorn Pass, to ultimately reach Bristol Dry Lake. Other loading areas (1% of Delta, 5% of Bullion, and 47% of Cleghorn Pass) also drain to Dale Lake, contributing to its potential MC loading (MCAGCC FMD, 2006).

Potential human receptors to surface water are the salt mine workers that work within Dale Lake. Salt mine workers operate within the playa, though they are unlikely to come into contact with surface water. Based on interviews with the Superior Salt owners, Dale Lake floods rarely, less than once every 10 years. Therefore, the potential interaction between human receptors and surface water is negligible.

Potential ecological receptors of surface water from Prospect are the MFTL and the desert tortoise. An exposure and toxicity assessment for MC in surface water entering playas at MCAGCC Twentynine Palms was conducted to address the potential impacts to ecological receptors (Malcolm Pirnie, 2007). Dale Lake is unsuitable habitat for the MFTL and desert tortoise, and neither species is likely to directly consume playa water, as described previously for Lead Mountain. Based upon the results of the exposure and toxicity assessment, concentrations of MC predicted to occur in Dale Lake are unlikely to pose a threat to the MFTL or desert tortoise. The complete exposure and toxicity assessment is provided as Appendix A.

7.11.2. Groundwater Analysis Results

A qualitative groundwater analysis was performed by analyzing the source media, migration mechanisms, and exposure pathways documented in the MCAGCC Twentynine Palms CSM. Based on the results of the qualitative analysis of the groundwater information, limited potential exists for MC migration to groundwater and no groundwater receptors associated with the indicator MC are present. Therefore, a groundwater screening-level analysis was not conducted. Discussions of the qualitative analysis and screening-level analysis are presented in **Section 4**.

7.11.3. Surface Water Analysis Results

A screening-level analysis of MC concentrations in surface water was conducted for the Prospect primary MC loading area and its upstream drainages, based on the high level of MC loading, the presence of surface drainages that extend off the installation boundary, and the proximity of a potential surface water exposure point with documented human and ecological presence (Dale Lake). The analysis was conducted as described in **Section 5**.

The surface water screening-level analysis was carried out for a time period ranging from 1969 to 2005. Historical MC loading areas that existed within the watershed areas of Dale Lake include the Delta, Foxtrot, and X-Ray RTAs. MC loading at these historical areas was estimated to occur for a time period ranging from 1969 to 1979. MC concentrations estimated in surface water runoff at the edge of MC loading areas from these historical MC loading areas were predicted to be negligible by year 2005, indicating negligible MC contributions from historical use areas into Dale Lake.

Table 7.11-3 presents the estimated percentage of MC mass contributed by individual loading areas to Dale Lake. The Prospect MC loading area was predicted to contribute two-thirds or more of the total RDX and TNT mass draining into Dale Lake, whereas the Cleghorn Pass primary MC loading area was predicted to contribute the highest mass of HMX and perchlorate into Dale Lake.

Table 7.11-3: Screening-Level Estimate of Percent MC Mass Contributed by Individual MC Loading Areas into Dale Lake

MC	From Prospect	From Delta	From Bullion	From Cleghorn Pass
RDX	65	2.0	1.0	32
TNT	72	4.2	1.0	22
HMX	20	0.7	0.02	79
Perchlorate	22	0.1	0.50	77

Note: Data are provided in percent mass.

Table 7.10-5, previously shown in **Section 7.10.3**, presents the estimated average annual edge-of-loading-area concentrations in surface water runoff from the Prospect primary MC loading area, as well as upstream MC loading areas that drain Dale Lake. Based on surface water screening calculations, the concentrations of RDX and TNT leaving the respective MC loading areas are estimated to exceed the REVA trigger values.

Table 7.11-4 presents the estimated MC concentrations in surface water entering Dale Lake, following downstream mixing. Concentrations of TNT in surface water runoff entering Dale Lake, after downstream mixing, were predicted to be slightly above the REVA trigger values. The post-mixing RDX, HMX, and perchlorate concentrations were estimated to be below the REVA trigger values.

Table 7.11-4: Screening-Level Estimates of Annual Average MC Concentrations in Runoff Entering Dale Lake

MC	Post-Mixing Concentrations Entering Dale Lake (µg/L)
RDX	0.15
TNT	**0.12**
HMX	3.0E-05
Perchlorate	1.3E-03

Note: **Shading and bold** indicate that the predicted concentration exceeds the REVA trigger value.

The evaporative concentration and accumulation method described in **Section 5** was used to estimate aqueous phase concentrations of MC in playas that account for evaporation and deposition. The maximum estimated concentrations in Dale Lake after evaporation and concentration at the end of the simulation period were estimated (Table 7.11-5). Accounting for evaporation and multiyear accumulation of MC, the surface water concentrations of RDX and TNT in Dale Lake were predicted to exceed the REVA trigger values.

Actual MC concentrations may be significantly less than predicted, due to the highly conservative nature of the analysis employed. The evaporative concentration and accumulation method used does not account for MC loss terms, such as decay, groundwater recharge, and sediment deposition, which are likely to be encountered in the washes and playas.

Table 7.11-5: Screening-Level Estimates of MC Concentrations in Dale Lake, Accounting for Evaporation and Multiyear Accumulation

MC	Concentration in Dale Lake (µg/L)
RDX	**37**
TNT	**30**
HMX	7.4E-03
Perchlorate	0.32

Note: **Shading and bold** indicate that the predicted concentration exceeds the REVA trigger value.

Although the TNT post-mixing concentration and RDX and TNT evaporative concentration / accumulation concentrations are estimated to be above the REVA trigger values at Dale Lake, there are no regulatory criteria established in the Colorado River Basin Plan for the MC associated with military munitions for surface waters (California Regional Water Quality Control Board, 2005). In addition, as discussed in preceding sections, there is no potential receptor (human or ecological) of surface water. As the estimated post-mixing concentration of TNT reaching Dale Lake is within the same order of magnitude as that estimated to reach Bristol Dry Lake, similar conclusions regarding ecotoxicity pertain to MC transport to Dale Lake. As such, it can be safely concluded that the MFTL and desert tortoise would not be adversely affected (Malcolm Pirnie, 2007).

7.12. Delta

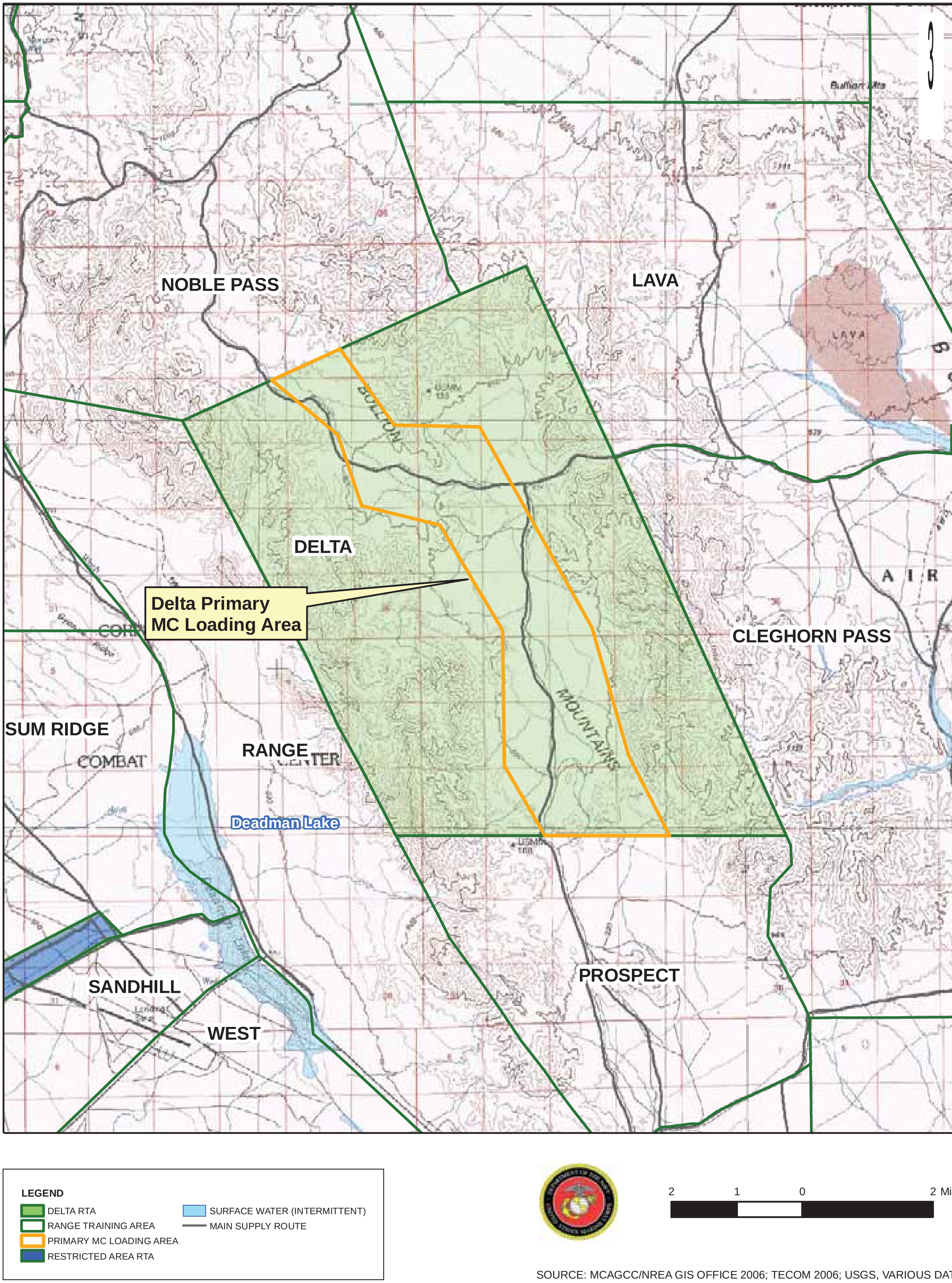
The historical Delta RTA present at the installation throughout the 1970s (described in **Section 7.6**) was slightly reconfigured in 1979, increasing its overall size to 39,257 acres in the same area of the installation as its predecessor (USACE, 2001a). This configuration for Delta remained in place through 1997. The current Delta RTA was established in 1998 following the division of the 1979–1997 Delta RTA into a smaller Delta RTA and a new Prospect RTA on the southern half of the original RTA. The current Delta RTA covers 29,761 acres in the central portion of MCAGCC Twentynine Palms (Figure 7.12-1) (USACE, 2001b).

The Delta RTA remains designated as a primary live-fire and maneuver area for air-to-ground and ground-to-ground exercises. Similar to Lead Mountain and Prospect, Delta contains CAX target emplacements. Convoy Course Stations 2 through 5 are located within this RTA, in proximity to the CAX targets (Table 7.12-1). The Convoy course stations have been established in recent years to train Marines to practice both offensive and defensive maneuvers during convoy operations; munitions use for these ranges generally consists of small arms ammunition. The Delta RTA also contains 14 LTAs for laser ground-to-ground and air-to-ground firing (USACE, 2001b).

Table 7.12-1: Fixed Ranges within the Delta RTA

Fixed Range	Range Type	Area (1,000 m^2)
LIVE-FIRE RANGES		
Convoy Course Station 2 (portion in Prospect)	Convoy course	131.15
Convoy Course Station 3	Convoy course	724.90
Convoy Course Station 4	Convoy course	894.08
Convoy Course Station 5	Convoy course	252.12

A primary MC loading area was identified in the Delta RTA based on interviews with Range Control and a review of the fixed target locations (MCAGCC FMD, 2006). The interviews and locations of the fixed target emplacements indicate the highest density of military munitions fired exists along the valley floor. The Delta primary MC loading area is 32,124,000 m^2 and is approximately 14,000 m in length, running along the entire valley floor, with an average width of approximately 2,500 m between bedrock outcrops.



SOURCE: MCAGCC/NREA GIS OFFICE 2006; TECOM 2006; USGS, VARIOUS DATES;

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MALCOLM PIRNIE	MCAGCC TWENTYNINE PALMS, CALIFORNIA RANGE ENVIRONMENTAL VULNERABILITY ASSESSMENT	DELTA RTA	MALCOLM PIRNIE, INC. AUGUST 2008 FIGURE 7.12-1

Military Munitions

The general classes of military munitions expected in this MC loading area include small arms ammunition and high explosive munitions. Detailed military munitions use data are presented in the PRA (USACE, 2001b), and detailed assumptions for the determination of MC loading rates are provided in the *REVA Reference Manual* (HQMC, 2006).

7.12.1. CSM

7.12.1.1. Estimated MC Loading

The primary MC loading area for the Delta RTA is depicted in Figure 7.12-1. The MC Loading Rate Calculator was used to estimate the amount of MC loaded to this area over time (Table 7.12-2). It was conservatively assumed that all military munitions expenditures for the Delta RTA were performed within the boundaries of the primary MC loading area, rather than across the entire RTA. Therefore, the MC loading amounts estimated for each identified time period during which the RTA was used, Time Periods D and E, were assumed to occur only within the primary loading area. There are no SARs located within the Delta RTA; therefore, qualitative assessments to determine the fate and transport of lead were not conducted for this RTA. Expenditure data were extrapolated for time periods for which expenditure data were not available.

Table 7.12-2: Estimated Annual MC Loading for the Delta RTA

MC Loading Area	Period	Begin Use	End Use	HMX (kg/m^2)	RDX (kg/m^2)	TNT (kg/m^2)	Perchlorate (kg/m^2)
Delta	D (1977-1988)	1979	1988	1.11E-11	1.63E-07	3.06E-07	8.15E-11
	E (1989-Present)	1989	2005	1.39E-11	2.04E-07	3.82E-07	1.02E-10

7.12.1.2. Geography and Topography

The Delta RTA is located in a valley of the Bullion Mountains, with the flanks of the mountains creating the eastern and western boundaries of the RTA. A rocky outcrop in the valley floor represents the divide between the Delta and Prospect RTAs. The north entrance to the valley represents the divide between the Noble Pass and Delta RTAs. The elevation in the Delta RTA ranges from 2,034 to 3,819 feet amsl (MCAGCC FMD, 2006). The terrain generally slopes toward the center of the RTA and then east. The primary MC loading area is generally defined as the alluvial deposits of the valley floor, with the floor sloping from the east and west edges toward the center of the MC loading area and then sloping to the east across the Lava and Lead Mountain RTAs toward the installation boundary.

7.12.1.3. Surface Water Features

There are no perennial surface water features within the Delta RTA. Streambeds are dry, except after infrequent, heavy rainfall (USDA NRCS, 1999). Portions of the Delta RTA are located in four different surface water basins: Bristol Dry Lake, Deadman Lake, Cleghorn Pass, and Dry Lake. Seventy-seven percent of the Delta RTA is within the Bristol Dry Lake surface water basin, which drains into Bristol Dry Lake, located east of the installation boundary. Drainages from the Delta RTA and its associated primary MC loading area run through the Lava RTA and the Lead Mountain RTA and its primary MC loading area prior to discharge at Bristol Dry Lake. The western, heavily mountainous portion of the Delta RTA drains westward into Deadman Lake. A small portion of the RTA drains into Cleghorn Pass basin through ephemeral streams that flow south across the Prospect and East RTAs and eventually off the installation boundary and discharge into Dale Lake, located approximately 18 miles downstream of the Prospect primary MC loading area (MCAGCC FMD, 2006).

Ninety-six percent of the Delta primary MC loading area drains into Bristol Dry Lake and four percent drains into Dale Lake.

7.12.1.4. Soil Characteristics and Land Cover

The Delta RTA is composed mainly of extremely gravelly coarse sand to loamy sand soils on the valley floor, with bedrock outcrops in the mountains. The soils types are primarily Goldroad-Dalvord-Rock outcrop association, Arizo Dry-Twobitter association, and Arizo extremely gravelly loamy sands. Goldroad, Arizo, and Twobitter series soils are generally well drained to excessively drained soils. The amount of surface water runoff from the soils is dependent on the slopes of the area, with runoff potential varying from negligible in the alluvial fans (where Arizo and Twobitter series soils are typical found) to very high in the areas with larger slopes (where Goldroad outcrops are found). The intense rainfall events enhance the amount of water that runs off the area compared to less intense rainfall events. Creosote bush scrub is the main vegetative type within the Delta RTA, with bare ground throughout, particularly in the bedrock outcrops in the Bullion Mountains (USDA NRCS, 1999).

7.12.1.5. Erosion Potential

The erodibility of the Delta MC loading area is moderate based on the coarse soil types found within the MC loading area. A low to moderate soil erodibility factor of 0.04 was selected for Delta MC loading area for use in the surface water analysis.

7.12.1.6. Groundwater Characteristics

The Delta RTA, like Prospect, is located within the Dale Valley intramountain basin at MCAGCC Twentynine Palms. As mentioned in **Section 7.11.1.6**, limited hydrogeologic data are available for the intramountain basins found within the Bullion Mountains. The subsurface conditions encountered in these areas are expected to be similar to the Bristol

Valley groundwater basin in the northeast portion of the installation and the Twentynine Palms basin in the southwest portion of the installation. The groundwater basin underlying Delta most likely flows north, following the local topography, although some flow could move to the southeast, to Dale Lake.

7.12.1.7. Potential Groundwater and Surface Water Pathways

Groundwater Pathways

MC deposited on the RTA have the potential to migrate toward the water table at Delta by dissolution into precipitation and subsequent infiltration into the subsurface. This transport mechanism is enhanced by the presence of coarse soils, such as sands and gravel. However, the vertical migration of MC to groundwater at Delta is likely limited due to the infrequent rate of rainfall in the area (less than 5 inches per year), the high evaporative rate, and the depth to the groundwater table. The actual potential concentration of any MC would be highly dependent on many factors, such as its mass loading at the surface, aqueous solubility, and retardation of the MC due to soil characteristics.

Surface Water Pathways

Surface water runoff is the dominant pathway for MC transport at MCAGCC Twentynine Palms compared to MC transport via groundwater infiltration. The intense rainfall events produce large volumes of water that rapidly run off bedrock in the mountainous area and then travel downstream through the ephemeral streams and dry washes to playas. The sparse vegetation on the installation does not dissipate the kinetic energy of the surface water or hold the soils and MC particles in the vegetation as it travels downstream, increasing the potential for MC to migrate due to surface water runoff. Surface runoff from the Delta primary MC loading area travels through ephemeral streams through the Lava RTA and the Lead Mountain primary MC loading area to Bristol Dry Lake located on the eastern border of the installation. A limited area (four percent) on the southern edge of the Delta primary MC loading area drains to the Dale Lake playa, located southeast of the installation.

7.12.1.8. Potential Groundwater and Surface Water Receptors

Groundwater Receptors

The Delta RTA and its associated primary MC loading area drain into the same groundwater and surface water basins as the southern portion of the Lead Mountain RTA and its associated primary MC loading area; therefore, the potential receptors are the same as those described for Lead Mountain. The potential groundwater receptors consist of workers at the salt mining operation located in Bristol Dry Lake. As previously discussed, the potential exposure of the workers to groundwater containing MC is negligible. No drinking water wells were identified within the Delta RTA or MC loading area or the MCAGCC Twentynine Palms boundaries down gradient of the MC loading area.

Surface Water Receptors

Potential surface water receptors include the salt mine workers and ecological receptors (MFTL and the desert tortoise). Bristol Dry Lake fills with surface water infrequently, less than once every 10 years; therefore, there is negligible potential for human exposure at this playa. Based upon the results of the exposure and toxicity assessment, concentrations of MC predicted to occur in Bristol Dry Lake are unlikely to pose a threat to the MFTL or the desert tortoise (Malcolm Pirnie, 2007).

7.12.2. Groundwater Analysis Results

A qualitative groundwater analysis was performed by analyzing the source media, migration mechanisms, and exposure pathways documented in the MCAGCC Twentynine Palms CSM. Based on the results of the qualitative analysis of the groundwater information, limited potential exists for MC migration to groundwater and no groundwater receptors associated with the indicator MC are present. Therefore, a groundwater screening-level analysis was not conducted. Discussions of the qualitative analysis and screening-level analysis are presented in **Section 4**.

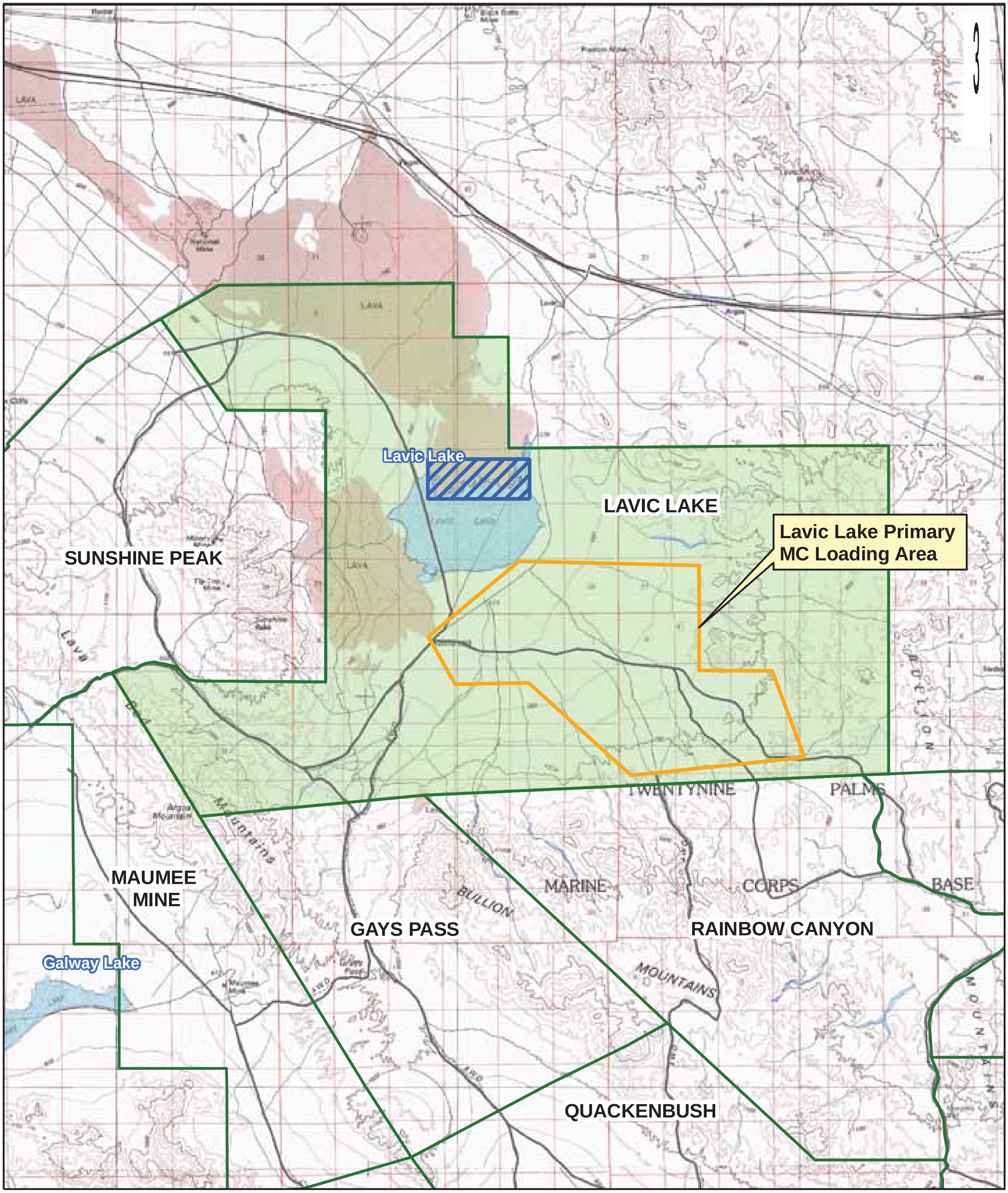
7.12.3. Surface Water Analysis Results

The majority of the Delta primary MC loading area (96%) drains into Bristol Dry Lake, with a small portion (4%) draining to Dale Lake. As part of the surface water screening conducted for the Lead Mountain and Prospect MC loading areas, the upstream MC loading contributions of Delta were included.

Based on the MC loading contributions and an analysis of the surface drainage, the Delta MC loading area is the largest potential contributor of RDX and TNT and the second largest potential contributor of HMX and perchlorate to Bristol Dry Lake from surface water runoff. It is estimated that Delta contributes 54.0% of the modeled RDX mass, 67.9% of the TNT mass, and 7.9% of the HMX and perchlorate masses entering Bristol Dry Lake (Table 7.10-4). These MC loading contributions were factored into the surface water transport screening-level analysis performed for the Lead Mountain primary MC loading area. The results of this analysis are presented in **Section 7.10.3.**

7.13. Lavic Lake

The Lavic Lake RTA is located in the northwest portion of MCAGCC Twentynine Palms (Figure 7.13-1) and covers 54,786 acres. The northern and eastern boundaries of the RTA make up the installation boundary (USACE, 2001a). Lavic Lake is currently used as a live-fire and maneuver area for air-to-ground and ground-to-ground exercises. There are no fixed ranges contained within the RTA. The RTA includes CAX targets and eight



LEGEND

- LAVIC LAKE RTA
- RANGE TRAINING AREA
- PRIMARY MC LOADING AREA
- SURFACE WATER (INTERMITTENT)
- MAIN SUPPLY ROUTE
- RESTRICTED AREA

2 1 0 2 Miles

SOURCE: MCAGCC/NREA GIS OFFICE 2006; TECOM 2006; USGS, VARIOUS DATES;

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MALCOLM PIRNIE	MCAGCC TWENTYNINE PALMS, CALIFORNIA RANGE ENVIRONMENTAL VULNERABILITY ASSESSMENT	LAVIC LAKE RTA	MALCOLM PIRNIE, INC. AUGUST 2008 FIGURE 7.13-1

LTAs for laser ground-to-ground and air-to-ground firing. Prior to 1998, the RTA was used for aviation exercises and as a live-fire maneuver area covering an area of approximately 45,400 acres, of which 36,600 acres were considered impact areas. A former RTA known as Mesa was present within the southern boundaries of this RTA from 1979 to 1997. The Mesa RTA was dissolved in the 1998 realignment of training areas (USACE, 2001b).

The Lavic Lake MC loading area was delineated based on interviews with Range Control and a review of the fixed target locations (MCAGCC FMD, 2006). The interviews and available data indicate the highest density of military munitions firing exists at the south of Lavic Lake toward the Rainbow Canyon RTA.

The Lavic Lake MC loading area is 40,939,000 m^2 located southeast of the Lavic Lake playa and north of the Bullion Mountains.

Military Munitions

The general classes of military munitions expected in this MC loading area include small arms ammunition and high explosive munitions. Detailed military munitions use data are presented in the PRA (USACE, 2001b), and detailed assumptions for the determination of MC loading rates are provided in the *REVA Reference Manual* (HQMC, 2006).

7.13.1. CSM

7.13.1.1. Estimated MC Loading

The primary MC loading area of Lavic Lake is depicted in Figure 7.13-1. The MC Loading Rate Calculator was used to estimate the amount of MC loaded on this area over time (Table 7.13-1). It is conservatively assumed that all military munitions expenditures for the Lavic Lake RTA were performed within the boundaries of the primary MC loading area, rather than across the entire RTA. The MC loading amounts estimated for the MC loading area for each identified time period during which the impact area was used, Time Periods D and E, were assumed to occur only within the primary loading area. There are no SARs located within the Lavic Lake RTA; therefore, qualitative assessments to determine the fate and transport of lead were not conducted for this RTA. Expenditure data were extrapolated for time periods for which expenditure data were not available.

Table 7.13-1: Estimated Annual MC Loading for the Lavic Lake RTA

MC Loading Area	Period	Begin Use	End Use	HMX (kg/m^2)	RDX (kg/m^2)	TNT (kg/m^2)	Perchlorate (kg/m^2)
Lavic Lake	D (1977-1988)	1979	1988	n/a	1.56E-07	2.59E-07	1.57E-11
	E (1989-Present)	1989	2005	n/a	1.95E-07	3.24E-07	1.97E-11

7.13.1.2. Geography and Topography

The Lavic Lake RTA is located north of the Bullion Mountain in an area primarily consisting of level lava formations. Volcanic activity is evidenced by Quaternary lava flows in the Lavic Lake playa in the northern section of the RTA. The Lava Bed Mountains border the RTA to the north and west (MCAGCC, 2006). The elevation in the Lavic Lake RTA ranges from 1,749 to 4,373 feet amsl (MCAGCC FMD, 2006). The terrain generally slopes from the western, southern, and eastern mountains toward the center of the RTA toward Lavic Lake playa. The primary MC loading area is southeast of the playa. The primary MC loading area slopes from southeast to northwest toward Lavic Lake playa.

7.13.1.3. Surface Water Features

There are no perennial surface water features within the Lavic Lake RTA or the primary MC loading area. Streambeds are dry, except after infrequent, heavy rainfall (USDA NRCS, 1999). Lavic Lake playa is located in the northern portion of the RTA. The majority of the Lavic Lake RTA (90%) drains to this playa, which is wholly contained within the installation boundary. Six percent of the RTA is in the East Sunshine surface water drainage basin, which drains northward off the installation; four percent of the area drains to Dry Lake, located in the Lead Mountain RTA; and less than one percent of the area is within the West Sunshine drainage area, which also drains northward. Dry Lake, East Sunshine, and West Sunshine drainage areas are considered minor drainage areas for the RTA. All of the Lavic Lake primary MC loading area drains to the Lavic Lake playa (MCAGCC FMD, 2006).

7.13.1.4. Soil Characteristics and Land Cover

The Lavic Lake RTA is composed of coarse soils that vary from sands to extremely gravelly coarse sand in the center of the RTA. Bedrock outcrops are located along the eastern and southern boundaries of the RTA. The soils types are primarily Arizo sand, Bristolake-Carrizo association, Arizo dry Twobitter association, and Goldroad-Dalvord-Rock outcrop association (USDA NRCS, 1999). Creosote bush scrub is the main vegetative type within Lavic Lake, with bare ground throughout (MCAGCC, 2006). Lavic Lake playa is located in the northern portion of the RTA and is mostly composed of finer soils, such as clays and loams, which inhibit vertical migration of MC.

7.13.1.5. Erosion Potential

The erodibility of the Lavic Lake primary MC loading area is moderate based on the coarse soil types found within the RTA. The soils at Lavic Lake are generally coarse soils that range from sands to extremely gravelly coarse sands. A low to moderate soil erodibility factor of 0.07 was selected for the Lavic Lake primary MC loading area.

7.13.1.6. Groundwater Characteristics

The Lavic Lake RTA and MC loading area are within the Lavic Valley intramountain groundwater basin at MCAGCC Twentynine Palms. As mentioned in **Section 7.11.1.6**, limited subsurface data are available for the intramountain basins, including the Lava Bed Mountains. The subsurface conditions encountered in these areas are expected to be similar to the Bristol Valley groundwater basin in the northeast portion of the installation and the Twentynine Palms basin in the southwest portion of the installation. The groundwater basins underlying Lavic Lake most likely flow toward the Lavic Lake playa. Groundwater may continue to flow to the north, off the installation.

7.13.1.7. Potential Groundwater and Surface Water Pathways

Groundwater Pathways

MC deposited on the RTA have the potential to migrate toward the water table at Lavic Lake by dissolution into precipitation and subsequent infiltration into the subsurface. The presence of coarse soils, such as sands and gravel, aid vertical migration; however, due to the high evaporation rate in the region, the wetted front in surface soil eventually decreases and minerals in the water precipitate out. The vertical migration of MC to groundwater has limited potential based on the infrequent nature of rainfall in the area (less than 5 inches per year), the high evaporation rate, and the depth to the groundwater. For areas with shallow groundwater, such as playas, the soils are generally made up of finer grained soils, which decrease the vertical migration rate of MC to groundwater. The potential concentration of any MC would be highly dependent on many factors, such as its mass loading at the surface, aqueous solubility, and retardation of the MC due to soil characteristics.

Surface Water Pathways

Surface water runoff is the dominant pathway for MC transport at MCAGCC Twentynine Palms. The intense rainfall events produce large volumes of water that rapidly run off the bedrock in mountainous areas and travel downstream through the ephemeral streams and dry washes to the playas. The sparse vegetation on the installation does not dissipate the kinetic energy of the surface water as it travels downstream, increasing the potential for MC migration due to surface water. Runoff from the primary loading area is eventually discharged to the Lavic Lake playa.

7.13.1.8. Potential Groundwater and Surface Water Receptors

Groundwater Receptors

The Lavic Lake RTA and MC loading area overlie the Lavic Valley intramountain groundwater basin, which has no known receptors. No drinking water receptors were identified within the anticipated groundwater basin.

Surface Water Receptors

The surface water runoff originating in Lavic Lake drains to Lavic Lake playa, contained wholly within the installation boundaries. Potential MFTL habitat is present within the Lavic Lake playa for the RTA. Desert tortoise habitat is present on alluvial deposits near the bedrock outcrops, located along the eastern and western portions of the RTA. As Lavic Lake playa is wholly contained within the installation boundaries and the entire RTA is considered range, exposures to receptors within this playa are not considered under the REVA. Although the Lavic Lake playa was not explicitly considered in the ecological exposure assessment, the results of the exposure and toxicity assessment indicate that MC entering Lavic Lake playa are unlikely to pose a threat to ecological receptors (Malcolm Pirnie, 2007).

7.13.2. Groundwater Analysis Results

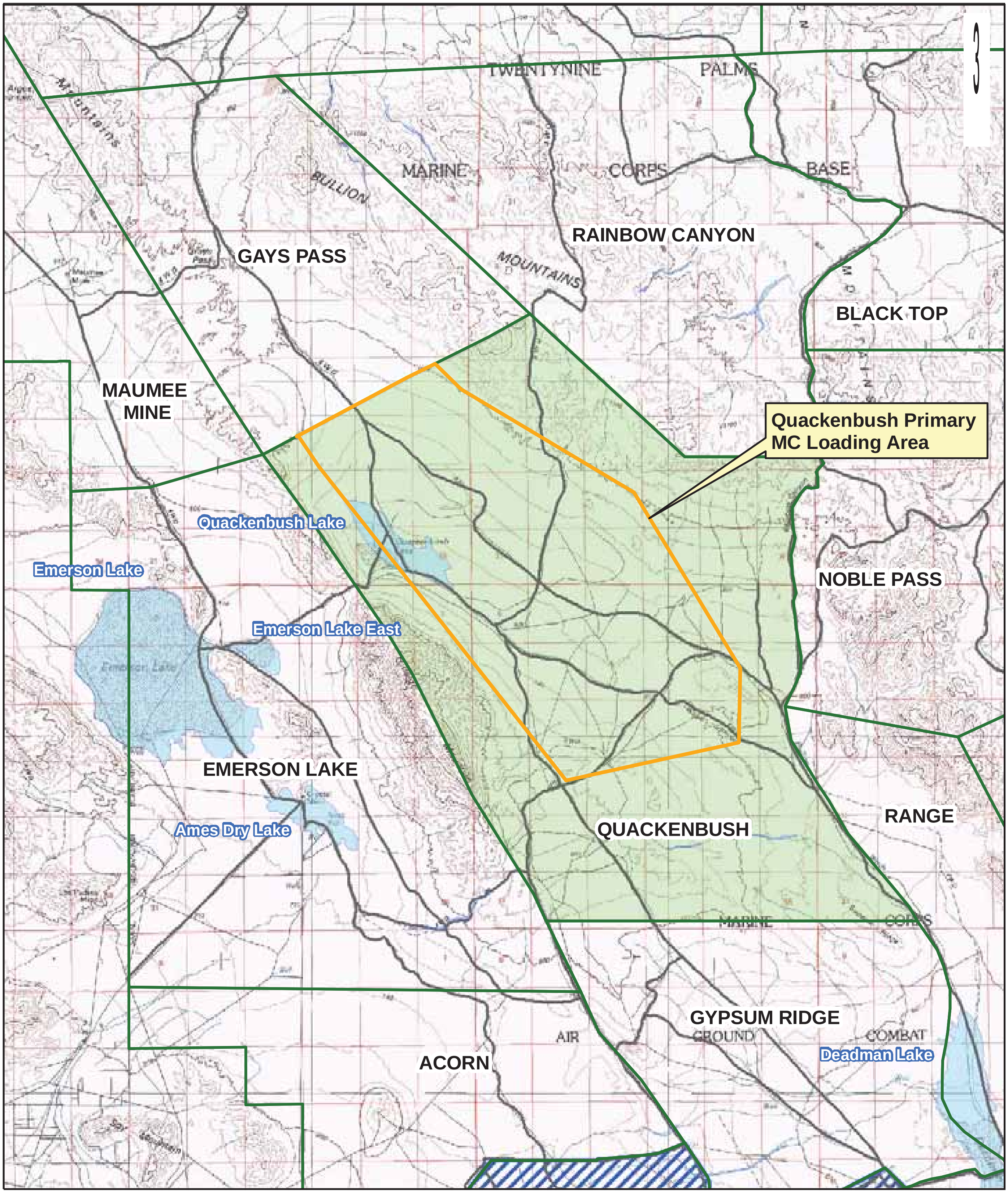
A qualitative groundwater analysis was performed by analyzing the source media, migration mechanisms, and exposure pathways documented in the MCAGCC Twentynine Palms CSM. Based on the results of the qualitative analysis of the groundwater information, limited potential exists for MC migration to groundwater and no groundwater receptors associated with the indicator MC are present. Therefore, a groundwater screening-level analysis was not conducted. Discussions of the qualitative analysis and screening-level analysis are presented in **Section 4**.

7.13.3. Surface Water Analysis Results

The Lavic Lake primary MC loading area drains into Lavic Lake playa, located within the boundaries of MCAGCC Twentynine Palms. Because all surface water drainages from the loading area remain within the boundaries of the installation, no off-range release of MC is likely to occur for this RTA. There are no human receptors that consume or use the limited surface water collected within the playas. Although ecological receptors (MFTL and desert tortoise) may be present, they are unlikely to consume surface water (Appendix A). Therefore, based on the lack of potential off-range receptors, surface water screening was not conducted for the Lavic Lake RTA.

7.14. Quackenbush

The Quackenbush RTA is located in the central portion of MCAGCC Twentynine Palms (Figure 7.14-1) and covers 42,435 acres (USACE, 2001a). The RTA is used for ground-based live fire, aviation, and maneuver training. The Quackenbush RTA contains CAX target systems and eight LTAs for laser ground-to-ground firing (USACE, 2001b). As of May 2006, three new fixed ranges were under construction at the Quackenbush RTA. The new ranges consist of one live-fire MOUT training range and two ranges with training operations to be determined (Ranges 620 and 630) (Table 7.14-1).



LEGEND

- QUACKENBUSH RTA
- RANGE TRAINING AREA
- PRIMARY MC LOADING AREA
- RESTRICTED AREA
- SURFACE WATER (INTERMITTENT)
- MAIN SUPPLY ROUTE

SOURCE: MCAGCC/NREA GIS OFFICE 2006; TECOM 2006; USGS, VARIOUS DATES.

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MALCOLM PIRNIE

MCAGCC TWENTYNINE PALMS, CALIFORNIA
RANGE ENVIRONMENTAL VULNERABILITY ASSESSMENT

QUACKENBUSH RTA

MALCOLM PIRNIE, INC.
AUGUST 2008
FIGURE 7.14-1

Table 7.14-1: Fixed Ranges within the Quackenbush RTA

Fixed Range	Range Type	Area (1,000 m^2)
LIVE-FIRE RANGES		
CAMOUT	Live-fire MOUT training	3,611.66
Range 620	TBD	1,004.71
Range 630	TBD	4,008.16

Between 1979 and 1997, the current Quackenbush RTA was known as the Quackenbush Lake RTA and covered approximately 29,900 acres (USACE, 2001a).

The Quackenbush primary MC loading area was delineated based on interviews with Range Control and the fixed target locations (MCAGCC FMD, 2006). The interviews and available data indicate the highest density of military munitions firing exists on the rolling hills of the valley floor. The Quackenbush MC loading area is roughly 73,836,000 m^2, running along the valley between the Hidalgo Mountains to the west and the Bullion Mountains to the east.

Military Munitions

The general classes of military munitions expected in this MC loading area include small arms ammunition and high explosive munitions. Detailed military munitions use data are presented in the PRA (USACE, 2001b), and detailed assumptions for the determination of MC loading rates are provided in the *REVA Reference Manual* (HQMC, 2006).

7.14.1. CSM

7.14.1.1. Estimated MC Loading

The MC loading area of Quackenbush is depicted in Figure 7.14-1. The MC Loading Rate Calculator was used to estimate the amount of MC loaded on this area over time (Table 7.14-2). It was conservatively assumed that all military munitions expenditures for the Quackenbush RTA were performed within the boundaries of the primary MC loading area, rather than across the entire RTA. The MC loading amounts estimated for the MC loading area for each identified time period during which the impact area was used, Time Periods D and E, were assumed to occur only within the primary loading area. There are no SARs located within the Quackenbush RTA; therefore, qualitative assessments to determine the fate and transport of lead were not conducted for this RTA.

Expenditure data were extrapolated for time periods for which expenditure data were not available.

Table 7.14-2: Estimated Annual MC Loading for the Quackenbush RTA

MC Loading Area	Period	Begin Use	End Use	HMX (kg/m^2)	RDX (kg/m^2)	TNT (kg/m^2)	Perchlorate (kg/m^2)
Quackenbush	D (1977-1988)	1979	1988	5.24E-12	2.48E-07	4.51E-07	9.14E-11
	E (1989-Present)	1989	2005	6.55E-12	3.10E-07	5.64E-07	1.14E-10

7.14.1.2. Geography and Topography

The Quackenbush RTA is located between the Hidalgo Mountains to the west and the Bullion Mountains to the east. The area is generally composed of low-level rolling hills with an estimated elevation between 1,962 and 4,564 feet amsl (MCAGCC FMD, 2006). The terrain generally slopes from northwest to southeast, with the Gays Pass RTA located northwest of Quackenbush and the Range and Gypsum Ridge RTAs located to the southeast. The western and eastern boundaries of the RTA are mountains with the slopes toward the center of the RTA.

7.14.1.3. Surface Water Features

There are no perennial surface water features within the Quackenbush RTA. Streambeds are dry, except after infrequent, heavy rainfall (USDA NRCS, 1999). The Quackenbush Lake playa is located on the western side of the RTA within the delineated extent of the primary MC loading area. Approximately 14% of the RTA drains into the Quackenbush Lake playa, which eventually drains into Deadman Lake, located approximately 2.5 miles southeast of the RTA boundary and 7 miles southeast of the primary MC loading area. Eighty-five percent of the RTA drains directly into Deadman Lake. The drainage basin consists of an ephemeral stream network with a parallel drainage pattern. Surface water runoff remains within the boundaries of MCAGCC Twentynine Palms (MCAGCC FMD, 2006).

The primary MC loading area drains to both the Quackenbush Lake playa (22%) and the Deadman Lake playa (78%). Both surface water bodies are fully contained within the installation boundaries.

7.14.1.4. Soil Characteristics and Land Cover

The Quackenbush RTA is composed of coarse soils that vary from sandy loam to extremely gravelly coarse sand. Bedrock outcrops are located along the eastern and western boundaries of the RTA. The soils types are primarily Arizo-Hypoint association, Eastrange gravelly sandy loam, and Calcio-Edalph-calcio dry complex soils. Creosote bush scrub is the main vegetative type within Quackenbush, with some sand dunes and partly bare ground throughout (USDA NRCS, 1999).

7.14.1.5. Erosion Potential

The erodibility of the soils within the Quackenbush primary MC loading area is moderate based on the coarse soil types found within the RTA. The soils at Quackenbush are generally coarse soils that range from sandy loam to extremely gravelly coarse sands. A low to moderate soil erodibility factor of 0.08 was selected for the Quackenbush primary MC loading area.

7.14.1.6. Groundwater Characteristics

The Quackenbush RTA and its associated primary MC loading area are within the Deadman Lake groundwater subbasin, part of the Twentynine Palms basin, which is the best-understood water bearing unit at the facility. The subbasins are divided hydrogeologically by bedrock outcrops, faults, and folds (Riley et al., 2001; Londquist and Martin, 1991; MCAGCC, 2006).

The groundwater bearing units within the basins are composed of unconsolidated to loosely consolidated Tertiary sediments and are divided along structural faults, which form very low permeability zones. The Tertiary age sedimentary deposits can be 2,500 to potentially 10,500 feet thick in the depositional centers and are underlain by the bedrock units, which form an effective groundwater barrier (Riley et al., 2001). Depth to groundwater ranges from 5 to 400 feet bgs; however, groundwater near the installation's water supply source and near Mainside is generally encountered at a depth of 185 to 260 feet bgs (RW Beck, 2002; NEESA, 1999). Thick clay deposits and perched groundwater tables, ranging in depth from 5 to 75 feet, are present in areas of the playas (Panacea, 2001a and 2001b; ENSR, 1990). These perched aquifers are assumed to be limited in extent based on the available groundwater data and relatively small aerial extent of the playas. It is uncertain if the perched groundwater recharges the deeper aquifer system. The general flow direction of the groundwater basin is to the southeast.

7.14.1.7. Potential Groundwater and Surface Water Pathways

Groundwater Pathways

MC deposited on the RTA have the potential to migrate toward the water table at Quackenbush by dissolution into precipitation and subsequent infiltration into the subsurface. The presence of coarse soils, such as sands and gravel, aid vertical migration; however, due to the high evaporation rate in the region, the wetted front in surface soil eventually decreases and minerals in the water precipitate out. The vertical migration of MC to groundwater has limited potential based on the infrequent nature of rainfall in the area (less than 5 inches per year), the high evaporation rate, and the depth to the groundwater. For areas with shallow groundwater, such as playas, the soils are generally made up of finer grained soils, which decrease the vertical migration rate of MC to groundwater. The potential concentration of any MC would be highly dependent on many factors, such as its mass loading at the surface, aqueous solubility, and retardation of the MC due to soil characteristics.

Surface Water Pathways

Surface water runoff is the dominant pathway for MC transport at MCAGCC Twentynine Palms. The intense rainfall events produce large volumes of water that rapidly run off the bedrock in mountainous areas and travel downstream through the ephemeral streams and dry washes to the playas. The sparse vegetation on the installation does not dissipate the kinetic energy of the surface water as it travels downstream, increasing the potential for MC migration due to surface water. Surface runoff travels through the ephemeral streams for ultimate discharge to the Quackenbush Lake and Deadman Lake playas.

7.14.1.8. Potential Groundwater and Surface Water Receptors

Groundwater Receptors

The Quackenbush RTA overlies the Deadman Lake groundwater subbasin. One potential water supply well was identified downgradient of the Quackenbush RTA and primary MC loading area. However, the well is inactive. The active installation drinking water wells are up gradient of the Quackenbush MC loading area and separated by various geologic faults in the area, particularly the West Calico and Surprise Springs faults. MC are unlikely to migrate to groundwater, given the high evaporation rates and the expected depth to groundwater at the primary MC loading area. Therefore, there are no identified groundwater receptors.

Surface Water Receptors

There are no human receptors for MC in surface water within the Quackenbush primary MC loading area. The Quackenbush Lake and Deadman Lake playas have the potential to have ecological receptors, including the MFTL and desert tortoise, located in nearby habitat. Potential desert tortoise habitat has been identified in the southern portion of the RTA, with a smaller area located along the western slopes of the Bullion Mountains. Because the Quackenbush Lake and Deadman Lake playas are wholly contained within the installation boundaries and the entire RTA is considered range, exposures to receptors within this playa are not considered under the REVA. Although this playa was not explicitly considered in the ecological exposure assessment, the results of the exposure and toxicity assessment indicate that MC entering the playas are unlikely to pose a threat to ecological receptors (Malcolm Pirnie, 2007).

7.14.2. Groundwater Analysis Results

A qualitative groundwater analysis was performed by analyzing the source media, migration mechanisms, and exposure pathways documented in the MCAGCC Twentynine Palms CSM. Based on the results of the qualitative analysis of the groundwater information, limited potential exists for MC migration to groundwater and no groundwater receptors associated with the indicator MC are present. Therefore, a groundwater screening-level analysis was not conducted. Discussions of the qualitative analysis and screening-level analysis are presented in **Section 4**.

7.14.3. Surface Water Analysis Results

Because all surface water drainages from the primary MC loading area remain within the boundaries of the installation, no off-range release of MC is likely to occur for this RTA. There are no human receptors that consume or use the limited surface water collected within the playas for any beneficial use. Although ecological receptors (MFTL and desert tortoise) may be present, they are unlikely to consume surface water (Appendix A). Therefore, based on the lack of potential off-site receptors, surface water screening was not conducted for the Quackenbush RTA.

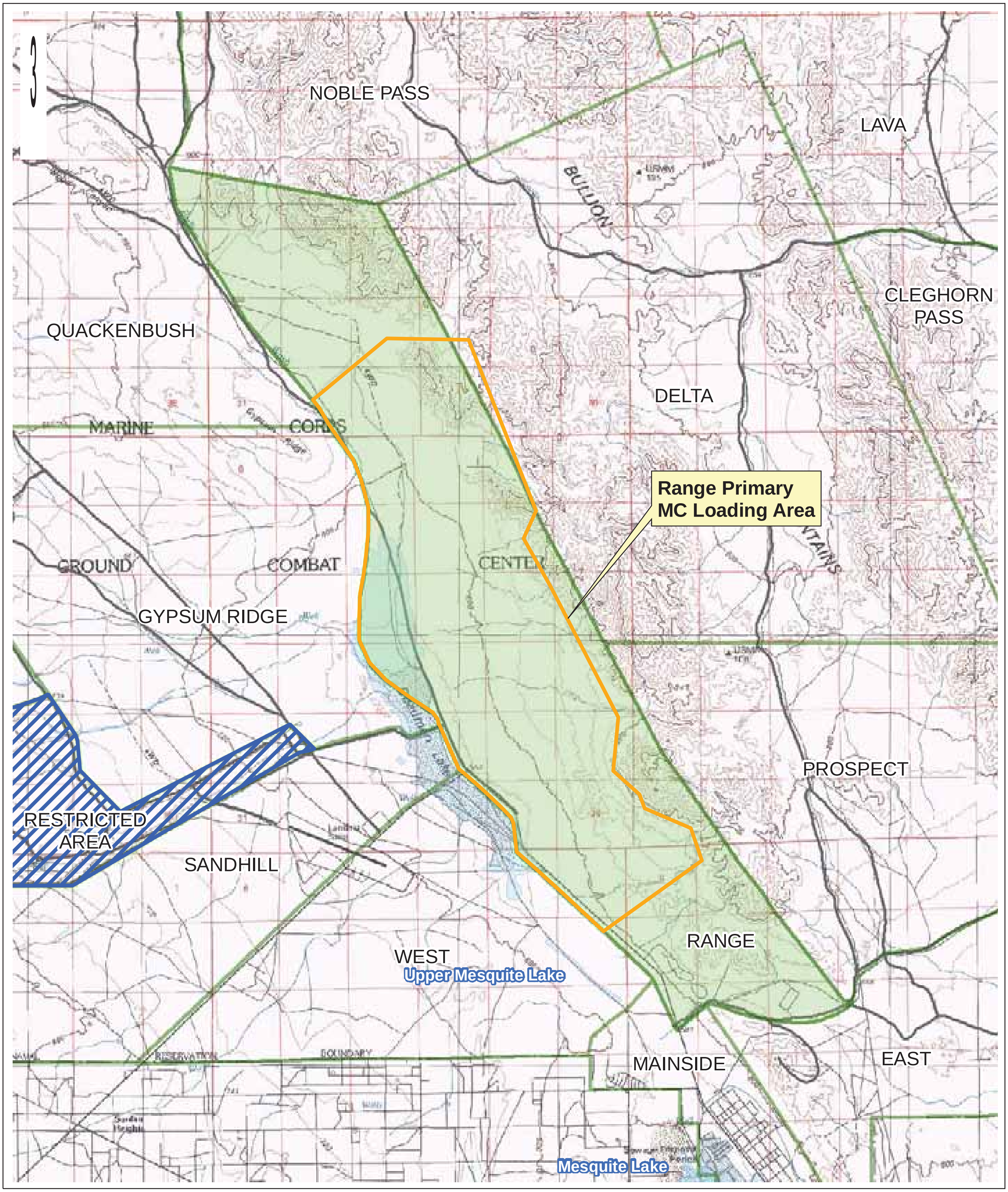
7.15. Range

The Range RTA is located in the south-central portion of MCAGCC Twentynine Palms (Figure 7.15-1) and covers an area of 21,749 acres (USACE, 2001a). It contains 27 of the 54 fixed ranges within the installation, summarized in Table 7.15-1. The overall use and training activities have changed little from the range use between 1969 and 1979. The Range RTA contains one sensitive fuze area, which serves as an impact area for Range 110. The former EOD Range, Range 112, was also a sensitive fuze area until the EOD Range was moved to what is now Range 051 (USACE, 2001b). Range 112 now serves as the NREA munitions and explosives of concern segregation area as part of the RRPS.

The MTU is located in the southeastern corner of the RTA. The training complex sits on a flat plateau at the base of a bedrock outcrop of the Bullion Mountains. Twelve SARs are located within the Range RTA. SARs are qualitatively assessed under REVA; as such, the MTU ranges are discussed in additional detail in **Section 8**. The Range primary MC loading area was delineated based on interviews with Range Control and the fixed target locations (MCAGCC FMD, 2006). The interviews and available data indicate the highest density of military munitions firing exists on the rolling hills of the valley floor. The Range primary MC loading area is roughly 51,785,000 m^2 located between the primary MSR and the base of the Bullion Mountains.

Military Munitions

The general classes of military munitions expected in this MC loading area include small arms ammunition (including blanks) and high explosive munitions.



LEGEND

- RANGE RTA
- RANGE TRAINING AREA
- PRIMARY MC LOADING AREA
- RESTRICTED AREA
- SURFACE WATER (INTERMITTENT)
- MAIN SUPPLY ROUTE

2 1 0 2 Miles

SOURCE: MCAGCC/NREA GIS OFFICE 2006; TECOM 2006; USGS, VARIOUS DATES.

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RANGE ENVIRONMENTAL VULNERABILITY ASSESSMENT

RANGE RTA

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FIGURE 7.15-1

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Table 7.15-1: Fixed Ranges within the Range RTA

Fixed Range	Range Type	Area (1,000 m^2)
LIVE-FIRE RANGES		
Range 051	EOD demilitarization range	149.12
Range 103	Automated squad defensive firing range	1,531.86
Range 104	Anti-mechanized/grenade range	1,357.37
Range 105	Gas chamber	242.48
Range 106	Mortar range	3,260.82
Range 106A	Basic hand grenade range	31.92
Range 107	Infantry squad assault range	4,391.54
Range 108	Infantry squad battle course	5,140.27
Range 109	Anti-armor live-fire tracking range	3,845.76
Range 110	Machine gun range	2,639.35
Sensitive Fuze Impact 1	Range 110 impact area	3,429.19
Range 110A	Grenade range	77.93
Range 111	MOUT assault course	583.66
Range 114	Combat Engineer demolition range	337.85
NON-LIVE-FIRE RANGES		
Range 112	NREA range residue processing area	1013.49
SARS		
Range 101	Armor, gun training range (subcaliber)	1,084.81
Range 101A	Small arms BZO range	3.72
Range 105A	Small arms BZO range	22.83
Range 113	Multipurpose machine gun range	3,997.60
Range 113A	Machine gun BZO range	3.87
Range 1	Known distance rifle range	523.90
Range 1A	Unknown distance rifle range	
Range 2	Known distance pistol range	
Range 2A	Combat pistol range	
Range 3	BZO grouping range	
Range 3A	BZO grouping range	
Range 4	Multipurpose range	

Detailed military munitions use data are presented the PRA (USACE, 2001b), and detailed assumptions for the determination of MC loading rates are provided in the *REVA Reference Manual* (HQMC, 2006).

7.15.1. CSM

7.15.1.1. Estimated MC Loading

The primary MC loading area located within the Range RTA is depicted in Figure 7.15-1. The MC Loading Rate Calculator was used to estimate the amount of MC loaded on this area over time (Table 7.15-2). It was conservatively assumed that all military munitions expenditures for the Range RTA were performed within the boundaries of the primary

MC loading area, rather than across the entire RTA. The MC loading amounts estimated for the MC loading area for each identified time period during which the impact area was used, Time Periods D and E, were assumed to occur only within the primary loading area. Expenditure data were extrapolated for time periods for which they were not available.

Table 7.15-2: Estimated Annual MC Loading for the Range RTA

MC Loading Area	Period	Begin Use	End Use	HMX (kg/m^2)	RDX (kg/m^2)	TNT (kg/m^2)	Perchlorate (kg/m^2)
Range	D (1977-1988)	1979	1988	2.95E-10	9.71E-08	4.39E-08	2.20E-09
	E (1989-Present)	1989	2005	3.69E-10	1.21E-07	5.49E-08	2.75E-09

7.15.1.2. Geography and Topography

The Range RTA is located along the western slope of the Bullion Mountains. The estimated elevation of the area is between 1,703 and 3,697 feet amsl (MCAGCC FMD, 2006). The terrain generally slopes from east to west, along the slopes of the mountains, which make up the eastern boundary of the RTA. The western portion of the RTA is generally rolling hills, with washes and ephemeral streams emanating from the mountains and heading toward Deadman Lake.

7.15.1.3. Surface Water Features

There are no perennial surface water features within the Range RTA. Streambeds are dry, except after infrequent, heavy rainfall (USDA NRCS, 1999). The Deadman Lake playa is located along the western boundary of the RTA and primary MC loading area. The majority of the RTA (92%) drains into Deadman Lake. The southern portion of the Range RTA, including the MTU, drains toward Mesquite Lake, located in Mainside. The entire primary MC loading area identified within the RTA drains to Deadman Lake. Quackenbush Lake, located north of the Range RTA in the Quackenbush RTA, is upstream and feeds Deadman Lake during periods of heavy precipitation (MCAGCC FMD, 2006).

7.15.1.4. Soil Characteristics and Land Cover

The Range RTA is composed of coarse soils that vary from sand to extremely gravelly coarse sand. Bedrock outcrops, part of the Bullion Mountains, are located along the eastern boundary of the RTA. The soils types are primarily Bluepoint sand, Arizo dry-Twobitter association, and Goldroad-Dalvord-Rock outcrop association soils. Deadman Lake playa is located in the western portion of the RTA; soils within this playa are generally finer grained than the surrounding area and typically are composed of clays, which inhibit the vertical migration of MC. Creosote bush scrub is the main vegetative type within the Range RTA, with bare ground throughout (USDA NRCS, 1999).

7.15.1.5. Erosion Potential

The erodibility of the Range MC loading area is moderate based on the coarse soil types found within the MC loading area. The soils at the Range RTA are generally coarse and range from sand to extremely gravelly coarse sands. A low to moderate soil erodibility factor of 0.05 was selected for the Range primary MC loading area.

7.15.1.6. Groundwater Characteristics

The Range RTA is located within the Deadman subbasin of the Twentynine Palms basin at MCAGCC Twentynine Palms, which is described in **Section 7.14.1.6**. No groundwater wells were identified within the Range RTA; however, the inferred groundwater flow direction is toward Deadman Lake playa, located on the western portion of the RTA. Groundwater is expected to be deeper along the eastern edge of the Bullion Mountains near the fixed range impact areas and generally decreases with topography to the west.

7.15.1.7. Potential Groundwater and Surface Water Pathways

Groundwater Pathways

MC deposited on the RTA have the potential to migrate toward the water table at the Range RTA by dissolution into precipitation and subsequent infiltration into the subsurface. The presence of coarse soils, such as sands and gravel, aid vertical migration; however, due to the high evaporation rate in the region, the wetted front in surface soil eventually decreases and minerals in the water precipitate out. The vertical migration of MC to groundwater has limited potential based on the infrequent nature of rainfall in the area (less than 5 inches per year), the high evaporation rate, and the depth to the groundwater. For areas with shallow groundwater, such as playas, the soils are generally made up of finer grained soils, which decrease the vertical migration rate of MC to groundwater. The potential concentration of any MC would be highly dependent on many factors, such as its mass loading at the surface, aqueous solubility, and retardation of the MC due to soil characteristics.

Surface Water Pathways

Surface water runoff is the dominant form of MC transport at MCAGCC Twentynine Palms compared to MC transport via groundwater infiltration. The intense rainfall events produce large volumes of water that rapidly run off the bedrock in mountainous areas and travel downstream through the ephemeral streams and dry washes to the playa lakes. The sparse vegetation on the installation does not dissipate the kinetic energy of the surface water as it travels downstream, increasing the potential for MC migration due to surface water. Deadman Lake is located downstream of the Range primary MC loading area and collects all surface runoff from the area following storm events.

7.15.1.8. Potential Groundwater and Surface Water Receptors

Groundwater Receptors

The Range RTA and its associated primary MC loading area overlie the same groundwater basin as the Quackenbush RTA. One potential drinking water well was identified as a possible exposure point for groundwater. However, this well is inactive. The active installation drinking water wells are up gradient of the Range MC loading area and separated by various geologic faults in the area, specifically the Hidalgo and Surprise Springs faults, which cause a 300-foot groundwater elevation differential.

Surface Water Receptors

There are no human receptors for MC in surface water within the Range primary MC loading area. Ecological receptors, including the MFTL and the desert tortoise, are potentially present near Deadman Lake playa. MFTL habitat is identified throughout the Range RTA, along the western slopes of the Bullion Mountains, and in the Deadman Lake playa. Deadman Lake is completely contained within the RTAs and installation boundary; thus, ecological receptors at this playa are not considered under REVA because they are on the operational range. Based on previous analysis provided for ecological receptor exposure and toxicity, MC potentially migrating to Deadman Lake do not pose a threat to ecological receptors (Malcolm Pirnie, 2007).

7.15.2. Groundwater Analysis Results

A qualitative groundwater analysis was performed by analyzing the source media, migration mechanisms, and exposure pathways documented in the MCAGCC Twentynine Palms CSM. Based on the results of the qualitative analysis of the groundwater information, limited potential exists for MC migration to groundwater and no groundwater receptors associated with the indicator MC are present. Therefore, a groundwater screening-level analysis was not conducted. Discussions of the qualitative analysis and screening-level analysis are presented in **Section 4**.

7.15.3. Surface Water Analysis Results

Because all surface water drainages from the loading area remain on range within the boundaries of the installation, no off-range release of MC is likely to occur for this RTA. There are no human receptors that consume or use the limited surface water collected within the playas for any beneficial use. Although ecological receptors (MFTL and desert tortoise) may be present, they are unlikely to consume surface water (Appendix A). Therefore, based on the lack of potential off-site receptors, surface water screening was not conducted for the Range RTA.

7.16. Black Top

The Black Top RTA is located on the north-central boundary of MCAGCC Twentynine Palms (Figure 7.16-1) and covers an area of 50,871 acres (USACE, 2001a). The RTA is currently designated a live-fire range for air-to-ground and ground-to-ground exercises. From 1979 through 1997, the RTA was used in a similar manner as the current training requirements. During this period, the RTA was approximately 45,418 acres, of which 36,626 acres were designated as impact area (USACE, 2001b). A C.C. course is located located in the Black Top RTA(Table 7.16-1).

Table 7.16-1: Fixed Ranges within the Black Top RTA

Fixed Range	Range Type	Area (1,000 m^2)
LIVE-FIRE RANGES		
C.C. Course Station 4	C.C. course	409.62

The Black Top primary MC loading area was delineated based on interviews with Range Control and a review of the fixed target locations (MCAGCC FMD, 2006). The interviews and review of available data indicate the highest density of military munitions firing exists in two distinct areas. Two primary MC loading areas were delineated for Black Top: Black Top I, located in the western portion of the RTA, and Black Top II, located in the eastern portion of the RTA. The Black Top I MC loading area is roughly 21,943,000 m^2, and the Black Top II MC loading area is roughly 25,156,000 m^2. The MC loading area was broken up into two separate loading areas in order to decrease the overall size of the MC loading area, thereby increasing the MC concentration within the MC loading area. In the event that screening-level analyses were required for this RTA, the MC would be distributed equally between the two primary MC loading areas in the Black Top RTA during the loading process.

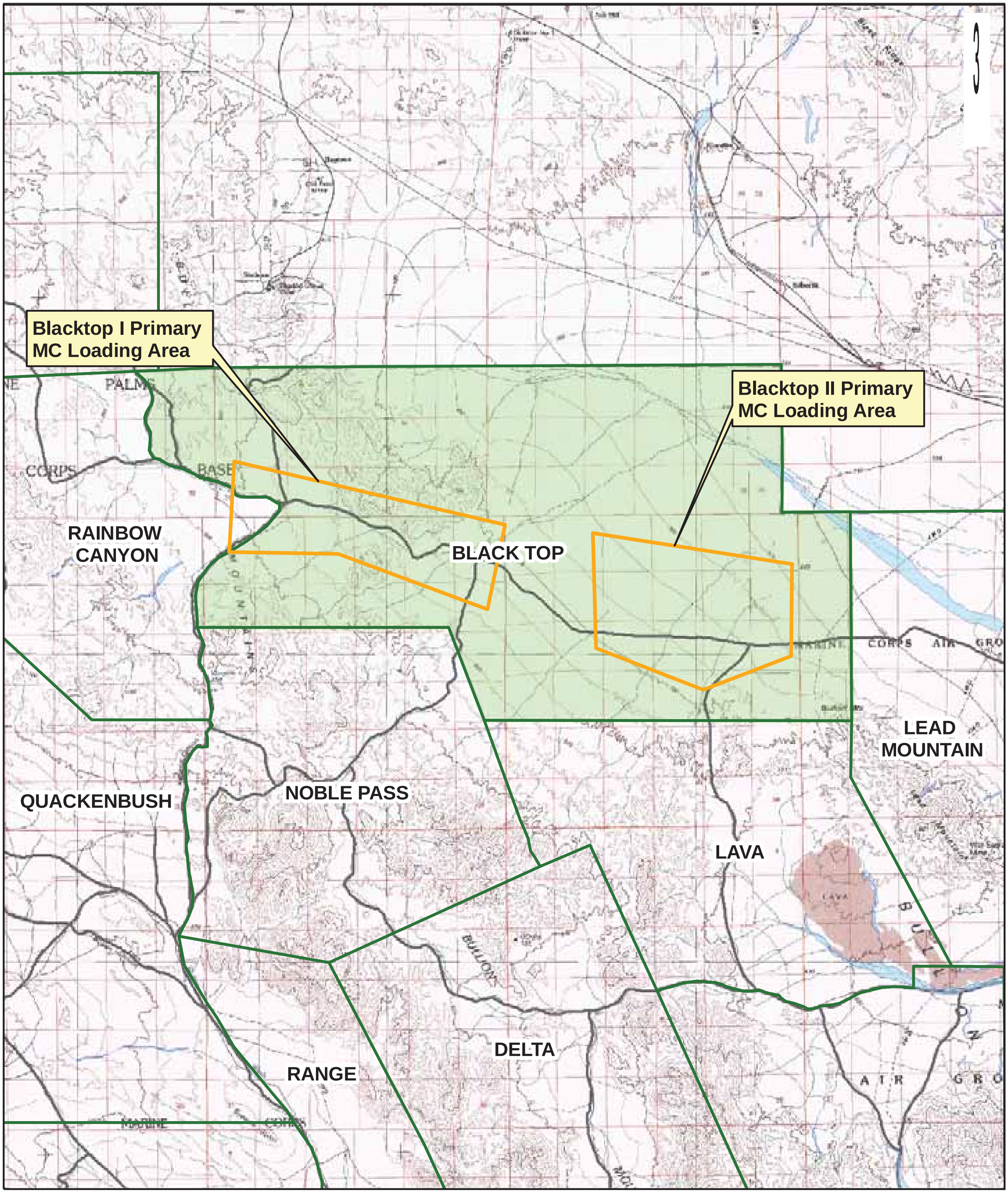
Military Munitions

The general classes of military munitions expected in these MC loading areas include small arms ammunition and high explosive munitions. Detailed military munitions use data are presented in the PRA (USACE, 2001b), and detailed assumptions for the determination of MC loading rates are provided in the *REVA Reference Manual* (HQMC, 2006).

7.16.1. CSM

7.16.1.1. Estimated MC Loading

The primary MC loading areas for Black Top are depicted in Figure 7.16-1. The MC Loading Rate Calculator was used to estimate the amount of MC loaded on these areas over time (Table 7.16-2). It was conservatively assumed that all military munitions



LEGEND

- BLACK TOP RTA
- RANGE TRAINING AREA
- PRIMARY MC LOADING AREA
- SURFACE WATER (INTERMITTENT)
- MAIN SUPPLY ROUTE

2 1 0 2 Miles

SOURCE: MCAGCC/NREA GIS OFFICE 2006; TECOM 2006; USGS, VARIOUS DATES.

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BLACK TOP RTA

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FIGURE 7.16-1

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expenditures for the Black Top RTA were performed within the boundaries of the primary MC loading areas, rather than across the entire RTA. The total MC loading for the Black Top I and Black Top II loading areas was combined to obtain a single loading rate for the RTA. The MC loading amounts estimated for the MC loading areas for each identified time period during which the impact areas were used, Time Periods D and E, were assumed to occur only within the primary loading area. There are no SARs located within the Black Top RTA; therefore, qualitative assessments to determine the fate and transport of lead were not conducted for this RTA. Expenditure data were extrapolated for time periods for which expenditure data were not available.

Table 7.16-2: Estimated Annual MC Loading for the Black Top RTA

MC Loading Area	Period	Begin Use	End Use	HMX (kg/m^2)	RDX (kg/m^2)	TNT (kg/m^2)	Perchlorate (kg/m^2)
Black Top	D (1977-1988)	1979	1988	2.64E-11	1.78E-07	2.44E-07	1.49E-10
	E (1989-Present)	1989	2005	3.30E-11	2.22E-07	3.05E-07	1.86E-10

7.16.1.2. Geography and Topography

The Black Top RTA is located northeast of the Bullion Mountains. The area is generally level and flat. The estimated elevation of the area is between 673 and 3,192 feet amsl (MCAGCC FMD, 2006). The terrain generally slopes from southwest to northeast toward the installation boundary to a dry wash that runs along the installation boundary and into Dry Lake, located in the Lead Mountain RTA.

7.16.1.3. Surface Water Features

There are no perennial surface water features within the Black Top RTA. Streambeds are dry, except after infrequent, heavy rainfall (USDA NRCS, 1999). There are no playas located within the RTA; the entire RTA drains into the Dry Lake playa. The RTA contains numerous ephemeral stream channels that drain into a dry wash located along the installation's northern boundary (MCAGCC FMD, 2006).

7.16.1.4. Soil Characteristics and Land Cover

The Black Top I and II MC loading areas are composed of coarse soils that vary from sand to extremely gravelly coarse sand soils. Bedrock outcrops are located in the northwestern portion of the RTA. The soil types in the Black Top I MC loading area are primarily Arizo-Twobitter association, Sunrock-Pacific-Mesa association, and Arizo sand. The Black Top II MC loading area contains Carrizo complex soils only. For both MC loading areas, the vegetation is mainly creosote bush scrub, with bare ground throughout (USDA NRCS, 1999).

7.16.1.5. Erosion Potential

The erodibility of the Black Top primary MC loading areas is moderate based on the coarse soil types found within the MC loading areas. The soils at both MC loading areas are generally coarse soils that range from sand to extremely gravelly coarse sands. Low to moderate soil erodibility factors of 0.08 and 0.02 were selected for the Black Top I and Black Top II MC primary loading areas, respectively.

7.16.1.6. Groundwater Characteristics

The Black Top RTA and its associated primary MC loading areas are within the Bristol Valley groundwater basin, located on the northeast portion of MCAGCC Twentynine Palms. As mentioned in **Section 7.10.1.6**, limited groundwater data are available for the area. Water level data collected from exploratory drilling, as well as production wells in the towns of Ludlow and Bagdad, show groundwater flows away from the Bullion and Bristol mountains and then southeast down the axis of the basin toward Bristol Dry Lake (Koehler, 1983). The general groundwater flow direction in Black Top is toward Dry Lake. Perched groundwater zones exist near Bristol Dry Lake and Dry Lake, with water levels recorded at 14 to 89 feet bgs (Koehler, 1983). The perched groundwater tables are assumed to be limited in extent based on the available groundwater data and the relatively small aerial extent of the playas. It is uncertain if the perched groundwater spills over into the deeper aquifer system.

7.16.1.7. Potential Groundwater and Surface Water Pathways

Groundwater Pathways

MC deposited on the RTA have the potential to migrate toward the water table at Black Top by dissolution into precipitation and subsequent infiltration into the subsurface. This transport mechanism may be aided by the presence of coarse soils, such as sands and gravel. However, the vertical migration of MC to groundwater at Black Top is likely limited based on the infrequent rate of rainfall in the area (less than 5 inches per year), the high evaporative rate, and the depth to the groundwater table. The actual potential concentration of any MC would be highly dependent on many factors, such as its mass loading at the surface, aqueous solubility, and retardation of the MC due to soil characteristics.

Surface Water Pathways

All surface water runoff from the Black Top primary MC loading areas travels by way of ephemeral streams to Dry Lake, located in the northern portion of the Lead Mountain RTA. Dry Lake is fully contained within the installation boundaries.

7.16.1.8. Potential Groundwater and Surface Water Receptors

Groundwater Receptors

No groundwater receptors were identified for the Black Top RTA. Groundwater from Black Top likely becomes shallow near or beneath Dry Lake playa. No drinking water or irrigation wells were identified down gradient of the Black Top RTA.

Surface Water Receptors

Surface water runoff originating on the Black Top RTA does not leave the installation boundaries, and no off-site human receptors were identified for the runoff. Dry Lake playa has the potential to have ecological receptors, including the MFTL and the desert tortoise. MFTL habitat is identified adjacent to Dry Lake, and desert tortoise habitat is identified west of the primary MC loading areas, near the boundary with Rainbow Canyon. Dry Lake is completely contained within the RTA and installation boundary; thus, ecological receptors at this playa were not explicitly evaluated. Based on previous analysis provided for ecological receptor exposure and toxicity, MC potentially migrating to Dry Lake do not pose a threat to ecological receptors (Malcolm Pirnie, 2007).

7.16.2. Groundwater Analysis Results

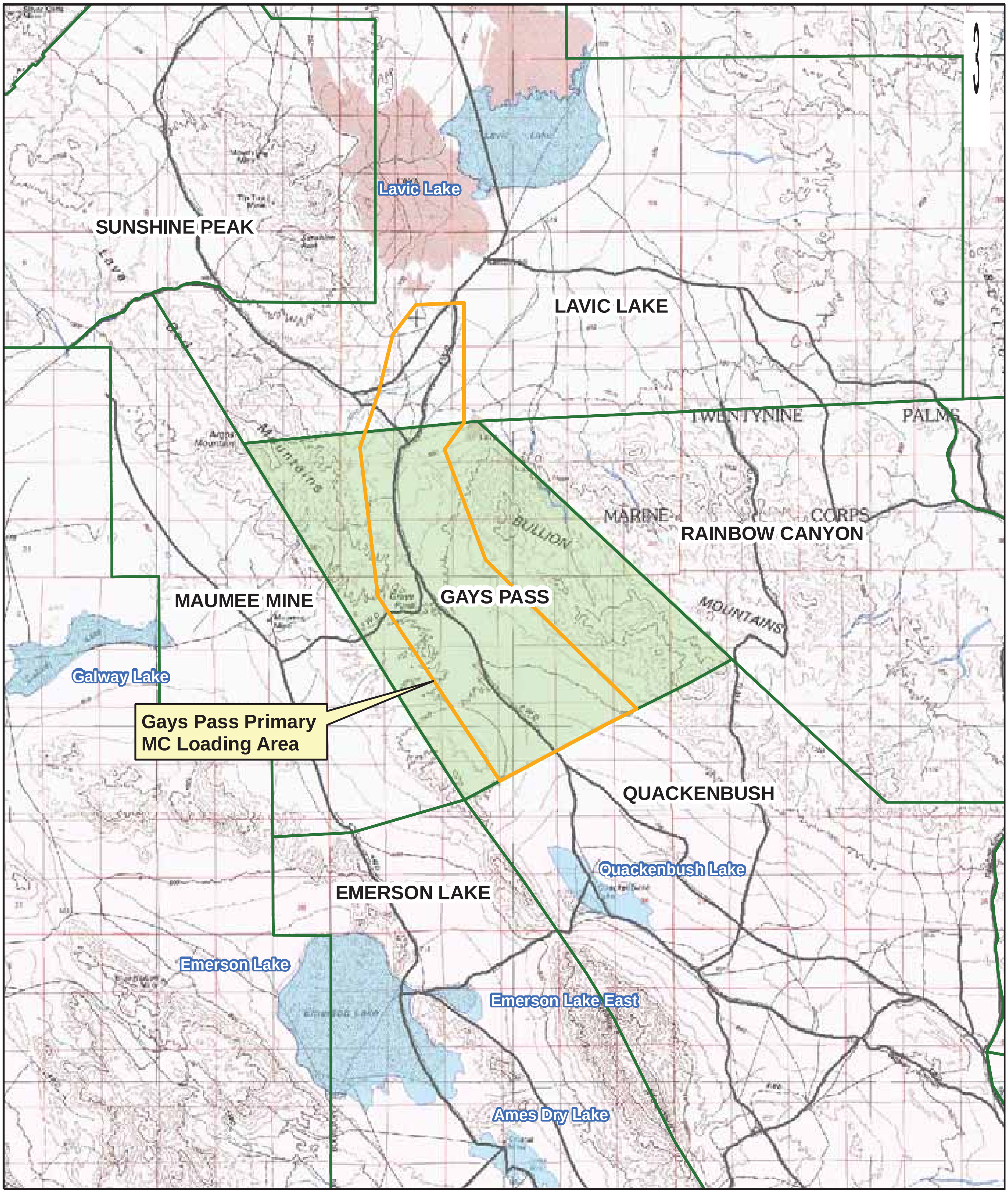
A qualitative groundwater analysis was performed by analyzing the source media, migration mechanisms, and exposure pathways documented in the MCAGCC Twentynine Palms CSM. Based on the results of the qualitative analysis of the groundwater information, limited potential exists for MC migration to groundwater and no groundwater receptors associated with the indicator MC are present. Therefore, a groundwater screening-level analysis was not conducted. Discussions of the qualitative analysis and screening-level analysis are presented in **Section 4**.

7.16.3. Surface Water Analysis Results

Because all surface water drainage from the loading area remains on range within the boundaries of the installation, no off-range release of MC is likely to occur for this RTA. There are no human receptors that consume or use the limited surface water collected within the playas. Although ecological receptors (MFTL and desert tortoise) may be present, they are unlikely to consume surface water (Appendix A). Therefore, based on the lack of potential off-site receptors, surface water screening was not conducted for the Black Top RTA.

7.17. Gays Pass

The Gays Pass RTA is located north of the Quackenbush RTA, in the northwest part of MCAGCC Twentynine Palms (Figure 7.17-1) and covers an area of 15,316 acres. From 1979 to 1987, the RTA was known as Gays Peak. This RTA also includes a small portion of the former Mesa RTA, which was present between 1979 and 1997 (USACE,



LEGEND

- GAYS PASS RTA
- RANGE TRAINING AREA
- PRIMARY MC LOADING AREA
- SURFACE WATER (INTERMITTENT)
- MAIN SUPPLY ROUTE

2 1 0 2 Miles

SOURCE: MCAGCC/NREA GIS OFFICE 2006; TECOM 2006; USGS, VARIOUS DATES.

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GAYS PASS RTA

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FIGURE 7.17-1

2001a). Since 1979, the Gays Pass RTA has been designated as a ground-based live-fire maneuver area and used for infantry battalion and company tactical training. The RTA contains CAX target systems and two LTAs for laser ground-to-ground firing. No fixed ranges are contained within the Gays Pass RTA (USACE, 2001b).

A primary MC loading area was delineated for this RTA based on interviews with Range Control and a review of the fixed target locations (MCAGCC FMD, 2006). The interviews and available data indicate the highest density of military munitions firing exists along the center of the RTA, between bedrock outcrops. The Gays Pass primary MC loading area is approximately 41,047,000 m^2; a portion of this loading area extends north into the Lavic Lake RTA. The southern end of the Gays Pass primary MC loading area is located adjacent to the Quackenbush MC loading area. The Quackenbush MC loading area and Gays Pass MC loading area form a continuous MC loading area, running along the valley floor between the Hidalgo Mountains and the Bullion Mountains.

Military Munitions

The general classes of military munitions expected in this MC loading area include small arms ammunition and high explosive munitions. Detailed military munitions use data are presented in the PRA (USACE, 2001b), and detailed assumptions for the determination of MC loading rates are provided in the *REVA Reference Manual* (HQMC, 2006).

7.17.1. CSM

7.17.1.1. Estimated MC Loading

The MC loading area for Gays Pass is depicted in Figure 7.17-1. The MC Loading Rate Calculator was used to estimate the amount of MC loaded on this area over time (Table 7.17-1). It was conservatively assumed that all military munitions expenditures for the Gays Pass RTA were performed within the boundaries of the primary MC loading area, rather than across the entire RTA. The MC loading amounts estimated for the MC loading area for each identified time period during which the impact area was used, Time Periods D and E, were assumed to occur only within the primary loading area. There are no SARs located within the Gays Pass RTA; therefore, qualitative assessments to determine the fate and transport of lead were not conducted for this RTA. Expenditure data were extrapolated for time periods for which expenditure data were not available.

Table 7.17-1: Estimated Annual MC Loading for the Gays Pass RTA

MC Loading Area	Period	Begin Use	End Use	HMX (kg/m^2)	RDX (kg/m^2)	TNT (kg/m^2)	Perchlorate (kg/m^2)
Gays Pass	D (1977-1988)	1979	1988	4.39E-13	1.24E-07	1.84E-07	2.91E-11
	E (1989-Present)	1989	2005	5.48E-13	1.55E-07	2.29E-07	3.64E-11

7.17.1.2. Geography and Topography

The Gays Pass RTA is located between the Hidalgo Mountains to the west and the Bullion Mountains to the east. The RTA is characteristic of a pass of level land. The estimated elevation of the area is between 2,461 and 4,580 feet amsl (MCAGCC FMD, 2006). The southern portion of the RTA general slopes from northwest to southeast toward the Quackenbush RTA. The northern portion of the RTA slopes from south to north toward the Lavic Lake playa.

7.17.1.3. Surface Water Features

There are no perennial surface water features within the Gays Pass RTA. Streambeds are dry, except after infrequent, heavy rainfall (USDA NRCS, 1999). There are no playas located within the RTA. The two surface water basins that cover the most area are Lavic Lake (50% of the RTA) and Quackenbush Lake (36% of the RTA). Galway Lake (seven percent), Upper Emerson (six percent), and Deadman Lake (one percent) cover the remaining portions of the RTA (MCAGCC FMD, 2006).

The Gays Pass primary MC loading area drains primarily to Lavic Lake (56%) and Quackenbush Lake (41%), with very small areas draining to Upper Emerson Lake, located in the Emerson Lake RTA, and Galway Lake, located due west of Gays Pass on the installation boundary.

7.17.1.4. Soil Characteristics and Land Cover

Gays Pass is composed of coarse soils that vary from very gravelly fine sandy loam to extremely gravelly coarse sand soils. Bedrock outcrops are located along the eastern boundary of the RTA and the northwest corner of the RTA. The soil types in the Gays Pass RTA are primarily Arizo extremely gravelly dry land sand, Arizo extremely gravelly loamy sand, and Haleburu-Noble Pass complex soil. The vegetation in the Gays Pass RTA is mainly creosote bush scrub, with bare ground throughout (USDA NRCS, 1999).

7.17.1.5. Erosion Potential

The erodibility of the Gays Pass primary MC loading area is low based on the coarse soil types found within the MC loading area. The soil at the MC loading area is generally coarse soils that range from sandy loam to extremely gravelly coarse sands. A low soil erodibility factor of 0.02 was selected for the Gays Pass primary MC loading area.

7.17.1.6. Groundwater Characteristics

The Gays Pass RTA and MC loading areas are divided between two groundwater basins; the southern portion is within the Deadman Lake subbasin of the Twentynine Palms basin, and the northern portion is within the Lavic Valley groundwater basin. The Deadman Lake subbasin is discussed in more detail in **Section 7.14.1.6**, and the Lavic Lake groundwater basin is discussed in more detail in **Section 7.13.1.6**. Groundwater flow within the Gays Pass RTA area of Deadman Lake is suspected to be to the southeast, along the valley floor toward Deadman Lake playa. The groundwater flow in the Lavic Valley groundwater basin is to the north toward Lavic Lake playa. Groundwater is believed to be deep below the Gays Pass RTA, given the high elevation and large distance to playas.

7.17.1.7. Potential Groundwater and Surface Water Pathways

Groundwater Pathways

MC deposited on the RTA have the potential to migrate toward the water table at Gays Pass by dissolution into precipitation and subsequent infiltration into the subsurface. This transport mechanism may be aided by the presence of coarse soils, such as sands and gravel. However, the vertical migration of MC to groundwater at Gays Pass is likely limited based on the infrequent rate of rainfall in the area (less than 5 inches per year), the high evaporative rate, and the depth to the groundwater table. The actual potential concentration of any MC would be highly dependent on many factors, such as its mass loading at the surface, aqueous solubility, and retardation of the MC due to soil characteristics.

Surface Water Pathways

Surface water runoff is the dominant pathway for MC transport at MCAGCC Twentynine Palms compared to MC transport via groundwater infiltration. The intense rainfall events produce large volumes of water that rapidly run off the bedrock in mountainous areas and travel downstream through the ephemeral streams and dry washes to the playas. The sparse vegetation on the installation does not dissipate the kinetic energy of the surface water as it travels downstream, increasing the potential for MC migration due to surface water. Deadman Lake and Lavic Lake receive runoff from the Gays Pass primary MC loading area and collect all surface runoff from the area following storm events. All surface runoff from this RTA remains on range within the installation boundaries.

7.17.1.8. Potential Groundwater and Surface Water Receptors

Groundwater Receptors

No groundwater receptors were identified for the Gays Pass primary MC loading area. An inactive water well is located near Deadman Lake; however, it does not represent a potential exposure point given its inactive status. The installation drinking water wells are up gradient of the Gays Pass MC loading area. No drinking water wells were identified in the Lavic Valley groundwater basin.

Surface Water Receptors

Surface water runoff originating on the Gays Pass RTA does not leave the installation boundaries, and no off-range human receptors were identified for the runoff. Both Lavic Lake and Deadman Lake have the potential to have ecological receptors, including the MFTL and the desert tortoise. Both Lavic Lake and Deadman Lake are completely contained within their respective RTAs and the installation boundary; thus, ecological receptors within these playas are not considered because they are on the operational range. Based on previous analysis provided for ecological receptor exposure and toxicity, MC potentially migrating to playas do not pose a threat to ecological receptors (Malcolm Pirnie, 2007).

7.17.2. Groundwater Analysis Results

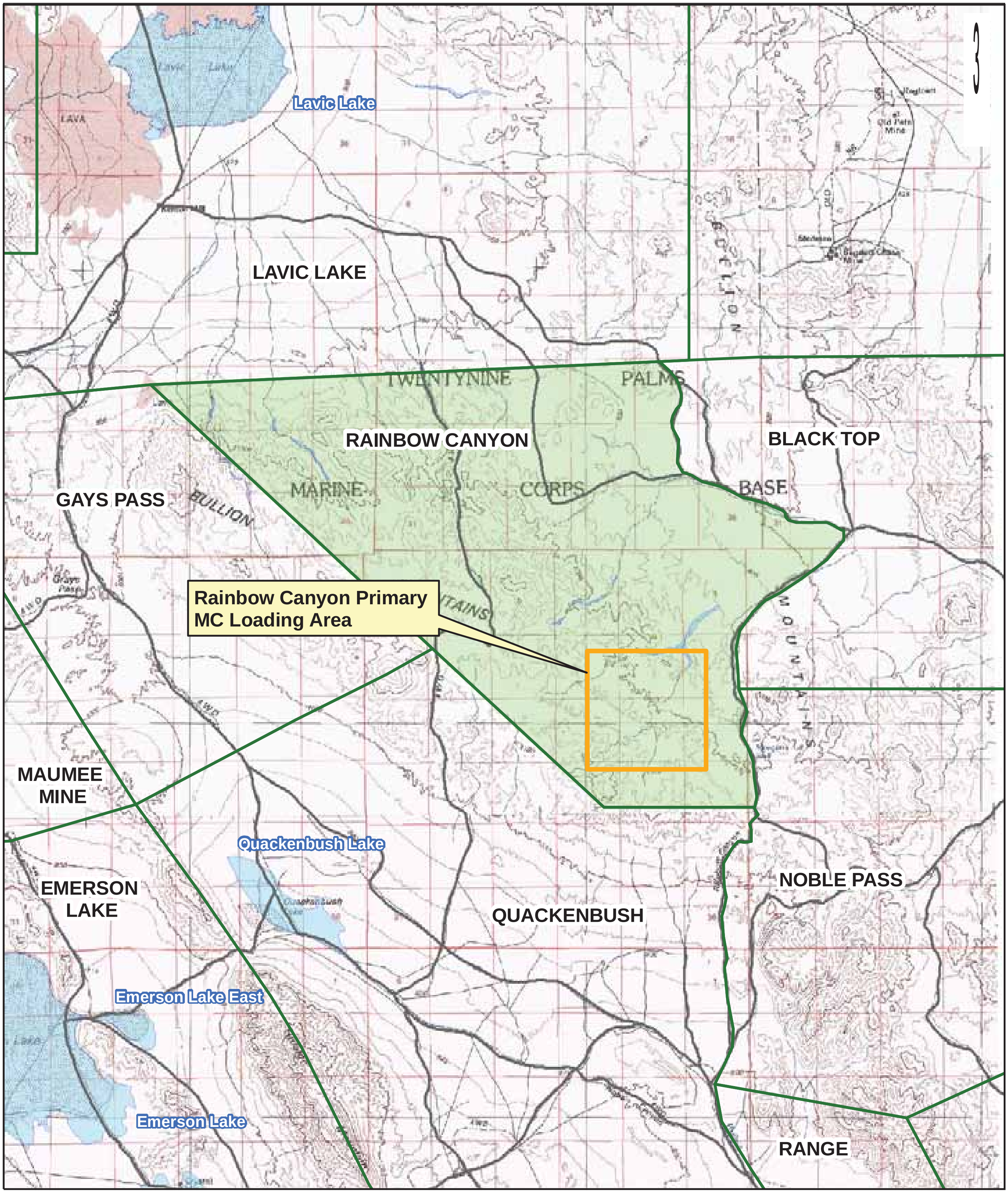
A qualitative groundwater analysis was performed by analyzing the source media, migration mechanisms, and exposure pathways documented in the MCAGCC Twentynine Palms CSM. Based on the results of the qualitative analysis of the groundwater information, limited potential exists for MC migration to groundwater and no groundwater receptors associated with the indicator MC are present. Therefore, a groundwater screening-level analysis was not conducted. Discussions of the qualitative analysis and screening-level analysis are presented in **Section 4**.

7.17.3. Surface Water Analysis Results

Because the majority of the surface water drainages from the RTA and all of the drainages within the primary MC loading area remain within the boundaries of the installation, no off-range release of MC is likely to occur for this RTA. There are no human receptors that consume or use the limited surface water collected within the playas. Although ecological receptors (MFTL and desert tortoise) might be present, they are unlikely to consume surface water (Appendix A). Therefore, based on the lack of potential off-site receptors, surface water screening was not conducted for the Gays Pass RTA.

7.18. Rainbow Canyon

The Rainbow Canyon RTA is located in the northern portion of MCAGCC Twentynine Palms (Figure 7.18-1) and covers an area of 25,578 acres, all of which are designated as impact area (USACE, 2001a). Since 1979, the RTA has been designated as a live-fire and maneuver area for air-to-ground and ground-to-ground exercises. Artillery units use the southern portion of the RTA as an impact area. The northern section of this RTA was part of the former Mesa RTA from 1979 to 1997. Range 601 (Sensitive Fuze Impact Range) is considered a no-maneuver area due to the likely presence of large volumes of



LEGEND

- RAINBOW CANYON RTA
- RANGE TRAINING AREA
- PRIMARY MC LOADING AREA
- SURFACE WATER (INTERMITTENT)
- MAIN SUPPLY ROUTE

2 1 0 2 Miles

SOURCE: MCAGCC/NREA GIS OFFICE 2006; TECOM 2006; USGS, VARIOUS DATES.

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RANGE ENVIRONMENTAL VULNERABILITY ASSESSMENT

RAINBOW CANYON RTA

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FIGURE 7.18-1

UXO (Table 7.18-1). This MC loading area is a major air-to-ground and ground-to-ground range for sensitive fuze munition items. The RTA includes a CAX target system and four LTAs for laser ground-to-ground firing. There are two main MSRs in the Rainbow Canyon RTA (USACE, 2001b).

Table 7.18-1: Fixed Ranges within the Rainbow Canyon RTA

Fixed Range	Range Type	Area (1,000 m^2)
LIVE-FIRE RANGES		
Range 601 (portion in Delta)	Sensitive fuze impact range	9,000.00

A primary MC loading area associated with the Rainbow Canyon RTA was identified based on interviews with Range Control and a review of the fixed target locations (MCAGCC FMD, 2006). The interviews and available data indicate that the highest density of military munitions firing exists within the mountainous regions of the Rainbow Canyon RTA. The primary MC loading area was delineated for Rainbow Canyon with an area of 9,000,000 m^2.

Military Munitions

The general classes of military munitions expected in this MC loading area include small arms ammunition and high explosive munitions. Detailed military munitions use data are presented in the PRA (USACE, 2001b), and detailed assumptions for the determination of MC loading rates are provided in the *REVA Reference Manual* (HQMC, 2006).

7.18.1. CSM

7.18.1.1. Estimated MC Loading

The MC loading area for Rainbow Canyon is depicted in Figure 7.18-1. The MC Loading Rate Calculator was used to estimate the amount of MC loaded on this area over time (Table 7.18-2). It was conservatively assumed that all military munitions expenditures for the Rainbow Canyon RTA were performed within the boundaries of the primary MC loading area, rather than across the entire RTA. The MC loading amounts estimated for the MC loading area for each identified time period during which the impact area was used, Time Periods D and E, were assumed to occur only within the primary loading area. There are no SARs located within the Rainbow Canyone RTA; therefore, qualitative assessments to determine the fate and transport of lead were not conducted for this RTA. Expenditure data were extrapolated for time periods for which expenditure data were not available.

Table 7.18-2: Estimated Annual MC Loading for the Rainbow Canyon RTA

MC Loading Area	Period	Begin Use	End Use	HMX (kg/m²)	RDX (kg/m²)	TNT (kg/m²)	Perchlorate (kg/m²)
Rainbow Canyon	D (1977-1988)	1979	1988	n/a	4.58E-07	7.33E-07	5.66E-11
	E (1989-Present)	1989	2005	n/a	5.72E-07	9.16E-07	7.07E-11

7.18.1.2. Geography and Topography

The Rainbow Canyon RTA is located within the Bullion Mountains; approximately 60% of the RTA is mountainous. The estimated elevation of the area is between 2,198 and 4,199 feet amsl (MCAGCC FMD, 2006). The terrain generally slopes from southwest to northeast in the eastern portion of the RTA and from south to north in the western portion of the RTA.

7.18.1.3. Surface Water Features

There are no perennial surface water features within the Rainbow Canyon RTA. Streambeds are dry, except after infrequent, heavy rainfall (USDA NRCS, 1999). There are no playas located within the RTA; runoff drains primarily to Dry Lake playa (51%) and Lavic Lake playa (41%). Approximately seven percent of the RTA (located along the western boundary) drains to Deadman Lake playa (MCAGCC FMD, 2006).

The primary MC loading area is located within the watershed that drains to Dry Lake. The surface water flow is through ephemeral streams and dry washes that pass through the Black Top RTA and downstream to Dry Lake. The surface water runoff from the Rainbow Canyon RTA does not leave the installation.

7.18.1.4. Soil Characteristics and Land Cover

The Rainbow Canyon primary MC loading area is composed of coarse soils that vary from very gravelly fine sandy loam to extremely gravelly coarse sand soils; however, the majority of the RTA is bedrock outcrops that make up the Bullion Mountains. The soil types in the Rainbow Canyon MC loading area are primarily Haleburu-Arizo association, Haleburu-Noble Pass complex, and Noble Pass-Pacific Mesa sunrock complex soils. The vegetation within the Rainbow Canyon RTA and MC loading area is mainly creosote bush scrub and some bare ground (USDA NRCS, 1999).

7.18.1.5. Erosion Potential

The erodibility of the Rainbow Canyon MC loading area is low to moderate based on the coarse soil types found within the MC loading area. The soils at the MC loading area are generally coarse soils that range from very gravelly fine sandy loam to extremely gravelly coarse sands. A low soil erodibility factor of 0.03 was selected for the Rainbow Canyon MC loading area.

7.18.1.6. Groundwater Characteristics

A large portion of the RTA consists of bedrock, which contains negligible amounts of groundwater. The remaining alluvial sections of the Rainbow Canyon RTA are within the Bristol Valley groundwater basin, located on the northeast portion of MCAGCC Twentynine Palms. As mentioned in **Section 7.10.1.6**, limited groundwater data are available for the area; no groundwater wells are present within this RTA. The general groundwater flow direction in the Rainbow Canyon RTA is suspected to be eastward toward Dry Lake. The northwest portion of the RTA overlies the Lavic Valley groundwater basin, which flows northward toward Lavic Lake playa. Groundwater is believed to be very deep, given the high elevation of the area.

7.18.1.7. Potential Groundwater and Surface Water Pathways

Groundwater Pathways

MC deposited on the RTA have the potential to migrate toward the water table at Rainbow Canyon by dissolution into precipitation and subsequent infiltration into the subsurface. This transport mechanism may be aided by the presence of coarse soils, such as sands and gravel. However, the vertical migration of MC to groundwater at Rainbow Canyon is likely limited based on the infrequent rate of rainfall in the area (less than 5 inches per year), the high evaporative rate, and the depth to the groundwater table. The actual potential concentration of any MC would be highly dependent on many factors, such as its mass loading at the surface, aqueous solubility, and retardation of the MC due to soil characteristics.

Surface Water Pathways

Surface water runoff is the dominant pathway for MC transport at the installation. The intense rainfall events produce large volumes of water that rapidly run off the bedrock in mountainous areas and travel downstream through the ephemeral streams and dry washes to the playas. The sparse vegetation on the installation does not dissipate the kinetic energy of the surface water as it travels downstream, increasing the potential for MC migration due to surface water. Dry Lake receives all of the runoff from the Rainbow Canyon primary MC loading area. All surface runoff from this RTA remains on range within the installation boundaries.

7.18.1.8. Potential Groundwater and Surface Water Receptors

Groundwater Receptors

No drinking water wells were identified down gradient of the Rainbow Canyon RTA and within the MCAGCC Twentynine Palms boundaries. Based on the direction of groundwater flow, no human receptors were identified.

Surface Water Receptors

Surface water runoff travels through ephemeral streams and alluvial washes into the Dry Lake playa. Surface water runoff does not leave the installation boundaries, and no off-site receptors were identified for the runoff. Ecological receptors (MFTL and desert tortoise) are unlikely to be present in the mountainous regions of the Rainbow Canyon RTA, but may be present near Dry Lake. Dry Lake is completely contained within the RTA and installation boundary; thus, ecological receptors at this playa are not considered because they are on the operational range. Based on previous analysis provided for ecological receptor exposure and toxicity, MC potentially migrating to Dry Lake do not pose a threat to ecological receptors (Malcolm Pirnie, 2007).

7.18.2. Groundwater Analysis Results

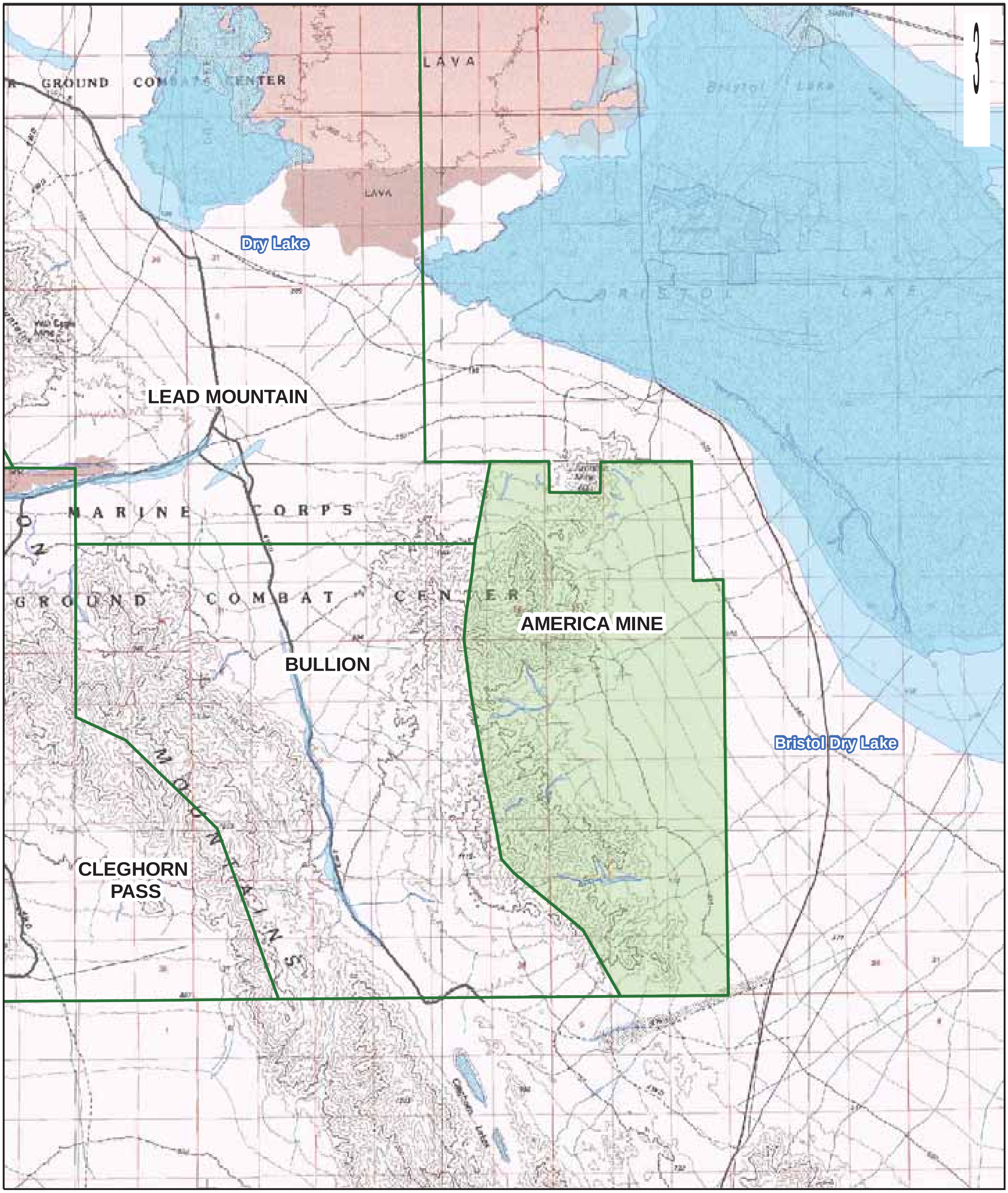
A qualitative groundwater analysis was performed by analyzing the source media, migration mechanisms, and exposure pathways documented in the MCAGCC Twentynine Palms CSM. Based on the results of the qualitative analysis of the groundwater information, limited potential exists for MC migration to groundwater and no groundwater receptors associated with the indicator MC are present. Therefore, a groundwater screening-level analysis was not conducted. Discussions of the qualitative analysis and screening-level analysis are presented in **Section 4**.

7.18.3. Surface Water Analysis Results

The Rainbow Canyon primary MC loading area drains into Dry Lake, which is wholly contained within the boundaries of MCAGCC Twentynine Palms. Because all surface water drainages from the loading area remain within the boundaries of the installation, no off-range release of MC is likely to occur for this RTA. There are no human receptors that consume or use the limited surface water collected within the playas. Although ecological receptors (MFTL and desert tortoise) may be present, they are unlikely to consume surface water (Appendix A). Therefore, based on the lack of potential off-site receptors, surface water screening was not conducted for the Rainbow Canyon RTA.

7.19. America Mine

The America Mine RTA is located on the far eastern boundary of MCAGCC Twentynine Palms (Figure 7.19-1) and covers an area of approximately 20,920 acres. Recently, the RTA has had limited use due to a lack of direct ground access (USACE, 2001a). Between 1979 and 1997, the RTA was used as a live-fire and maneuver area for air-to-ground and ground-to-ground exercises. The RTA's primary training uses were for patrolling, infantry company tactical training, and Light Armor Vehicle (LAV) testing. There are no fixed ranges within this RTA. No primary MC loading area was identified within the America Mine RTA, due to the lower level of live-fire training conducted at this training area.



LEGEND

- AMERICA MINE RTA
- RANGE TRAINING AREA
- SURFACE WATER (INTERMITTENT)
- MAIN SUPPLY ROUTE

2 1 0 2 Miles

SOURCE: MCAGCC/NREA GIS OFFICE 2006; TECOM 2006; USGS, VARIOUS DATES.

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RANGE ENVIRONMENTAL VULNERABILITY ASSESSMENT

AMERICA MINE RTA

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FIGURE 7.19-1

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Military Munitions

The general classes of military munitions expected in this RTA include small arms ammunition and high explosive munitions. Detailed military munitions use data are presented in the PRA (USACE, 200b), and detailed assumptions for the determination of MC loading rates are provided in the *REVA Reference Manual* (HQMC, 2006).

7.19.1. CSM

7.19.1.1. Estimated MC Loading

Because no primary MC loading area was designated for America Mine, MC loading was estimated for an area representing 10% of the total RTA area. An MC loading area of 8,466,000 m^2 was assumed. The MC Loading Rate Calculator was used to estimate the amount of MC loaded on this area over time (Table 7.19-1). The MC loading amounts estimated for the area for each identified time period during which the impact areas were used, Time Periods D and E, were assumed to occur only within the estimated MC loading area. There are no SARs located within the America Mine RTA; therefore, qualitative assessments to determine the fate and transport of lead were not conducted for this RTA. Expenditure data were extrapolated for time periods for which expenditure data were not available.

Table 7.19-1: Estimated Annual MC Loading for the America Mine RTA

MC Loading Area	Period	Begin Use	End Use	HMX (kg/m^2)	RDX (kg/m^2)	TNT (kg/m^2)	Perchlorate (kg/m^2)
America Mine	D (1977-1988)	1979	1988	6.93E-10	6.28E-09	5.26E-09	3.92E-10
	E (1989-Present)	1989	2005	8.66E-10	7.85E-09	6.58E-09	4.90E-10

7.19.1.2. Geography and Topography

The America Mine RTA is located within the Bullion Mountains and is mainly mountainous terrain with rolling hills. The eastern half of the RTA consists of more level alluvial plains. The estimated elevation of the area is between 604 and 3,681 feet amsl (MCAGCC FMD, 2006). The terrain generally slopes from west to east along the eastern slope of the Bullion Mountains.

7.19.1.3. Surface Water Features

There are no perennial surface water features within the America Mine RTA. Streambeds are dry, except after infrequent, heavy rainfall (USDA NRCS, 1999). Most of the RTA is within the America Mine surface water drainage basin; a small section of the northwest corner is part of the Bristol Dry Lake basin. The majority of the RTA (98%) drains to the southern end of Bristol Dry Lake. Two percent of the RTA (in the southwestern corner) drains to Cleghorn Lake. There are no playas located within this RTA (MCAGCC FMD, 2006).

7.19.1.4. Soil Characteristics and Land Cover

The soils at the America Mine RTA are generally coarse and consist of extremely gravelly sandy loams, sands, and coarse sands. Bedrock outcrops from the western portion of the RTA. The vegetation within the America Mine RTA is mainly creosote bush scrub and some bare ground (USDA NRCS, 1999).

7.19.1.5. Erosion Potential

The America Mine was not considered for MC transport analysis due to the lower level of training conducted within the RTA. Based on the similar soil types and slopes compared to other RTAs, the erodibility of the soils at America Mine was considered moderate.

7.19.1.6. Groundwater Characteristics

The America Mine RTA overlays the Bristol Valley groundwater basin, located on the northeast portion MCAGCC Twentynine Palms. As described previously, limited groundwater data are available for the area. The general groundwater flow direction in the America Mine RTA is expected to be to the northeast toward Bristol Dry Lake. Perched groundwater zones exist near Bristol Dry Lake, with water levels recorded at 14 to 89 feet bgs (Koehler, 1983). The perched groundwater tables are assumed to be limited in extent based on the available groundwater data and the relatively small aerial extent of the playas. It is uncertain if the perched groundwater spills over into the deeper aquifer system.

7.19.1.7. Potential Groundwater and Surface Water Pathways

Groundwater Pathways

MC deposited on the RTA have the potential to migrate toward the water table at America Mine by dissolution into precipitation and subsequent infiltration into the subsurface. This transport mechanism may be aided by the presence of coarse soils, such as sands and gravel. However, the vertical migration of MC to groundwater at America Mine is likely limited based on the infrequent rate of rainfall in the area (less than 5 inches per year), the high evaporative rate, and the depth to the groundwater table. The actual potential concentration of any MC would be highly dependent on many factors, such as its mass loading at the surface, aqueous solubility, and retardation of the MC due to soil characteristics.

Surface Water Pathways

Surface water runoff is the dominant form of MC transport at MCAGCC Twentynine Palms compared to MC transport via groundwater infiltration. The intense rainfall events produce large volumes of water that rapidly run off the bedrock in mountainous areas and travel downstream through the ephemeral streams and dry washes to the playa lakes. The sparse vegetation on the installation does not dissipate the kinetic energy of the surface water as it travels downstream, increasing the potential for MC migration due to surface water. Surface water runoff collects within the Bristol Dry Lake, located outside the installation boundaries.

7.19.1.8. Potential Groundwater and Surface Water Receptors

Groundwater Receptors

Potential groundwater receptors of the America Mine MC loading area are the same as those described previously for the Lead Mountain primary MC loading area (salt mining operations within Bristol Dry Lake). However, there is negligible potential interaction between human receptors and MC in groundwater. No drinking water wells were identified within the America Mine RTA.

Surface Water Receptors

There are no surface water receptors within the RTA. Surface water runoff travels through ephemeral streams and alluvial washes into the southern portion of Bristol Dry Lake. Salt mining activities are located farther to the north of the discharge point from America Mine; MC in surface water from America Mine are unlikely to travel to these operations. Ecological receptors (MFTL and desert tortoise) are considered potential receptors to surface water originating from the America Mine RTA. Desert tortoise habitat is located along the southern boundary of the RTA. No MFTL habitat is located within the RTA; habitat may exist downstream of the RTA. However, both species are unlikely to directly consume surface water containing MC (Malcolm Pirnie, 2007).

7.19.2. Groundwater Analysis Results

A qualitative groundwater analysis was performed by analyzing the source media, migration mechanisms, and exposure pathways documented in the MCAGCC Twentynine Palms CSM. Based on the results of the qualitative analysis of the groundwater information, limited potential exists for MC migration to groundwater and no groundwater receptors associated with the indicator MC are present. Therefore, a groundwater screening-level analysis was not conducted. Discussions of the qualitative analysis and screening-level analysis are presented in **Section 4**.

7.19.3. Surface Water Analysis Results

The majority of the America Mine RTA (98%) drains into Bristol Dry Lake. As part of the surface water screening conducted for Lead Mountain, the upstream MC loading contributions of America Mine were included in the screening-level transport analysis.

Based on the MC loading contributions and an analysis of the surface drainage, the America Mine RTA is the largest potential contributor of HMX and the lowest potential contributor of RDX and TNT to Bristol Dry Lake from surface water runoff. It is estimated that the America Mine RTA contributes 80.5% of the modeled HMX mass, 7% of the perchlorate mass, and less than 1% of the RDX and TNT masses entering Bristol Dry Lake (Table 7.10-4) (MCAGCC FMD, 2006). These MC loading contributions were factored into the surface water transport screening analysis performed for the Lead Mountain primary MC loading area. The results of this analysis are presented in **Section 7.10.3**.

7.20. Bullion

The Bullion RTA is located along the southern boundary of MCAGCC Twentynine Palms, west of the America Mine RTA (Figure 7.20-1), and covers an area of 28,874 acres (USACE, 2001a). Since 1979, the RTA has been used as a live-fire and maneuver area for air-to-ground and ground-to-ground exercises. The primary training includes small arms firing,ground-based firing, defensive infantry tactics, and aviation training activities. Range 210, a live-fire MOUT training facility, is located in the RTA (Table 7.20-1) (USACE, 2001b). Range 607, a strafe range, was identified in the ASR as currently under construction in the Bullion RTA (USACE, 2001a); however, this range was used lightly and has since been inactivated, according to Range Control.

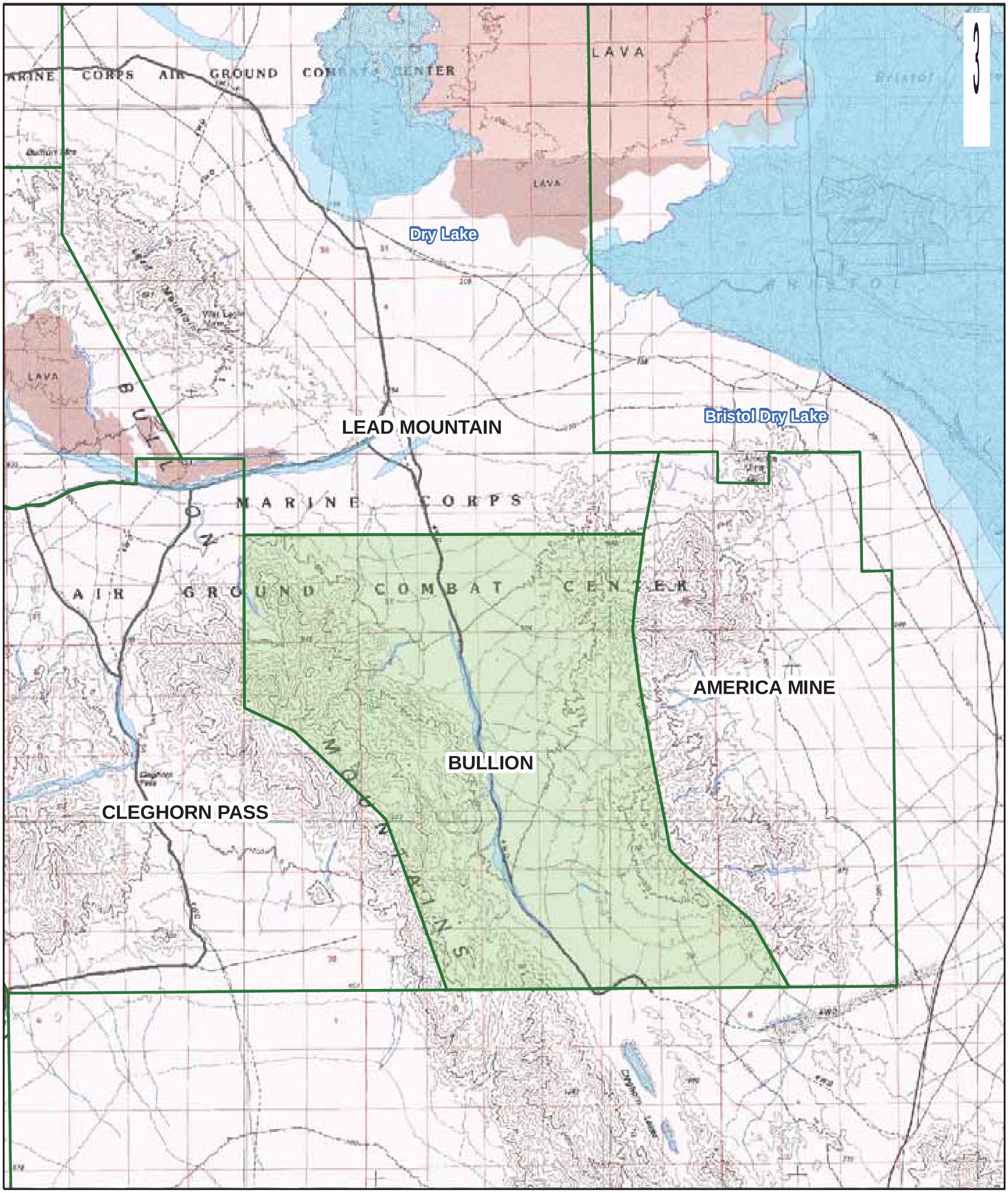
Table 7.20-1: Fixed Ranges within the Bullion RTA

Fixed Range	Range Type	Area (1,000 m^2)
LIVE-FIRE RANGES		
Range 210	Live-fire MOUT training facility	578.08

Based on interviews with Range Control, no primary MC loading area was identified within Bullion, although a small portion of the Lead Mountain MC loading area overlaps the RTA. It was assumed that MC were loaded onto an area representing 10% of the total RTA acreage.

Military Munitions

The general classes of military munitions expected in this RTA include small arms ammunition and high explosive munitions. Detailed military munitions use data are presented in the PRA (USACE, 2001b), and detailed assumptions for the determination of MC loading rates are provided in the *REVA Reference Manual* (HQMC, 2006).



LEGEND

- BULLION RTA
- RANGE TRAINING AREA
- SURFACE WATER (INTERMITTENT)
- MAIN SUPPLY ROUTE

2 1 0 2 Miles

SOURCE: MCAGCC/NREA GIS OFFICE 2006; TECOM 2006; USGS, VARIOUS DATES.

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RANGE ENVIRONMENTAL VULNERABILITY ASSESSMENT

BULLION RTA

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FIGURE 7.20-1

7.20.1. CSM

7.20.1.1. Estimated MC Loading

An MC loading area of 11,684,000 m^2 was calculated for the Bullion RTA. The MC Loading Rate Calculator was used to estimate the amount of MC loaded on this area over time (Table 7.20-2). The MC loading amounts estimated for the area for each identified time period during which the impact areas were used, Time Periods D and E, were assumed to occur only within the estimated MC loading area. There are no SARs located within the Bullion RTA; therefore, qualitative assessments to determine the fate and transport of lead were not conducted for this RTA. Expenditure data were extrapolated for time periods for which expenditure data were not available.

Table 7.20-2: Estimated Annual MC Loading for the Bullion RTA

MC Loading Area	Period	Begin Use	End Use	HMX (kg/m^2)	RDX (kg/m^2)	TNT (kg/m^2)	Perchlorate (kg/m^2)
Bullion	D (1977-1988)	1979	1988	2.21E-13	4.79E-08	4.39E-08	2.13E-10
	E (1989-Present)	1989	2005	2.76E-13	5.98E-08	5.49E-08	2.66E-10

7.20.1.2. Geography and Topography

The Bullion RTA is bounded by the Bullion Mountains on the east and west. It is mostly mountainous terrain, with limited access to the south. The valley floor gently slopes from south to north toward the Lead Mountain RTA. The southeast corner of the RTA slopes from northeast to southwest, off the installation. The estimated elevation of the area is between 1,102 and 4,019 feet amsl (MCAGCC FMD, 2006).

7.20.1.3. Surface Water Features

There are no perennial surface water features within the Bullion RTA. Streambeds are dry, except after infrequent, heavy rainfall (USDA NRCS, 1999). The majority of the RTA (87%) drains northward toward the Lead Mountain primary MC loading area for eventual discharge to the Bristol Dry Lake playa through a dry wash that runs along the center of the valley floor. The MSR is generally located alongside this dry wash. Approximately five percent of the Bullion RTA drainage travels southward from the Cleghorn Pass surface water drainage basin, which eventually drains to Dale Lake, located southeast of the installation boundary. Eight percent of the Bullion RTA is within the Cleghorn Lake surface water drainage basin; however, the area is limited to the southeast corner of the RTA and is considered negligible (MCAGCC FMD, 2006).

7.20.1.4. Soil Characteristics and Land Cover

The soils at the Bullion RTA are generally coarse and consist of extremely gravelly coarse sandy loams, sandy loams, sands, and coarse sands. Bedrock outcrops form the eastern and western portions of the RTA. The vegetation within the Bullion RTA is mainly creosote bush scrub and bare ground (USDA NRCS, 1999).

7.20.1.5. Erosion Potential

The erodibility of the Bullion RTA is moderate based on the coarse soil types found within the area. The soils at the RTA are generally coarse soil, as described above. A low soil erodibility factor of 0.02 was selected for the Bullion RTA for use in the surface water transport analysis (**Section 7.10.3**).

7.20.1.6. Groundwater Characteristics

The Bullion RTA is located within the Bristol Valley groundwater basin, on the northeast and east sides of MCAGCC Twentynine Palms. As previously described, limited groundwater data are available for the area. The general groundwater flow direction in the Bullion RTA is northeast toward Bristol Dry Lake. The depth to groundwater in the Bullion RTA is unknown; there are no known groundwater wells installed in the RTA. The predicted direction of groundwater flow is north toward Dry Lake and Bristol Dry Lake.

7.20.1.7. Potential Groundwater and Surface Water Pathways

Groundwater Pathways

MC deposited on the RTA have the potential to migrate toward the water table at Bullion by dissolution into precipitation and subsequent infiltration into the subsurface. This transport mechanism may be aided by the presence of coarse soils, such as sands and gravel. However, the vertical migration of MC to groundwater at Bullion is likely limited based on the infrequent rate of rainfall in the area (less than 5 inches per year), the high evaporative rate, and the depth to the groundwater table. The actual potential concentration of any MC would be highly dependent on many factors, such as its mass loading at the surface, aqueous solubility, and retardation of the MC due to soil characteristics.

Surface Water Pathways

Surface water runoff is the dominant pathway for MC transport at MCAGCC Twentynine Palms compared to MC transport via groundwater infiltration. The intense rainfall events produce large volumes of water that rapidly run off the bedrock in mountainous areas and travel downstream through the ephemeral streams and dry washes to the playas. The sparse vegetation on the installation does not dissipate the kinetic energy of the surface water as it travels downstream, increasing the potential for MC migration due to surface water. The majority of the surface water runoff collects within the Bristol Dry Lake, located outside the installation boundaries.

7.20.1.8. Potential Groundwater and Surface Water Receptors

Groundwater Receptors

The Bullion RTA is located within the same groundwater basin as the Lead Mountain primary MC loading area; therefore, the potential receptors are the same as those described for Lead Mountain. The only potential groundwater receptors are the salt mining workers at the salt mines in Bristol Dry Lake, but exposure of the workers to groundwater containing MC is negligible. No drinking water wells were identified within the Bullion RTA or in down gradient RTAs.

Surface Water Receptors

Potential surface water receptors include the salt mine workers and ecological receptors (MFTL and the desert tortoise). Bristol Dry Lake fills with surface water infrequently, less than once every 10 years; therefore, this playa is considered a negligible potential human exposure point. Desert tortoise habitat is located in the southern portion of the RTA, along the valley floor. MFTL habitat is not identified within the RTA; however, potential MFTL habitat may exist downstream of the RTA near the playa. Based upon the results of the exposure and toxicity assessment, concentrations of MC estimated to reach Bristol Dry Lake from Lead Mountain and its upstream contributors, including the Bullion RTA, are unlikely to pose a threat to the MFTL or the desert tortoise (Malcolm Pirnie, 2007).

7.20.2. Groundwater Analysis Results

A qualitative groundwater analysis was performed by analyzing the source media, migration mechanisms, and exposure pathways documented in the MCAGCC Twentynine Palms CSM. Based on the results of the qualitative analysis of the groundwater information, limited potential exists for MC migration to groundwater and no groundwater receptors associated with the indicator MC are present. Therefore, a groundwater screening-level analysis was not conducted. Discussions of the qualitative analysis and screening-level analysis are presented in **Section 4**.

7.20.3. Surface Water Analysis Results

The majority of the Bullion RTA (87%) drains into Bristol Dry Lake, with a small portion (5%) draining to Dale Lake. As part of the surface water screening conducted for Lead Mountain and Prospect MC loading areas, the upstream MC loading contributions of Bullion were included in the screening-level transport analyses.

Based on the MC loading contributions and an analysis of the surface drainage, the Bullion RTA is a small contributor of MC to Bristol Dry Lake from surface water runoff. It is estimated that Bullion contributes approximately seven percent of the perchlorate mass load and less than five percent of the RDX, TNT, and HMX mass loads to Bristol

Dry Lake (Table 7.10-4). These MC loading contributions were factored into the surface water transport screening analysis performed for the Lead Mountain primary MC loading area. The Bullion RTA contributes an even smaller portion of the MC mass to the Dale Lake transport analysis. The results of these analyses are presented in **Section 7.10.3** and **Section 7.11.3**.

7.21. Cleghorn Pass

The Cleghorn Pass RTA is located along the southern boundary of MCAGCC Twentynine Palms, between the Delta and Prospect RTAs to the west and the Bullion RTA to the east (Figure 7.21-1). It covers an area of 36,318 acres (USACE, 2001a). The RTA is used primarily for small arms, tank gunnery, LAV live-fire, and maneuvers. Between 1979 and 1997, the northern portion of the RTA was used for live-fire maneuvers for infantry company tactical training and air-delivered ordnance. The southern portion of the RTA contained several fixed ranges. A restricted area is contained within the northeast corner of the RTA. Live fire is now restricted to the southern half of the RTA, which includes four fixed live-fire ranges (Table 7.21-1). This RTA currently contains a CAX target system.

Ranges 203 through 207 are no longer in use. Range 203 was a tank zeroing range, Range 204 was a mobile land target system range, Range 205 was a tank combat course, Range 206 was a stationary target anti-tank system, and Range 207 was a tank combat course for qualification. Ranges 204, 205, and 207 used practice ammunition only (USACE, 2001b).

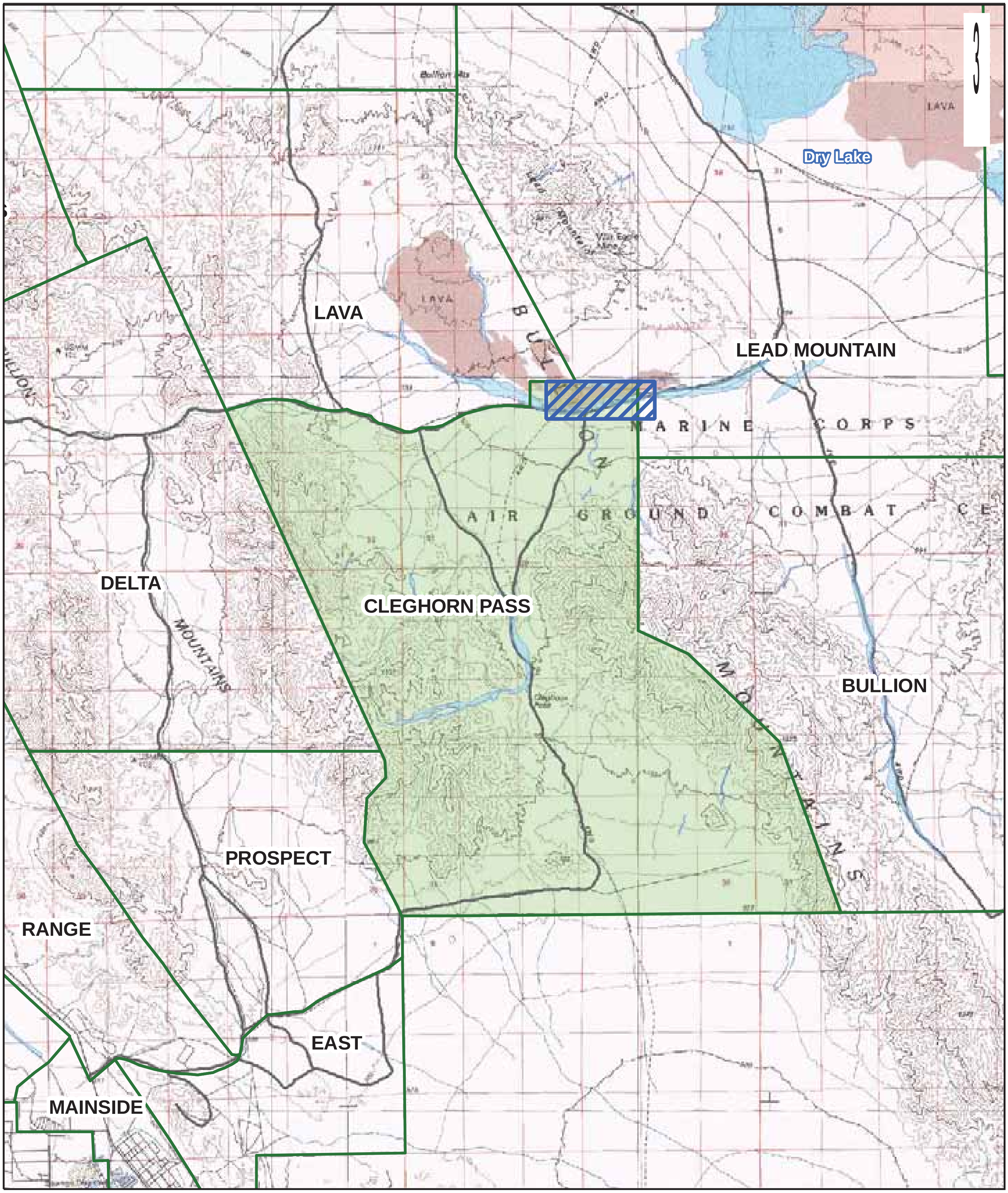
Based on interviews with Range Control, a primary MC loading area was not delineated for Cleghorn Pass. Therefore, it was assumed that MC were loaded onto an area representing 10% of the total RTA acreage.

Table 7.21-1: Fixed Ranges at the Cleghorn Pass RTA

Fixed Range	Range Type	Area (1,000 m^2)
LIVE-FIRE RANGES		
Range 400	Company live-fire and maneuver range	2,907.13
Range 410	Platoon live-fire and maneuver range	941.40
Range 410A	Rifle platoon hasty attack and maneuver range	1,188.56
Range 500	Armor multipurpose range complex	7,381.31

Military Munitions

The general classes of military munitions expected in this RTA include small arms ammunition and high explosive munitions. Detailed military munitions use data are presented in the PRA (USACE, 2001b), and detailed assumptions for the determination of MC loading rates are provided in the *REVA Reference Manual* (HQMC, 2006).



LEGEND

- CLEGHORN PASS RTA
- RANGE TRAINING AREA
- SURFACE WATER (INTERMITTENT)
- MAIN SUPPLY ROUTE
- RESTRICTED AREA

2 1 0 2 Miles

SOURCE: MCAGCC/NREA GIS OFFICE 2006; TECOM 2006; USGS, VARIOUS DATES.

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RANGE ENVIRONMENTAL VULNERABILITY ASSESSMENT

CLEGHORN PASS RTA

MALCOLM PIRNIE, INC.

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FIGURE 7.21-1

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7.21.1. CSM

7.21.1.1. Estimated MC Loading

An MC loading area of 14,697,000 m^2 was calculated for the Cleghorn Pass RTA. The MC Loading Rate Calculator was used to estimate the amount of MC loaded on this area over time (Table 7.21-2). The MC loading amounts estimated for the area for each identified time period during which the impact areas were used, Time Periods D and E, were assumed to occur only within the estimated MC loading area. There are no SARs located within the Cleghorn Pass RTA; therefore, qualitative assessments to determine the fate and transport of lead were not conducted for this RTA. Expenditure data were extrapolated for time periods for which expenditure data were not available.

Table 7.21-2: Estimated Annual MC Loading for the Cleghorn Pass RTA

MC Loading Area	Period	Begin Use	End Use	HMX (kg/m^2)	RDX (kg/m^2)	TNT (kg/m^2)	Perchlorate (kg/m^2)
Cleghorn Pass	D (1977-1988)	1979	1988	6.12E-11	1.23E-07	7.99E-08	2.62E-09
	E (1989-Present)	1989	2005	7.65E-11	1.54E-07	9.99E-08	3.28E-09

7.21.1.2. Geography and Topography

The Cleghorn Pass RTA consists mostly of mountainous terrain with large bedrock outcrops on the eastern and western boundaries of the RTA. The estimated elevation of the area is between 1,230 and 4,071 feet amsl (MCAGCC FMD, 2006). The southern portion of the RTA slopes to the southeast, and the northern portion slopes to the north.

7.21.1.3. Surface Water Features

There are no perennial surface water features within the Cleghorn Pass RTA. Streambeds are dry, except after infrequent, heavy rainfall (USDA NRCS, 1999). Surface water drainage is divided between Bristol Lake (53% of the RTA area), which drains into Bristol Dry Lake playa, and Cleghorn Pass (47% of the RTA area), which drains into Dale Lake playa. Portions of the Delta, Prospect, and Noble Pass RTAs drain through a large, steep, surface drainage feature that enters Cleghorn Pass from Delta, flows east toward the valley floor, and then flows northeast toward Bristol Dry Lake (MCAGCC FMD, 2006).

7.21.1.4. Soil Characteristics and Land Cover

The soils at the Cleghorn Pass RTA are generally coarse and consist of extremely gravelly coarse sandy loams, sandy loams, sands, and coarse sands. Bedrock outcrops are located on the eastern and western portions, with significant bedrock outcrops along the center of the RTA. The bedrock outcrops form the surface water drainage divide within the RTA. The vegetation within the Cleghorn Pass RTA is mainly creosote bush scrub and bare ground (USDA NRCS, 1999).

7.21.1.5. Erosion Potential

The erodibility of the Cleghorn Pass RTA is low based on the coarse soil types found within the area. The soils at the MC loading area are generally coarse soils that range from extremely gravelly sandy loam to extremely gravelly coarse sands. A low soil erodibility factor of 0.02 was selected for the Cleghorn Pass MC loading area for use in the surface water transport analysis (**Section 7.10.3** and **Section 7.11.3**).

7.21.1.6. Groundwater Characteristics

The Cleghorn Pass RTA overlays two groundwater basins: the Bristol Valley groundwater basin, located on the northeast portion of the installation, and the Dale Lake groundwater basin, which is considered an intramountain groundwater basin. The general groundwater flow direction within the Bristol Valley groundwater basin in the Cleghorn Pass RTA is north and then east through the Lead Mountain RTA toward Bristol Dry Lake. The assumed direction of flow in the Dale Valley groundwater basin is to the southeast toward Dale Lake. Subsurface data are not available for the intramountain basins found within the Bullion Mountains, including the Dale Valley. The subsurface conditions encountered in these areas are expected to be similar to those described for the Bristol Valley and Twentynine Palms basins with some exceptions, as described in **Section 7.14.1.6**.

7.21.1.7. Potential Groundwater and Surface Water Pathways

Groundwater Pathways

MC deposited on the RTA have the potential to migrate toward the water table at Cleghorn Pass by dissolution into precipitation and subsequent infiltration into the subsurface. This transport mechanism may be enhanced by the presence of coarse soils, such as sands and gravel. However, the vertical migration of MC to groundwater at Cleghorn Pass is likely limited based on the infrequent rate of rainfall in the area (less than 5 inches per year), the high evaporative rate, and the depth to the groundwater table. The actual potential concentration of any MC would be highly dependent on many factors, such as its mass loading at the surface, aqueous solubility, and retardation of the MC due to soil characteristics.

Surface Water Pathways

Surface water runoff is the dominant pathway for MC transport at MCAGCC Twentynine Palms. The intense rainfall events produce large volumes of water that rapidly run off the bedrock in mountainous areas and travel downstream through the ephemeral streams and dry washes to the playas. The sparse vegetation on the installation does not dissipate the kinetic energy of the surface water as it travels downstream, increasing the potential for

MC migration due to surface water. Bristol Dry Lake and Dale Lake are downstream of the Cleghorn Pass RTA and receive runoff following storm events.

7.21.1.8. Potential Groundwater and Surface Water Receptors

Groundwater Receptors

The Cleghorn Pass RTA is located within the same groundwater basins as the Lead Mountain and Prospect primary MC loading areas; therefore, the potential receptors are the same as for Lead Mountain and Prospect. The potential groundwater receptors are the salt mining workers at the salt mines in both playas. The potential exposure of the workers to groundwater containing MC is considered negligible. No drinking water wells were identified within the Cleghorn Pass RTA or within down gradient RTAs.

Surface Water Receptors

Potential surface water receptors include the salt mine workers and ecological receptors (MFTL and the desert tortoise). Bristol Dry Lake and Dale Lake fill with surface water infrequently, less than once every 10 years; therefore, these playas are considered negligible potential human exposure points. Desert tortoise habitat is located in the southern portion of the RTA, generally on the valley floor. No MFTL habitat is located within the RTA; however, potential habitat may exist downstream of the RTA near the playas. Based upon the results of the exposure and toxicity assessment, concentrations of MC estimated to occur in Bristol Dry Lake and Dale Lake are unlikely to pose a threat to the MFTL or the desert tortoise (Malcolm Pirnie, 2007).

7.21.2. Groundwater Analysis Results

A qualitative groundwater analysis was performed by analyzing the source media, migration mechanisms, and exposure pathways documented in the MCAGCC Twentynine Palms CSM. Based on the results of the qualitative analysis of the groundwater information, limited potential exists for MC migration to groundwater and no groundwater receptors associated with the indicator MC are present. Therefore, a groundwater screening-level analysis was not conducted. Discussions of the qualitative analysis and screening-level analysis are presented in **Section 4**.

7.21.3. Surface Water Analysis Results

Portions of the Cleghorn Pass RTA drain into both Bristol Dry Lake (53%) and Dale Lake (47%) (MCAGCC FMD, 2006). The upstream contributions of the Cleghorn Pass RTA were included in the surface water screening transport analysis conducted for the Lead Mountain and Prospect primary MC loading areas.

The Cleghorn Pass RTA is the primary contributor of perchlorate to both Bristol Dry Lake (69.9%) and Dale Lake (77%). The RTA is a minor contributor of RDX (9.9%), TNT (4.1%), and HMX (10.7%) to Bristol Dry Lake (Table 7.10-4). The Cleghorn Pass

RTA is the largest potential contributor of HMX (79%) and the second largest contributor, after Prospect, of RDX (32%) and TNT (22%) to Dale Lake (Table 7.11-3). The surface water transport analysis results are provided in **Section 7.10.3** and **Section 7.11.3**.

7.22. Lava

The Lava RTA is located in the central portion of MCAGCC Twentynine Palms (Figure 7.22-1) and covers approximately 22,785 acres (USACE, 2001a). Currently, the Lava RTA contains one fixed live-fire range, C.C. Course Station 5, and four LTAs for laser ground-to-ground and air-to-ground firing (Table 7.22-1). Lava is accessible from the south through Cleghorn Pass and from the west through Delta. Between 1979 and 1997, it contained approximately 47,000 acres, all of which were considered impact area.

The Lava RTA was used primarily for battalion tactical training, including ground-based live fire. A Combat Engineer demolition and field fortification range was located within Lava from the mid-1980s through the mid-1990s. The range is no longer in use (USACE, 2001b).

Table 7.22-1: Fixed Ranges at within the Lava RTA

Fixed Range	Range Type	Area (1,000 m^2)
LIVE-FIRE RANGES		
C.C. Course Station 5	C.C. course (small arms)	727.11

Based on interviews with Range Control, a primary MC loading area was not delineated for Lava. Therefore, it was assumed that MC were loaded onto an area representing 10% of the total RTA size.

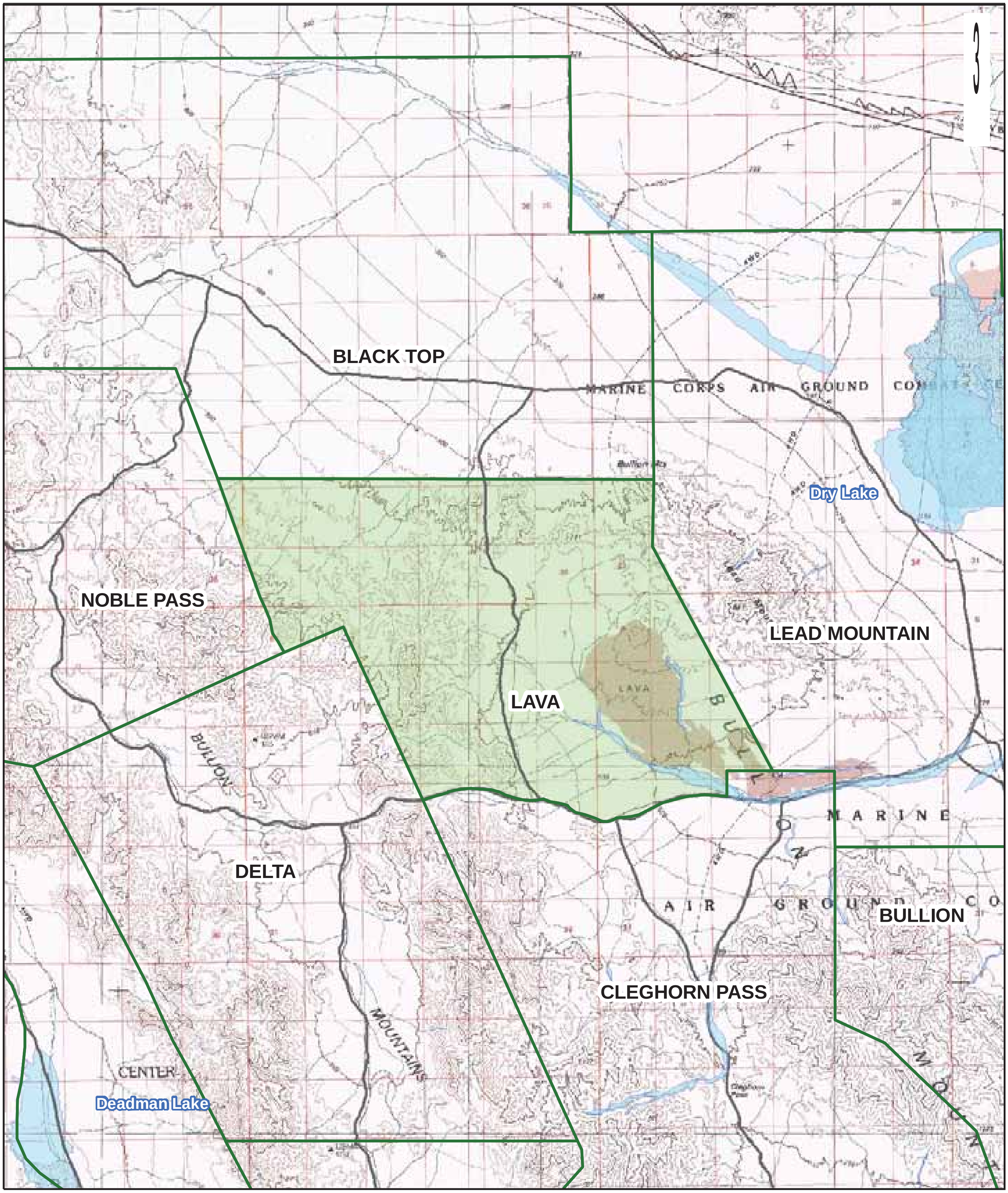
Military Munitions

The general classes of military munitions expected in this RTA include small arms ammunition and high explosive munitions. Detailed military munitions use data are presented in the PRA (USACE, 2001b), and detailed assumptions for the determination of MC loading rates are provided in the *REVA Reference Manual* (HQMC, 2006).

7.22.1. CSM

7.22.1.1. Estimated MC Loading

An MC loading area of 9,220,000 m^2 was established for the Lava RTA. The MC Loading Rate Calculator was used to estimate the amount of MC loaded on this area over time (Table 7.22-1). The MC loading amounts estimated for the area for each identified time period during which the impact areas were used, Time Periods D and E, were assumed to occur only within the estimated MC loading area. There are no SARs located



LEGEND

- LAVA RTA
- RANGE TRAINING AREA
- SURFACE WATER (INTERMITTENT)
- MAIN SUPPLY ROUTE

2 1 0 2 Miles

SOURCE: MCAGCC/NREA GIS OFFICE 2006; TECOM 2006; USGS, VARIOUS DATES.

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RANGE ENVIRONMENTAL VULNERABILITY ASSESSMENT

LAVA RTA

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FIGURE 7.22-1

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within the Lava RTA; therefore, qualitative assessments to determine the fate and transport of lead were not conducted for this RTA. Expenditure data were extrapolated for time periods for which expenditure data were not available.

Table 7.22-2: Estimated Annual MC Loading for the Lava RTA

MC Loading Area	Period	Begin Use	End Use	HMX (kg/m^2)	RDX (kg/m^2)	TNT (kg/m^2)	Perchlorate (kg/m^2)
Lava	D (1977-1988)	1979	1988	1.32E-12	9.33E-08	1.49E-07	1.13E-12
	E (1989-Present)	1989	2005	1.65E-12	1.17E-07	1.86E-07	1.41E-12

7.22.1.2. Geography and Topography

The Lava RTA is located on the northeast side of the Bullion Mountains, in an area that contains large amounts of lava rock. Lead Mountain forms the eastern boundary of the RTA. Bedrock outcrops extend from the western boundary, bend to the north, and continue to the northeast corner of the RTA. The estimated elevation of the area is between 1,355 and 3,061 feet amsl (MCAGCC FMD, 2006). The area generally slopes to the east toward Lead Mountain and Bristol Dry Lake; the northern portion of the RTA, north of the bedrock outcrops, slopes toward the Black Top RTA.

7.22.1.3. Surface Water Features

There are no perennial surface water features within the Lava RTA. Streambeds are dry, except after infrequent, heavy rainfall (USDA NRCS, 1999). Approximately 59% of the surface water runoff drains to Bristol Dry Lake through the Cleghorn Pass and Lead Mountain RTAs. The remaining surface drainages are located in the northern mountains and travel toward Dry Lake through the Black Top and Lead Mountains RTAs through ephemeral streams and dry washes (MCAGCC FMD, 2006).

7.22.1.4. Soil Characteristics and Land Cover

The soils at the Lava RTA are generally coarse and consist of extremely gravelly and very gravelly coarse sandy loams, sandy loams, sands, and coarse sands. Lava beds are found in the eastern portion of the RTA. The bedrock outcrops form the surface water drainage divide within the RTA. The vegetation within the Lava RTA is mainly creosote bush scrub and bare ground, particularly on areas defined by lava beds (USDA NRCS, 1999).

7.22.1.5. Erosion Potential

The erodibility of the Lava RTA is low to moderate based on the coarse soil types found within the area. A low to moderate soil erodibility factor of 0.07 was selected for Lava for use in the surface water transport analysis (**Section 7.10.3**).

7.22.1.6. Groundwater Characteristics

The Lava RTA is located in the Bristol Valley groundwater basin on the northeast portion MCAGCC Twentynine Palms. The general groundwater flow direction within the Bristol Valley groundwater basin in the Lava RTA is east toward Bristol Dry Lake. Groundwater depths are not known; however, groundwater is expected to be found at deep levels, given the high elevation of the RTA.

7.22.1.7. Potential Groundwater and Surface Water Pathways

Groundwater Pathways

MC deposited on the RTA have the potential to migrate toward the water table at Lava by dissolution into precipitation and subsequent infiltration into the subsurface. This transport mechanism may be aided in areas containing coarse soils, such as sands and gravel. However, the vertical migration of MC to groundwater at Lava is probably limited due to the infrequent rate of rainfall in the area (less than 5 inches per year), the high evaporative rate, and the depth to groundwater. The actual potential concentration of any MC would be highly dependent on many factors, such as its mass loading at the surface, aqueous solubility, and retardation of the MC due to soil characteristics.

Surface Water Pathways

Surface water runoff is the dominant pathway for MC transport at MCAGCC Twentynine Palms compared to MC transport via groundwater infiltration. The intense rainfall events produce large volumes of water that rapidly run off the bedrock in mountainous areas and travel downstream through the ephemeral streams and dry washes to the playas. The sparse vegetation on the installation does not dissipate the kinetic energy of the surface water as it travels downstream, increasing the potential for MC migration due to surface water. Bristol Dry Lake and Dry Lake are downstream of the Lava RTA drainages and receive runoff from this RTA.

7.22.1.8. Potential Groundwater and Surface Water Receptors

Groundwater Receptors

The Lava RTA is located within the same groundwater basin as the Lead Mountain RTA; therefore, the potential receptors are the same as those described for the Lead Mountain RTA. The only potential groundwater receptors are the salt mining workers at the salt mines in Bristol Dry Lake; however the potential exposure of the workers to groundwater containing MC is negligible. No drinking water wells were identified within the Lava RTA or within down gradient RTAs.

Surface Water Receptors

Potential surface water receptors include the salt mine workers and ecological receptors (MFTL and the desert tortoise). Bristol Dry Lake fills with surface water infrequently, less than once every 10 years; therefore, human exposure at this playa is considered negligible. MFTL and desert tortoise are considered potential ecological receptors, although no habitat for either species has been characterized within the RTA. Downstream ecological receptors may come into contact with surface water that originated within the Lava RTA. Based upon the results of the exposure aand toxicity assessment, concentrations of MC estimated to occur in Bristol Dry Lake and Dale Lake are unlikely to pose a threat to the MFTL or the desert tortoise (Malcolm Pirnie, 2007).

7.22.2. Groundwater Analysis Results

A qualitative groundwater analysis was performed by analyzing the source media, migration mechanisms, and exposure pathways documented in the MCAGCC Twentynine Palms CSM. Based on the results of the qualitative analysis of the groundwater information, limited potential exists for MC migration to groundwater and no groundwater receptors associated with the indicator MC are present. Therefore, a groundwater screening-level analysis was not conducted. Discussions of the qualitative analysis and screening-level analysis are presented in **Section 4**.

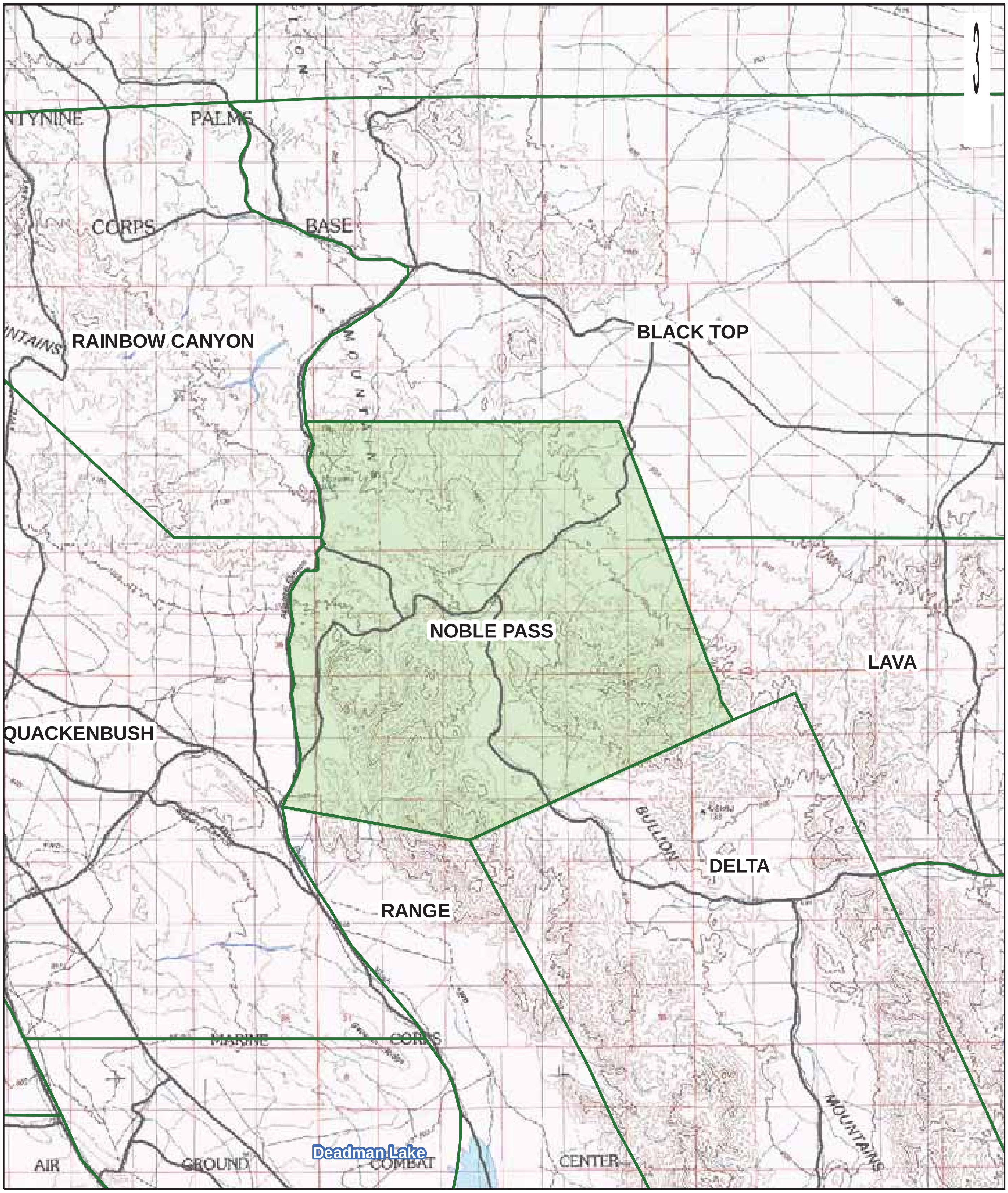
7.22.3. Surface Water Analysis Results

The upstream contributions of the Lava RTA were included in the surface water screening transport analysis conducted for the Lead Mountain primary MC loading area. The Lava RTA is a minor contributor of MC to Bristol Dry Lake; loading at this RTA contributes 8.4% by mass of RDX to Bristol Dry Lake, with smaller contributions of TNT (5.7%), HMX (0.2%), and perchlorate (0.02%) (Table 7.10-4). The results of the surface water transport analysis are provided in **Section 7.10.3**.

7.23. Noble Pass

The Noble Pass RTA is located in the central portion of MCAGCC Twentynine Palms (Figure 7.23-1) and covers approximately 24,040 acres (USACE, 2001a). The area is generally mountainous terrain that limits vehicle mobility. It commonly is used for combination aviation- and ground-based fire, tank battle, and small infantry tactics exercises. The historical use of Noble Pass is similar to the current use of the RTA. Currently, Noble Pass includes a CAX target system and one LTA for laser ground-to-ground firing. There are no fixed firing ranges within the RTA (USACE, 2001b).

Based on interviews with Range Control, a primary MC loading area was not delineated for Noble Pass. Therefore, MC loading as conducted on an area representing 10% of the total RTA size.



LEGEND

- NOBLE PASS RTA
- RANGE TRAINING AREA
- SURFACE WATER (INTERMITTENT)
- MAIN SUPPLY ROUTE

2 1 0 2 Miles

SOURCE: MCAGCC/NREA GIS OFFICE 2006; TECOM 2006; USGS, VARIOUS DATES.

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MALCOLM PIRNIE	MCAGCC TWENTYNINE PALMS, CALIFORNIA RANGE ENVIRONMENTAL VULNERABILITY ASSESSMENT	NOBLE PASS RTA	MALCOLM PIRNIE, INC. AUGUST 2008 FIGURE 7.23-1

Military Munitions

The general classes of military munitions expected in this RTA include small arms ammunition and high explosive munitions. Detailed military munitions use data are presented in the PRA (USACE, 2001b), and detailed assumptions for the determination of MC loading rates are provided in the *REVA Reference Manual* (HQMC, 2006).

7.23.1. CSM

7.23.1.1. Estimated MC Loading

An MC loading area of 9,728,000 m^2 was established for the Noble Pass RTA. The MC Loading Rate Calculator was used to estimate the amount of MC loaded on this area over time (Table 7.23-1). The MC loading amounts estimated for the area for each identified time period during which the impact areas were used, Time Periods D and E, were assumed to occur only within the estimated MC loading area. There are no SARs located within the Noble Pass RTA; therefore, qualitative assessments to determine the fate and transport of lead were not conducted for this RTA. Expenditure data were extrapolated for time periods for which they were not available.

Table 7.23-1: Estimated Annual MC Loading for the Noble Pass RTA

MC Loading Area	Period	Begin Use	End Use	HMX (kg/m^2)	RDX (kg/m^2)	TNT (kg/m^2)	Perchlorate (kg/m^2)
Noble Pass	D (1977-1988)	1979	1988	6.35E-13	1.58E-08	1.79E-08	1.54E-10
	E (1989-Present)	1989	2005	7.93E-13	1.98E-08	2.24E-08	1.93E-10

7.23.1.2. Geography and Topography

The Noble Pass RTA is located within the Bullion Mountains. Bedrock outcrops are found on the majority of the RTA. The estimated elevation of the area is between 2,008 and 3,973 feet amsl (MCAGCC FMD, 2006). The southern portion of the RTA slopes toward Delta, and the northern portion of the RTA slopes northeast toward the Black Top RTA.

7.23.1.3. Surface Water Features

There are no perennial surface water features within the Noble Pass RTA. Streambeds are dry, except after infrequent, heavy rainfall (USDA NRCS, 1999). The majority of the RTA (61%) falls within the Dry Lake surface water drainage basin. Twenty-seven percent of the area, mainly the western slopes of the Bullion Mountains, drains to Deadman Lake playa, and 12% of the area drains to Bristol Dry Lake (MCAGCC FMD, 2006).

7.23.1.4. Soil Characteristics and Land Cover

The alluvial soils at the Noble Pass RTA are generally coarse and consist of sand loams with varying degrees of gravel. The RTA is predominantly bedrock with outcrops forming the surface water drainage divide within the RTA. The vegetation within the Noble Pass RTA is mainly creosote bush scrub and bare ground (USDA NRCS, 1999).

7.23.1.5. Erosion Potential

The erodibility of the Noble Pass RTA is low to moderate based on the coarse soil types found within the area. A low to moderate soil erodibility factor of 0.03 was selected for Lava for use in the surface water transport analysis.

7.23.1.6. Groundwater Characteristics

The southern section of the Noble Pass RTA is located within the Dale Valley intramountain basin. Groundwater within this basin is believed to flow to the southeast. However, specific subsurface data are not available for the intramountain basins, including the Dale Valley. The subsurface conditions encountered in these areas are expected to be similar to those described for the Bristol Valley and Twentynine Palms basins, with some exceptions, as described in **Section 7.14.1.6**. The northern portion of the Noble Pass RTA is located within portions of the Bristol Valley groundwater basin. The general groundwater flow direction within the Bristol Valley groundwater basin in the Noble Pass RTA is east toward the Dry Lake playa.

7.23.1.7. Potential Groundwater and Surface Water Pathways

Groundwater Pathways

MC deposited on the RTA have the potential to migrate toward the water table at Noble Pass by dissolution into precipitation and subsequent infiltration into the subsurface. This transport mechanism can be enhanced by the presence of coarse soils, such as sands and gravel. However, the vertical migration of MC to groundwater at Noble Pass is likely limited due to the infrequent rate of rainfall in the area (less than 5 inches per year), the high evaporative rate, and the depth to the groundwater table. The actual potential concentration of any MC would be highly dependent on many factors, such as its mass loading at the surface, aqueous solubility, and retardation of the MC due to soil characteristics.

Surface Water Pathways

Surface water runoff is the dominant pathway of MC transport at MCAGCC Twentynine Palms. The intense rainfall events produce large volumes of water that rapidly run off the bedrock in mountainous areas and travel downstream through the ephemeral streams and dry washes to the playas. The sparse vegetation on the installation does not dissipate the kinetic energy of the surface water as it travels downstream, increasing the potential for

MC migration due to surface water. Bristol Dry Lake, Deadman Lake, and Dry Lake receive runoff from drainages located within the Noble Pass RTA.

7.23.1.8. Potential Groundwater and Surface Water Receptors

Groundwater Receptors

The Noble Pass RTA overlies the same groundwater basins as Lead Mountain and Prospect primary MC loading areas; therefore, the potential receptors are the same as those described for Lead Mountain and Prospect. The potential groundwater receptors consist of workers at the salt mining operation located in Bristol Dry Lake. As previously discussed, the potential exposure of the workers to groundwater containing MC is negligible. .No drinking water wells were identified within the Noble Pass RTA or the groundwater basins down gradient of the RTA. Therefore, there are no groundwater receptors identified for this RTA.

Surface Water Receptors

Potential surface water receptors include the salt mine workers, for whom there is negligible exposure, and ecological receptors within the Bristol Dry Lake (MFTL and the desert tortoise). Desert tortoise habitat is found throughout the alluvial material within the RTA. MFTL habitat has not been characterized within the RTA. Bristol Dry Lake fills with surface water infrequently, less than once every 10 years. Based upon the results of the exposure and toxicity assessment, concentrations of MC estimated to occur in Bristol Dry Lake are unlikely to pose a threat to the MFTL or the desert tortoise (Malcolm Pirnie, 2007).

7.23.2. Groundwater Analysis Results

A qualitative groundwater analysis was performed by analyzing the source media, migration mechanisms, and exposure pathways documented in the MCAGCC Twentynine Palms CSM. Based on the results of the qualitative analysis of the groundwater information, limited potential exists for MC migration to groundwater and no groundwater receptors associated with the indicator MC are present. Therefore, a groundwater screening-level analysis was not conducted. Discussions of the qualitative analysis and screening-level analysis are presented in **Section 4**.

7.23.3. Surface Water Analysis Results

More than one-half of the Noble Pass RTA (61%) drains into Dry Lake playa, 27% drains into Deadman Lake playa, and 12% drains into Bristol Dry Lake. As part of the surface water screening conducted for Lead Mountain, the upstream MC loading contributions of the Noble Pass RTA were included in the screening-level transport analysis.

Based on the MC loading contributions and an analysis of the surface drainage, the Noble Pass RTA is one of the lowest potential contributors of RDX, TNT, HMX, and perchlorate to Bristol Dry Lake from surface water runoff. It is estimated that the Noble Pass RTA contributes less than one percent of the modeled RDX, TNT, and HMX masses and approximately three percent of the perchlorate mass entering Bristol Dry Lake (Table 7.10-4). These MC loading contributions were factored into the surface water transport screening analysis performed for the Lead Mountain primary MC loading area.

7.24. Sunshine Peak

The Sunshine Peak RTA is located in the northwest corner of MCAGCC Twentynine Palms (Figure 7.24-1) and covers an area of 22,902 acres (USACE, 2001a). Since 1979, training exercises have included aviation and artillery bombardment and missile requalification. The Sunshine Peak RTA is also used as a hung ordnance range for aviation, which restricts vehicle traffic through this area, and all other uses require special permission. There are no fixed ranges within Sunshine Peak. This RTA includes three LTAs for laser ground-to-ground firing. In the mid-1980s, Range 605 was located in Sunshine Peak. It was a vehicular column engagement (door gunner) range. Range use was discontinued in the mid-1990s when Range 605 was constructed in the Bullion RTA (USACE, 2001b).

Based on interviews with Range Control, a primary MC loading area was not delineated for the Sunshine Peak RTA. Therefore, MC loading was conducted on an area representing 10% of the total RTA size.

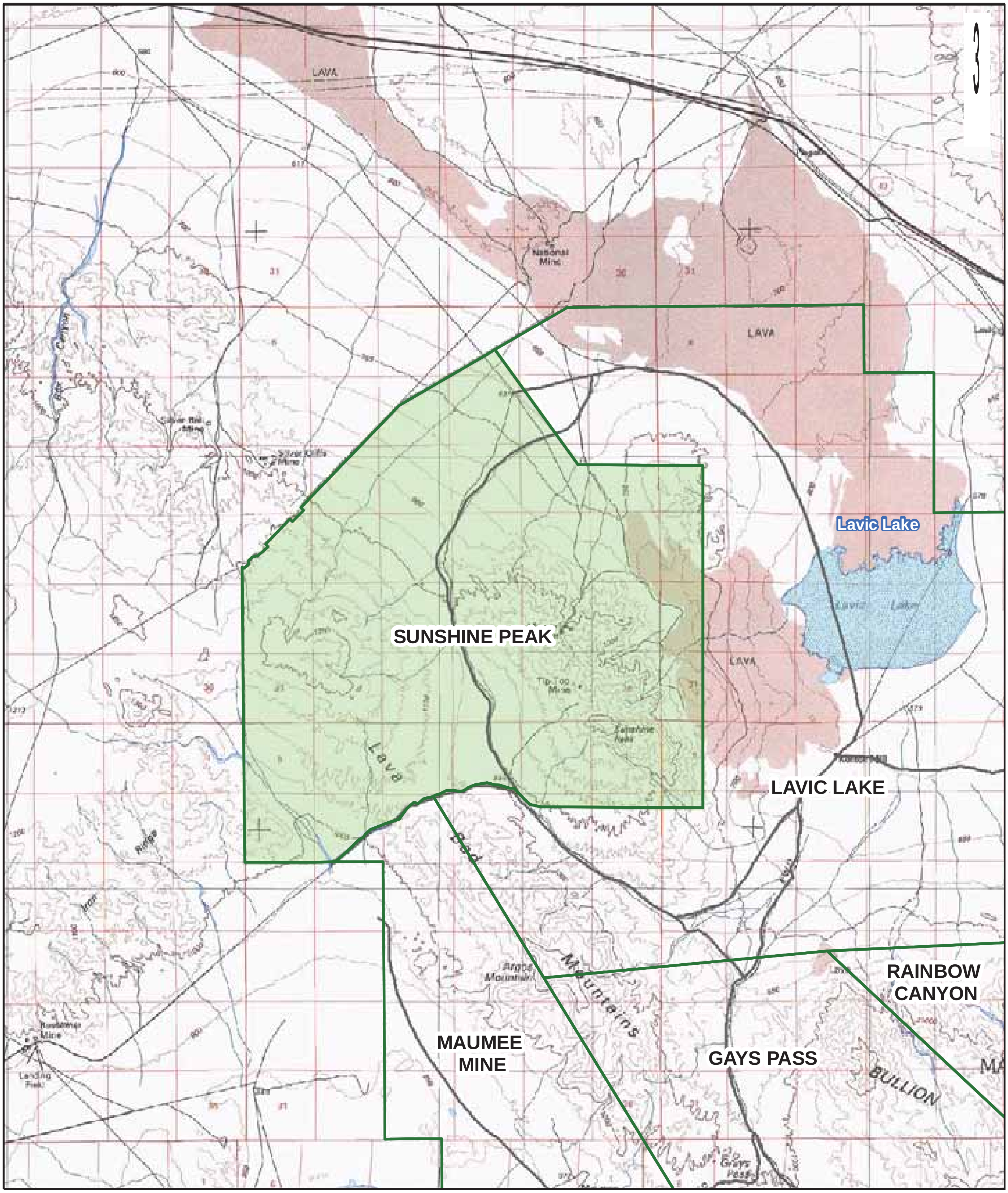
Military Munitions

The general classes of military munitions expected in this RTA include high explosive munitions. Detailed military munitions use data are presented in PRA (USACE, 2001b), and detailed assumptions for the determination of MC loading rates are provided in the *REVA Reference Manual* (HQMC, 2006).

7.24.1. CSM

7.24.1.1. Estimated MC Loading

An MC loading area of 9,268,000 m^2 was established for the Sunshine Peak RTA. The MC Loading Rate Calculator was used to estimate the amount of MC loaded on this area over time (Table 7.24-1). The MC loading amounts estimated for the area for each identified time period during which the impact areas were used, Time Periods D and E, were assumed to occur only within the estimated MC loading area. There are no SARs located within the Sunshine Peak RTA; therefore, qualitative assessments to determine the fate and transport of lead were not conducted for this RTA. Expenditure data were extrapolated for time periods for which they were not available.



LEGEND

- SUNSHINE PEAK RTA
- RANGE TRAINING AREA
- SURFACE WATER (INTERMITTENT)
- MAIN SUPPLY ROUTE

2 1 0 2 Miles

SOURCE: MCAGCC/NREA GIS OFFICE 2006; TECOM 2006; USGS, VARIOUS DATES.

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RANGE ENVIRONMENTAL VULNERABILITY ASSESSMENT

SUNSHINE PEAK RTA

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AUGUST 2008
FIGURE 7.24-1

Table 7.24-1: Estimated Annual MC Loading for the Sunshine Peak RTA

MC Loading Area	Period	Begin Use	End Use	HMX (kg/m^2)	RDX (kg/m^2)	TNT (kg/m^2)	Perchlorate (kg/m^2)
Sunshine Peak	D (1977-1988)	1979	1988	n/a	5.81E-10	n/a	n/a
	E (1989-Present)	1989	2005	n/a	7.27E-10	n/a	n/a

7.24.1.2. Geography and Topography

The Sunshine Peak RTA is located within the Lava Bed Mountains. Bedrock outcrops are found throughout the RTA, particularly on the western and eastern margins. A small valley separates these outcrops in the center of the RTA. The estimated elevation of the area is between 2,103 and 4,318 feet amsl (MCAGCC FMD, 2006). The terrain is generally mountainous, which prevents easy access to the RTA. The alluvial material in the northern section of the RTA generally slopes to the northeast.

7.24.1.3. Surface Water Features

There are no perennial surface water features within the Sunshine Peak RTA. Streambeds are dry, except after infrequent, heavy rainfall (USDA NRCS, 1999). The Sunshine Peak RTA falls within four surface water drainage basins: East Sunshine (41%), Lavic Lake (27%), West Sunshine (17%), and Galway Lake (15%). Lavic Lake surface water drainage basin drains to the east for discharge to the Lavic Lake playa. The Galway Lake drainage basin drains toward Lower Sunshine Lake, located on the western installation boundary in the Maumee Mine RTA. East and West Sunshine drainage basins drain north, off the installation (MCAGCC FMD, 2006).

7.24.1.4. Soil Characteristics and Land Cover

The soils at the Sunshine Peak RTA are generally coarse and consist of loamy sands and sand with varying amounts of gravel. The bedrock outcrops are located primarily in the central section of the RTA and form the surface water drainage divides within the RTA. The vegetation within the Sunshine Peak RTA is mainly creosote bush scrub and bare ground (USDA NRCS, 1999).

7.24.1.5. Erosion Potential

The erodibility of the Sunshine Peak RTA is low to moderate based on the coarse soil types found within the area. The Sunshine Peak RTA was not included in the surface water screening; therefore, an erodibility factor was not selected for the RTA.

7.24.1.6. Groundwater Characteristics

Sunshine Peak RTA is located primarily in the Lavic Valley groundwater basin. A small portion of the Bessemer Valley subbasin of the Twentynine Palms basin lies under the western portion of the RTA. Subsurface data are not available for the intramountain basins found within the Lava Bed Mountains, including the Lavic Valley subbasins. The subsurface conditions encountered in these areas are expected to be similar to those described for the Bristol Valley and Twentynine Palms basins, with some exceptions, as described in **Section 7.14.1.6**.

7.24.1.7. Potential Groundwater and Surface Water Pathways

Groundwater Pathways

MC have the potential to migrate toward the water table at the Sunshine Peak RTA after dissolution into infiltrating rainwater. This pathway is enhanced by the presence of coarse soils, such as sands and gravel. However, MC have limited potential to migrate vertically downward based on the infrequent nature of rainfall in the area (less than 5 inches per year), the high evaporative rate, and the depth to the groundwater table. The actual potential concentration of any MC would be highly dependent on many factors, such as its mass loading at the surface, aqueous solubility, and retardation of the MC due to soil characteristics.

Surface Water Pathways

Surface water runoff is the dominant form of MC transport at MCAGCC Twentynine Palms compared to MC transport via groundwater infiltration. The intense rainfall events produce large volumes of water that rapidly run off the bedrock in mountainous areas and travel downstream through the ephemeral streams and dry washes to the playas. The sparse vegetation on the installation does not dissipate the kinetic energy of the surface water as it travels downstream, increasing the potential for MC migration due to surface water. Surface runoff drains radially away from the RTA, with approximately one-half draining off the installation and the remaining portion (44%) retained on range within the installation boundaries.

7.24.1.8. Potential Groundwater and Surface Water Receptors

Groundwater Receptors

The Sunshine Peak RTA overlies the Lavic Valley groundwater subbasin. There are no known users of groundwater in this basin. A portion of the RTA also overlies the Bessemer subbasin of the Twentynine Palms basin. Sunshine Peak is located cross gradient and many miles from the installation drinking water wells. No drinking water wells were identified within the Sunshine Peak RTA.

Surface Water Receptors

Potential receptors include ecological receptors such as the MFTL and the desert tortoise, which are present off range. Based upon the results of the exposure and toxicity assessment, MC transported to playas from the lightly used Sunshine Peak RTA are unlikely to pose a threat to the MFTL or desert tortoise.

7.24.2. Groundwater Analysis Results

A qualitative groundwater analysis was performed by analyzing the source media, migration mechanisms, and exposure pathways documented in the MCAGCC Twentynine Palms CSM. Based on the results of the qualitative analysis of the groundwater information, limited potential exists for MC migration to groundwater and no groundwater receptors associated with the indicator MC are present. Therefore, a groundwater screening-level analysis was not conducted. Discussions of the qualitative analysis and screening-level analysis are presented in **Section 4**.

7.24.3. Surface Water Analysis Results

Surface water runoff from the Sunshine Peak RTA was not included in the transport analysis, due to the low MC loading rate and the lack of potential receptors.

7.25. Emerson Lake

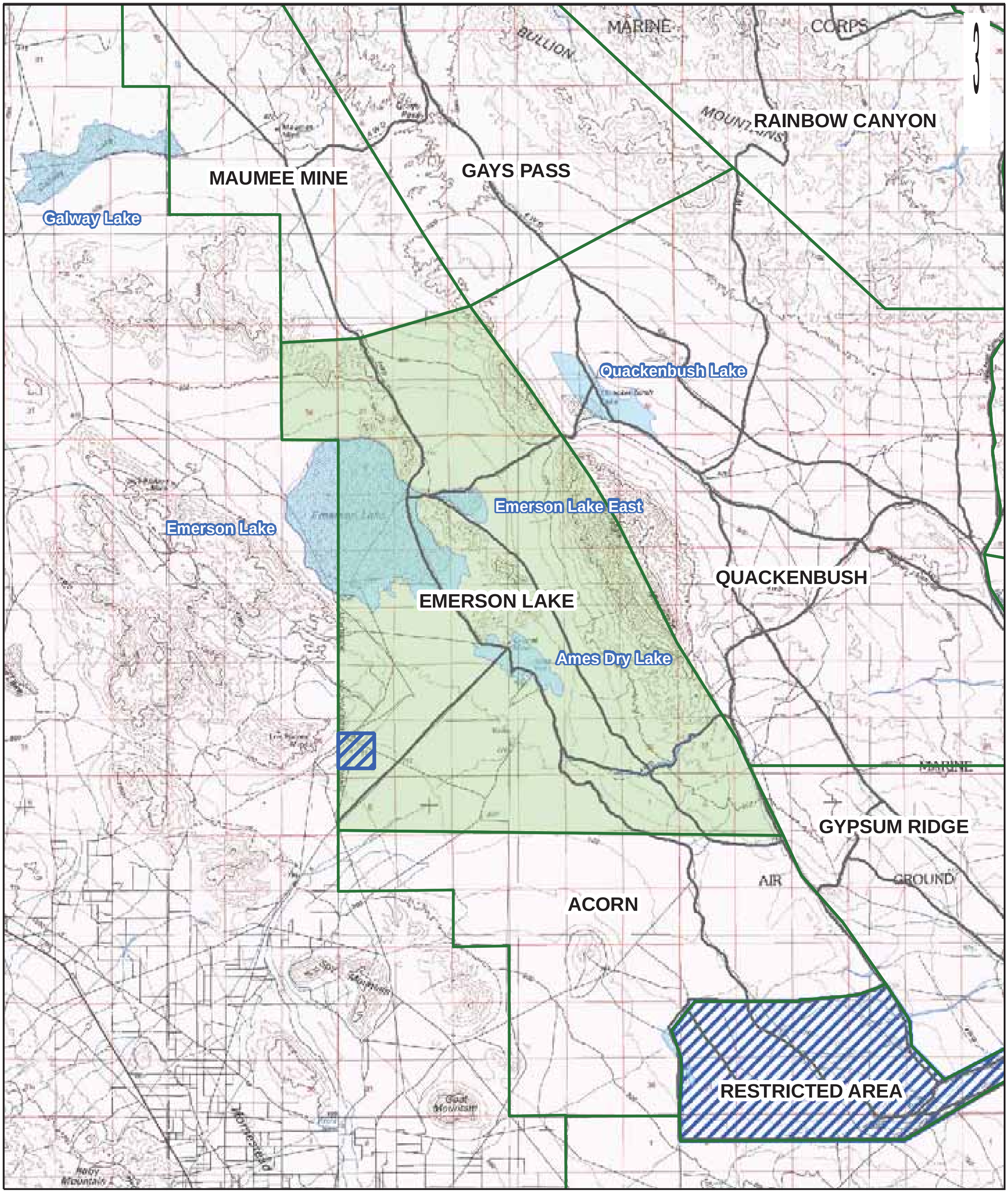
The Emerson Lake RTA is located on the western boundary of MCAGCC Twentynine Palms (Figure 7.25-1) and covers approximately 32,155 acres (USACE, 2001a). In 1997, the area was declared a no-impact area, except by express permission of the Director, Operations and Training of MCAGCC Twentynine Palms. The RTA contains seven LTAs for laser ground-to-ground firing. There are no fixed ranges within the RTA.

A restricted area is located in the southwestern corner of the RTA. Between 1979 and 1997, the area was used mainly for live-fire maneuvering and aerial targeting. Due to the noise buffer around the installation, artillery fire in the RTA was directed into the Gypsum Ridge and Quackenbush RTAs, located east of the Emerson Lake RTA. The Raked Range was identified in the ASR as a 1.5-kilometer diameter circle. The range is no longer in use (USACE, 2001b).

Based on interviews with Range Control, a primary MC loading area was not delineated for the Emerson Lake RTA. Therefore, MC loading was conducted on an area representing 10% of the total RTA size.

Military Munitions

The general classes of military munitions expected in this RTA include small arms ammunition and high explosive munitions. Detailed military munitions use data are



LEGEND

- EMERSON LAKE RTA
- RANGE TRAINING AREA
- SURFACE WATER (INTERMITTENT)
- RESTRICTED AREA
- MAIN SUPPLY ROUTE

2 1 0 2 Miles

SOURCE: MCAGCC/NREA GIS OFFICE 2006; TECOM 2006; USGS, VARIOUS DATES.

MALCOLM PIRNIE	MCAGCC TWENTYNINE PALMS, CALIFORNIA RANGE ENVIRONMENTAL VULNERABILITY ASSESSMENT	EMERSON LAKE RTA	MALCOLM PIRNIE, INC. AUGUST 2008 FIGURE 7.25-1

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presented in the PRA (USACE, 2001b), and detailed assumptions for the determination of MC loading rates are provided in the *REVA Reference Manual* (HQMC, 2006).

7.25.1. CSM

7.25.1.1. Estimated MC Loading

An MC loading area of 13,012,000 m^2 was established for the Emerson Lake RTA. The MC Loading Rate Calculator was used to estimate the amount of MC loaded on this area over time (Table 7.25-1). The MC loading amounts estimated for the area over each identified time period during which the impact areas were used, Time Periods D and E, were assumed to occur only within the estimated MC loading area. There are no SARs located within the Emerson Lake RTA; therefore, qualitative assessments to determine the fate and transport of lead were not conducted for this RTA. Expenditure data were extrapolated for time periods for which they were not available.

Table 7.25-1: Estimated Annual MC Loading for the Emerson Lake RTA

MC Loading Area	Period	Begin Use	End Use	HMX (kg/m^2)	RDX (kg/m^2)	TNT (kg/m^2)	Perchlorate (kg/m^2)
Emerson Lake	D (1977-1988)	1979	1988	2.84E-12	4.62E-08	5.99E-08	2.21E-10
	E (1989-Present)	1989	2005	3.55E-12	5.77E-08	7.49E-08	2.77E-10

7.25.1.2. Geography and Topography

The Emerson Lake RTA is located southwest of the Hidalgo Mountains. The area generally slopes from northeast to southwest toward the Emerson Lake playa. The southern portion of the RTA is generally flat. Based on topographic maps, the elevation ranges from approximately 700 to over 2,000 feet amsl (MCAGCC FMD, 2006).

7.25.1.3. Surface Water Features

There are no perennial surface water features within the Emerson Lake RTA. Streambeds are dry, except after infrequent, heavy rainfall (USDA NRCS, 1999). The Emerson Lake RTA falls mainly within Emerson Lake (73%) and Upper Emerson (25%) surface water drainage basin (MCAGCC FMD, 2006). The Emerson Lake drainage basin drains to Emerson Lake, located on and extending across the MCAGCC Twentynine Palms boundary, and Ames Dry Lake, located within the installation. The Upper Emerson drainage basin drains to Emerson Lake East, located within the installation boundaries (MCAGCC FMD, 2006).

7.25.1.4. Soil Characteristics and Land Cover

The soils at the Emerson Lake RTA are generally finer-grained than most other soils at MCAGCC Twentynine Palms. Soil types range from stratified silt loam to silty clay loams to very cobbly sandy loams. Bedrock outcrops are located along the boundary between Emerson Lake and the Quackenbush RTA. Typic Haplosalids soils are found within each of the three playas in the Emerson Lake RTA. These soils are generally a silt loam soil over a stratified silt loam to silty clay loam. The finer-grained soils in the playas inhibit the vertical migration of MC. The vegetation within the Emerson Lake RTA is mainly creosote bush scrub and bare ground (USDA NRCS, 1999).

7.25.1.5. Erosion Potential

The erodibility of the soils within the Emerson Lake RTA is low based on the soil types and slopes within the area. The Emerson Lake RTA was not included in the surface water transport screening; therefore, an erodibility factor was not selected for the RTA.

7.25.1.6. Groundwater Characteristics

The Emerson Lake RTA overlies the Giant Rock groundwater subbasin of the Twentynine Palms basin. The interpolated groundwater flow for the groundwater basin under Emerson Lake is southeast toward the Surprise Springs subbasin. Groundwater levels are moderately deep in this RTA (100–200 feet bgs) and become shallower near the playas. The depth to groundwater at an inactive water well in the Emerson Lake RTA is approximately 70 feet bgs.

7.25.1.7. Potential Groundwater and Surface Water Pathways

Groundwater Pathways

MC have the potential to migrate toward the water table at the Emerson Lake RTA after dissolution into infiltrating rainwater. This pathway is enhanced by the presence of coarse-grained soils, such as sands and gravel. MC have limited potential to migrate vertically downward based on the infrequent nature of rainfall in the area (less than 5 inches per year), the high evaporative rate, and the depth to the groundwater table. The concentrations of any MC in groundwater would be highly dependent on many factors, such as its mass loading at the surface, aqueous solubility, and retardation of the MC due to soil characteristics. Groundwater from the Giant Rock subbasin generally flows to the east to recharge the Surprise Springs subbasin. A portion of the groundwater within the Giant Rock subbasin probably moves toward the playas.

Surface Water Pathways

Surface water runoff is the dominant pathway for MC transport at MCAGCC Twentynine Palms. The intense rainfall events produce large volumes of water that rapidly run off the bedrock in mountainous areas and travel downstream through the ephemeral streams and dry washes to the playas. The sparse vegetation on the installation does not dissipate the kinetic energy of the surface water as it travels downstream, increasing the potential for MC migration due to surface water. Runoff collects in the three playas located within the RTA.

7.25.1.8. Potential Groundwater and Surface Water Receptors

Groundwater Receptors

The Emerson Lake RTA overlies the Giant Rock subbasin of the Twentynine Palms groundwater basin. The Emerson Lake RTA is up gradient of the drinking water supply wells of MCAGCC Twentynine Palms. However, MC are unlikely to reach the deep groundwater beneath the Emerson Lake RTA. Perched groundwater beneath the playas, if present, would not be used as a drinking water source. One inactive drinking water well was identified within Emerson Lake, but it is not considered a potential drinking water source.

Surface Water Receptors

Potential surface water receptors generally are limited to ecological receptors, the MFTL and the desert tortoise. MFTL habitat is located on the eastern portion of the RTA, west of the Hidalgo Mountains. Desert tortoise habitat is located south of the Emerson Lake playa. However, these areas are located on range; thus, these receptors are not included in the REVA. Also, based upon the results of the exposure and toxicity assessment, MC transported to playas are unlikely to pose a threat to the MFTL or desert tortoise (Malcolm Pirnie, 2007).

7.25.2. Groundwater Analysis Results

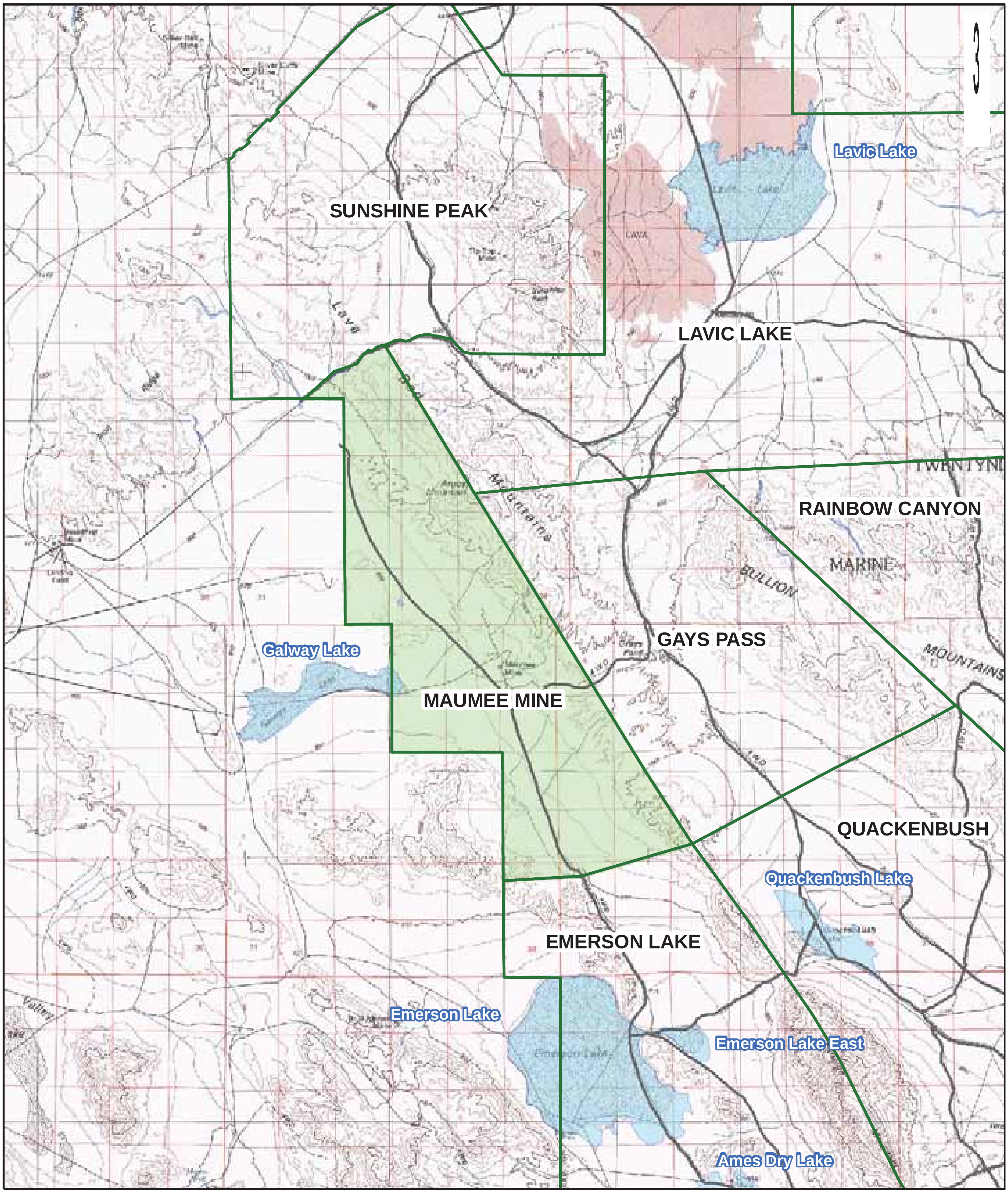
A qualitative groundwater analysis was performed by analyzing the source media, migration mechanisms, and exposure pathways documented in the MCAGCC Twentynine Palms CSM. Based on the results of the qualitative analysis of the groundwater information, limited potential exists for MC migration to groundwater and no groundwater receptors associated with the indicator MC are present. Therefore, a groundwater screening-level analysis was not conducted. Discussions of the qualitative analysis and screening-level analysis are presented in **Section 4**.

7.25.3. Surface Water Analysis Results

Surface water runoff was not modeled for the Emerson Lake RTA due to the low concentration of MC calculated for the RTA and the lack of potential receptors.

7.26. Maumee Mine

The Maumee Mine RTA is located on the western boundary of MCAGCC Twentynine Palms, between Sunshine Peak and Emerson Lake (Figure 7.26-1), and covers an area of 16,110 acres (USACE, 2001a). The general shape of the RTA is long (approximately 10 miles) and relatively thin (maximum 3 miles at the southern end) in comparison to other RTAs. Currently, the RTA is used as a fire and maneuver range for air-to-ground and ground-to-ground exercises. Due to the noise buffer in effect along the installation boundary, artillery fire generally is directed toward the Gays Pass and Lavic Lake RTAs.



LEGEND

- MAUMEE MINE RTA
- RANGE TRAINING AREA
- SURFACE WATER (INTERMITTENT)
- MAIN SUPPLY ROUTE

2 1 0 2 Miles

SOURCE: MCAGCC/NREA GIS OFFICE 2006; TECOM 2006; USGS, VARIOUS DATES.

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MAUMEE MINE RTA

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FIGURE 7.26-1

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The RTA was used for artillery and maneuver training with the Marine Corps Combat Readiness Evaluation System between 1979 and 1997. There are no fixed ranges or targets within the RTA (USACE, 2001b). Based on interviews with Range Control, a primary MC loading area was not delineated for the Maumee Mine RTA. Therefore, MC loading was conducted on an area representing 10% of the total RTA size.

Military Munitions

The general classes of military munitions expected in this RTA include small arms ammunition and high explosive munitions. Detailed military munitions use data are presented in the PRA (USACE, 2001b), and detailed assumptions for the determination of MC loading rates are provided in the *REVA Reference Manual* (HQMC, 2006).

7.26.1. CSM

7.26.1.1. Estimated MC Loading

An MC loading area of 6,519,000 m^2 was established for the Maumee Mine RTA. The MC Loading Rate Calculator was used to estimate the amount of MC loaded on this area over time (Table 7.26-1). The MC loading amounts estimated for the area over each identified time period during which the impact areas were used, Time Periods D and E, were assumed to occur only within the estimated MC loading area. There are no SARs located within the Maumee Mine RTA; therefore, qualitative assessments to determine the fate and transport of lead were not conducted for this RTA. Expenditure data were extrapolated for time periods for which they were not available.

Table 7.26-1: Estimated Annual MC Loading for the Maumee Mine RTA

MC Loading Area	Period	Begin Use	End Use	HMX (kg/m^2)	RDX (kg/m^2)	TNT (kg/m^2)	Perchlorate (kg/m^2)
Maumee Mine	D (1977-1988)	1979	1988	4.36E-12	2.08E-08	1.90E-08	4.37E-11
	E (1989-Present)	1989	2005	5.45E-12	2.60E-08	2.37E-08	5.47E-11

7.26.1.2. Geography and Topography

The Maumee Mine RTA is located along the southwest slopes of the Lava Bed Mountains. The area generally slopes from northeast to southwest toward Emerson and Galway lakes. The Lava Bed Mountains extend to over 4,000 feet amsl along the eastern boundary of the RTA. The elevation in the RTA ranges from 2,543 to 4,367 feet amsl (MCAGCC FMD, 2006). The majority of the RTA west of the mountains is gently sloping alluvial plains.

7.26.1.3. Surface Water Features

There are no perennial surface water features within the Maumee Mine RTA. Streambeds are dry, except after infrequent, heavy rainfall (USDA NRCS, 1999). The Maumee Mine RTA falls mainly within the Galway Lake (65%) and Upper Emerson (32%) surface water drainage basins. The Galway Lake drainage basin drains to Galway Lake, located on the western boundary of the installation. The Upper Emerson drainage basin drains southward to the Emerson Lake East playa, located within the Emerson Lake RTA (MCAGCC FMD, 2006).

7.26.1.4. Soil Characteristics and Land Cover

The soils at the Maumee Mine RTA are generally coarse-grained soils that range from loams to extremely gravelly coarse sand. Bedrock crops out along the boundary between the Maumee Mine and Gays Pass RTAs. No site-specific information on soil types in the Galway Lake playa are available; typically, soils in playas are more finely grained than the surrounding area and would inhibit the vertical migration of MC. The vegetation within the Maumee Mine RTA is mainly creosote bush scrub and bare ground. The density of creosote bushes slightly increases on the northern edge of the Galway Lake playa (USDA NRCS, 1999; MCAGCC FMD, 2006).

7.26.1.5. Erosion Potential

The erodibility of the Maumee Mine RTA is low to moderate based on the soil types and slopes within the area. The Maumee Mine RTA was not part of the surface water screening; therefore, an erodibility factor was not selected for the RTA.

7.26.1.6. Groundwater Characteristics

The Maumee Mine RTA overlies the Bessemer Valley and Giant Rock groundwater subbasins of the Twentynine Palms basin. The groundwater bearing units within the basins are composed of unconsolidated to loosely consolidated Tertiary sediments and are divided along structural faults, which form very low permeability zones. No water wells have been installed in this RTA, and the predicted groundwater flow direction is to the southeast. Groundwater depths in this area are not known. However, given the topography and elevation, groundwater is expected to be deep within the Maumee Mine RTA.

7.26.1.7. Potential Groundwater and Surface Water Pathways

Groundwater Pathways

MC have the potential to migrate toward the water table at the Maumee Mine RTA after dissolution into infiltrating rainwater. This pathway is enhanced by the presence of coarse-grained soils, such as sands and gravel. MC have limited potential to migrate vertically based on the infrequent nature of rainfall in the area (less than 5 inches per year), the high evaporation rate, and the depth to the groundwater table. The concentration of MC in groundwater would be highly dependent on many factors, such as its mass loading at the surface, aqueous solubility, and retardation of the MC due to soil characteristics. Groundwater flow directions are unknown, but it may move toward the Galway Lake and Emerson Lake East playas.

Surface Water Pathways

Surface water runoff is the dominant pathway for MC transport at MCAGCC Twentynine Palms. The intense rainfall events produce large volumes of water that rapidly run off the bedrock in mountainous areas and travel downstream through the ephemeral streams and dry washes to the playas. The sparse vegetation on the installation does not dissipate the kinetic energy of the surface water as it travels downstream, increasing the potential for MC migration due to surface water. Runoff collects in the Emerson Lake East and Galway Lake playas.

7.26.1.8. Potential Groundwater and Surface Water Receptors

Groundwater Receptors

No drinking water wells were identified within the Maumee Mine RTA or west of the installation boundary. Therefore, there are no groundwater receptors for this RTA.

Surface Water Receptors

The potential surface water receptors at Maumee Mine include ecological receptors, the MFTL and the desert tortoise. MFTL habitat is located within the RTA, west of the Lava Bed Mountains, and desert tortoise habitat is located in a mountain pass within the RTA. However, both species are unlikely to interact with surface water and are not considered receptors. There are no human receptors associated with either playa that receives runoff from the Maumee Mine RTA.

7.26.2. Groundwater Analysis Results

A qualitative groundwater analysis was performed by analyzing the source media, migration mechanisms, and exposure pathways documented in the MCAGCC Twentynine Palms CSM. Based on the results of the qualitative analysis of the groundwater information, limited potential exists for MC migration to groundwater and no groundwater receptors associated with the indicator MC are present. Therefore, a groundwater screening-level analysis was not conducted. Discussions of the qualitative analysis and screening-level analysis are presented in **Section 4**.

7.26.3. Surface Water Analysis Results

Surface water MC transport analysis was not conducted for the Maumee Mine RTA, primarily due to a lack receptors and the lower overall MC loading for the RTA. Based on surface water screening methods conducted for Bristol Dry Lake and Dale Lake, potential MC loading to surface water bodies within the RTA is unlikely to a pose threat to the MFTL or the desert tortoise (Malcolm Pirnie, 2007). There are no human receptors for surface water for the Maumee Mine RTA.

7.27. Acorn

The Acorn RTA is located on the western boundary of MCAGCC Twentynine Palms, south of the Emerson Lake RTA (Figure 7.27-1), and covers approximately 17,471 acres (USACE, 2001a). The RTA currently is designated a non-live-fire maneuver area. Between 1979 and 1997, the Acorn RTA was part of the Emerson Lake RTA, which was used for artillery and maneuver training with the Marine Corps Combat Readiness Evaluation System, and the Sand Hill RTA, which was used as a maneuver area. Between 1987 and the mid-1990s, a weapons impact scoring range was located in the RTA. The range was used for aerial bombing using inert ordnance; the range was replaced with Range 603 in the Bullion RTA (USACE, 2001b). Based on interviews with Range Control, a primary MC loading area was not delineated for the Acorn RTA due to its use as a non-live-fire maneuver area.

Military Munitions

The general classes of military munitions expected in this RTA include small arms ammunition and high explosive munitions. Detailed military munitions use data are presented in the PRA (USACE, 2001b), and detailed assumptions for the determination of MC loading rates are provided in the *REVA Reference Manual* (HQMC, 2006).

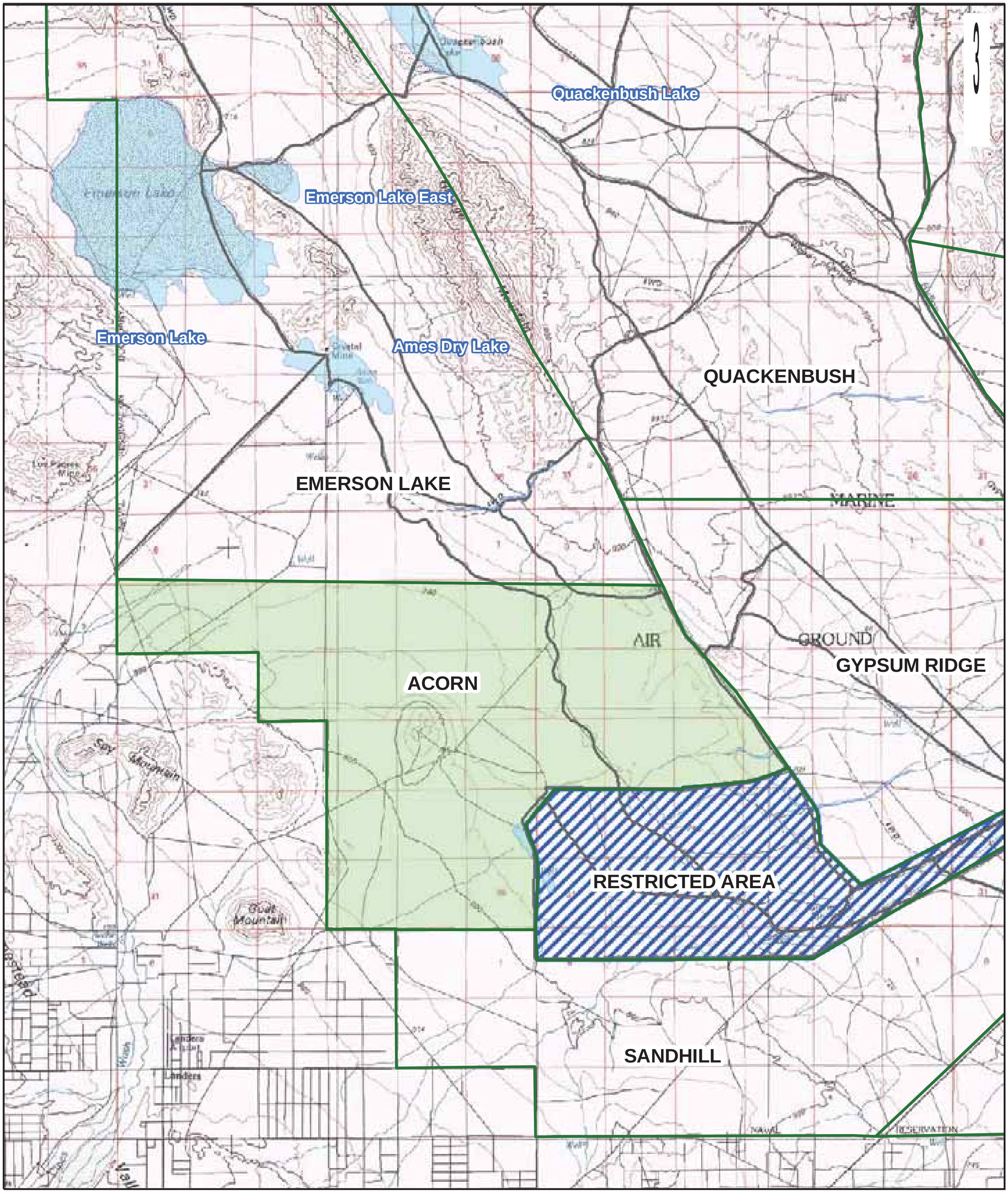
7.27.1. CSM

7.27.1.1. Estimated MC Loading

Range Control recorded no military munitions expenditures for the Acorn RTA between 2001 and 2005. Because of the lack of expenditure data and the use of this RTA as a strict non-live-fire maneuver area, MC loading was not estimated. Historical use MC loading for the Acorn RTA area is captured under the Alpha RTA (from 1969 to 1979) and the Emerson Lake RTA (from 1979 to 1997). There are no SARs located within the Acorn RTA; therefore, qualitative assessments to determine the fate and transport of lead were not conducted for this RTA.

7.27.1.2. Geography and Topography

The Acorn RTA is located in the southwest corner of MCAGCC Twentynine Palms, east of Goat Mountain. The area is a generally flat plateau in the northwest portion of the RTA, with gently rolling hills that slope to the east and north. The elevation in the RTA ranges from 2,142 to 2,943 feet amsl (MCAGCC FMD, 2006).



LEGEND

- ACORN RTA
- RANGE TRAINING AREA
- RESTRICTED AREA
- SURFACE WATER (INTERMITTENT)
- MAIN SUPPLY ROUTE

2 1 0 2 Miles

SOURCE: MCAGCC/NREA GIS OFFICE 2006; TECOM 2006; USGS, VARIOUS DATES.

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ACORN RTA

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FIGURE 7.27-1

7.27.1.3. Surface Water Features

There are no perennial surface water features within the Acorn RTA. Streambeds are dry, except after infrequent, heavy rainfall (USDA NRCS, 1999). The Acorn RTA falls within three surface water drainage basins: Emerson Lake (51%), Deadman Lake (26%), and Goat Mountain (23%). Dry washes drain the plateau to Ames Dry Lake to the north, Deadman Lake to the east, and Miller Dry Lake, contained within the Restricted Area, to the east. Runoff stays within the installation boundaries (MCAGCC FMD, 2006).

7.27.1.4. Soil Characteristics and Land Cover

The soils at the Acorn RTA are generally sands that range from loamy sand to coarse sand. The vegetation within the Acorn RTA is mainly creosote bush scrub and bare ground (USDA NRCS, 1999).

7.27.1.5. Erosion Potential

The erodibility of the Acorn RTA is low to moderate based on the soil types and slopes within the area. The Acorn RTA was not modeled for surface water screening; therefore, an erodibility factor was not selected for the RTA.

7.27.1.6. Groundwater Characteristics

The Acorn RTA overlies the Giant Rock and Surprise Springs groundwater subbasins of the Twentynine Palms basin. The groundwater bearing units within the basins are composed of unconsolidated to loosely consolidated Tertiary sediments and are divided along structural faults, which form very low permeability zones. Depth to groundwater ranges from 5 to 400 feet bgs; however, groundwater near the installation’s water supply wells and near Mainside is generally encountered at a depth of 185 to 260 feet bgs (RW Beck, 2002; NEESA, 1999). Groundwater for potable use has been derived from the unconfined portions of the aquifer. Thick clay deposits and perched groundwater tables, ranging in depth from 5 to 75 feet, are present in areas of the playas (Panacea, 2001a and 2001b; ENSR, 1990). These perched aquifers are assumed to be limited in extent based on the available groundwater data and relatively small aerial extent of the playas. It is uncertain if the perched groundwater recharges the deeper aquifer system. The groundwater flow underneath the Acorn RTA is to the east toward the Surprise Springs subbasin.

7.27.1.7. Potential Groundwater and Surface Water Pathways

Groundwater Pathways

MC have the potential to migrate toward the water table at the Acorn RTA after dissolution into infiltrating rainwater. This pathway is accentuated by the presence of coarse soils, such as sands and gravel. MC have limited potential to migrate vertically based on the infrequent nature of rainfall in the area (less than 5 inches per year), the high evaporative rate, and the depth to the groundwater table. In addition, MC loading is no longer occurring at this RTA and was greatly limited in the past due to its proximity to the installation boundary and the water supply wells.

Surface Water Pathways

Surface water runoff is the dominant pathway for MC transport at MCAGCC Twentynine Palms. The intense rainfall events produce large volumes of water that rapidly run off the bedrock in mountainous areas and travel downstream through the ephemeral streams and dry washes to the playas. The sparse vegetation on the installation does not dissipate the kinetic energy of the surface water as it travels downstream, increasing the potential for MC migration due to surface water. Runoff within the Acorn RTA drains to Ames Dry Lake, Deadman Lake, and Miller Dry Lake.

7.27.1.8. Potential Groundwater and Surface Water Receptors

Groundwater Receptors

The Acorn RTA overlies the Giant Rock and Surprise Springs subbasins of the Twentynine Palms basin. Up gradient of the drinking water supply wells, the Acorn RTA is not considered a potential source of MC because live-fire training does not occur at this RTA. Therefore, no groundwater receptors were identified for this RTA.

Surface Water Receptors

Potential surface water receptors for the Acorn RTA are ecological receptors (MFTL and desert tortoise) potentially present near playas. Both MFTL and desert tortoise habitat are located within the RTA. However, none of the potential exposure points are located off range; thus, they are not considered surface water receptors. Based upon the results of the exposure and toxicity assessment, the potential concentrations of MC in Ames Dry Lake, Deadman Lake, and Miller Dry Lake are not likely to pose an exposure risk to either the MFTL or the desert tortoise (Malcolm Pirnie, 2007).

7.27.2. Groundwater Analysis Results

A qualitative groundwater analysis was performed by analyzing the source media, migration mechanisms, and exposure pathways documented in the MCAGCC Twentynine Palms CSM. Based on the results of the qualitative analysis of the groundwater information, limited potential exists for MC migration to groundwater and no groundwater receptors associated with the indicator MC are present. Therefore, a groundwater screening-level analysis was not conducted. Discussions of the qualitative analysis and screening-level analysis are presented in **Section 4**.

7.27.3. Surface Water Analysis Results

Surface water MC transport analysis was not conducted for the Acorn RTA due to a lack of munitions expenditures and off-installation receptors associated with this non-live-fire RTA.

7.28. East

The East RTA is located on the southern boundary of MCAGCC Twentynine Palms, east of Mainside (Figure 7.28-1). The East RTA covers approximately 6,893 acres (USACE, 2001a). Currently, the RTA is used as a maneuver area and has been designated a no-impact area since 1979. A Range Training Support Site is located within the RTA. From 1979 through 1997, the RTA was used mainly for live fire with impact in the Delta (currently, Prospect) RTA. Several non-live-fire fixed ranges are contained within the East RTA (Table 7.28-1) (USACE, 2001b).

Table 7.28-1: Fixed Ranges at the East RTA

Fixed Range	Range Type	Area (1,000 m^2)
NON-LIVE-FIRE RANGES		
Range 100	Squad maneuver range	4,887.86
Range 200	Non-live-fire MOUT training facility	193.10
Range 215	Non-live-fire MOUT training facility	577.83
Range 215A	Non-live-fire MOUT training facility	4.13
FOB 1	FOB support for Ranges 200 and 215	270.35
FOB 2	FOB support for Ranges 200 and 215	178.99
FOB 3	FOB support for Ranges 200 and 215	320.51

A primary MC loading area was not delineated for the East RTA because it is currently a non-live-fire maneuver area. Instead, MC loading was estimated for an area representing 10% of the total RTA size.

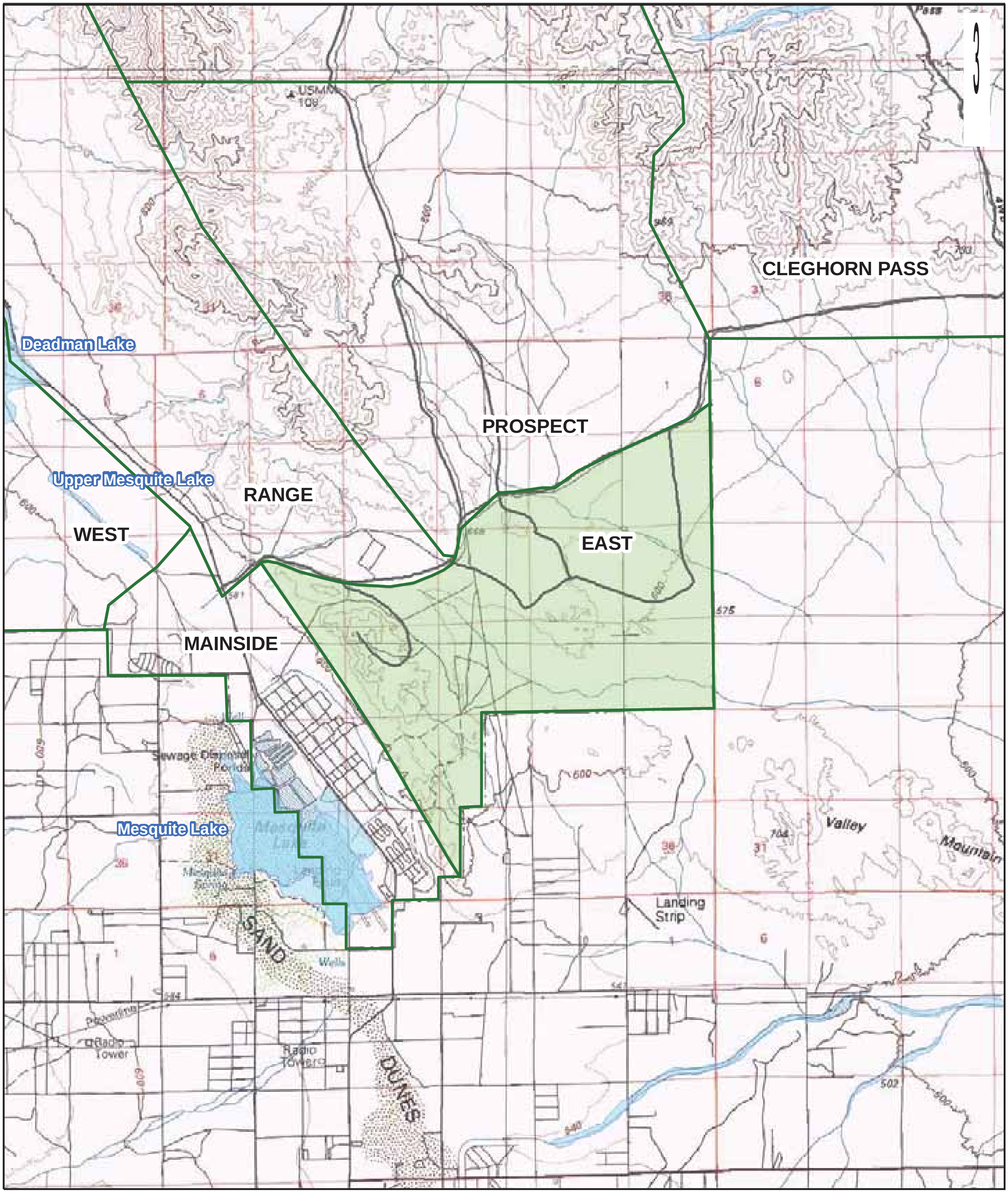
Military Munitions

The general classes of military munitions expected in this RTA include blank small arms ammunition and high explosive munitions. Detailed military munitions use data are presented in the PRA (USACE, 2001b), and detailed assumptions for the determination of MC loading rates are provided in the *REVA Reference Manual* (HQMC, 2006).

7.28.1. CSM

7.28.1.1. Estimated MC Loading

An MC loading area of 2,789,000 m^2 was established for the East RTA. The MC Loading Rate Calculator was used to estimate the amount of MC loaded on this area over time (Table 7.28-2). The MC loading amounts estimated for the area over each identified



LEGEND

- EAST RTA
- RANGE TRAINING AREA
- SURFACE WATER (INTERMITTENT)
- MAIN SUPPLY ROUTE

2 1 0 2 Miles

SOURCE: MCAGCC/NREA GIS OFFICE 2006; TECOM 2006; USGS, VARIOUS DATES.

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RANGE ENVIRONMENTAL VULNERABILITY ASSESSMENT

EAST RTA

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FIGURE 7.28-1

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time period during which the impact areas were used, Time Periods D and E, were assumed to occur only within the estimated MC loading area. There are no SARs located within the East RTA; therefore, qualitative assessments to determine the fate and transport of lead were not conducted for this RTA. Expenditure data were extrapolated for time periods for which they were not available.

Table 7.28-2: Estimated Annual MC Loading for the East RTA

MC Loading Area	Period	Begin Use	End Use	HMX (kg/m^2)	RDX (kg/m^2)	TNT (kg/m^2)	Perchlorate (kg/m^2)
East	D (1977-1988)	1979	1988	n/a	n/a	2.50E-14	1.24E-09
	E (1989-Present)	1989	2005	n/a	n/a	3.13E-14	1.55E-09

Even though the RTA is designated for non-live-fire use, the MC loading for the East RTA resulted in estimates for TNT deposition. A review of the expenditure data provided by Range Control indicates very small traces of TNT within the items, which are used to initiate the dispersion of the pyrotechnic material.

7.28.1.2. Geography and Topography

The East RTA is located on the southeastern slopes of the Bullions Mountains. The area slopes from northwest to southeast toward the installation boundary. The elevation of the RTA ranges from 1,355 to 3,061 feet amsl (MCAGCC FMD, 2006). The central and southern sections of the RTA sit on relatively flat to gently rolling alluvial plains.

7.28.1.3. Surface Water Features

There are no perennial surface water features within the East RTA. Streambeds are dry, except after infrequent, heavy rainfall (USDA NRCS, 1999). The East RTA falls within three surface water drainage basins. The majority of the drainages are split between the East Mainside (48%) and Cleghorn Pass (40%) basins, both of which drain to Dale Lake, located southeast of the installation. The remaining 12% of the RTA drains southwest to Mesquite Lake, located within Mainside (MCAGCC FMD, 2006).

7.28.1.4. Soil Characteristics and Land Cover

The soils at the East RTA are generally coarse-grained soils that range from loamy sand to extremely gravelly coarse sandy loams. Bedrock outcrops occur along the western boundary of the RTA and separate the RTA from Mainside. The vegetation within the East RTA is mainly creosote bush scrub and some bare ground (USDA NRCS, 1999).

7.28.1.5. Erosion Potential

The erodibility of the East RTA is low to moderate based on the soil types and slopes within the area. The RTA was not modeled for surface water screening; therefore, an erodibility factor was not selected for the RTA.

7.28.1.6. Groundwater Characteristics

The East RTA overlies the Dale Valley intramountain groundwater basin. Subsurface data were not available for the intramountain basins found within the Bullion and Lava Bed mountains, including the Dale Valley. The assumed direction of flow in the Dale Valley groundwater basin is to the southeast toward Dale Lake. There are no water wells located within the RTA. The subsurface conditions encountered in these areas are expected to be similar to those described for the Bristol Valley and Twentynine Palms basins, with some exceptions, as described in **Section 7.14.1.6**.

7.28.1.7. Potential Groundwater and Surface Water Pathways

Groundwater Pathways

MC have the potential to migrate toward the water table at the East RTA after dissolution into infiltrating rainwater. This pathway is accentuated by the presence of coarse soils, such as sands and gravel. MC have limited potential to migrate vertically based on the infrequent nature of rainfall in the area (less than 5 inches per year), the high evaporative rate, and the depth to the groundwater table. The actual concentration MC in groundwater would be highly dependent on many factors, such as its mass loading at the surface, aqueous solubility, and retardation of the MC due to soil characteristics.

Surface Water Pathways

Surface water runoff is the dominant pathway for MC transport. The intense rainfall events produce large volumes of water that rapidly run off the bedrock in mountainous areas and travel downstream through the ephemeral streams and dry washes to the playa lakes. The sparse vegetation on the installation does not dissipate the kinetic energy of the surface water as it travels downstream, increasing the potential for MC migration due to surface water. MC are unlikely to be transported from this non-live-fire range in measurable quantities to the off-range Dale Lake playa (18 miles downstream).

7.28.1.8. Potential Groundwater and Surface Water Receptors

Groundwater Receptors

The East RTA overlies the same groundwater basin as the Prospect RTA and MC loading area; therefore, the potential receptors are the same as those described for Prospect in **Section 7.11.1.8**. The only potential groundwater receptors are the salt mining workers at the salt mine at Dale Lake; however, given the distance to Dale Lake, the potential exposure of the workers to groundwater containing measurable quantities of MC is likely negligible.

Surface Water Receptors

The potential human receptors for the East RTA are the salt mine workers that work within Dale Lake, whose exposure is considered negligible, and the ecological receptors (MFTL and the desert tortoise) that were considered in the ecological risk assessment. The results of the ecological risk assessment indicate that exposure to MC is unlikely and that the concentrations are unlikely to pose a threat to the ecological receptors. MFTL habitat is located within the RTA along the slopes of the Bullion Mountains. Both species may be present on or near Dale Lake, though they are not expected to be affected by MC in surface water draining from the East RTA to Dale Lake.

7.28.2. Groundwater Analysis Results

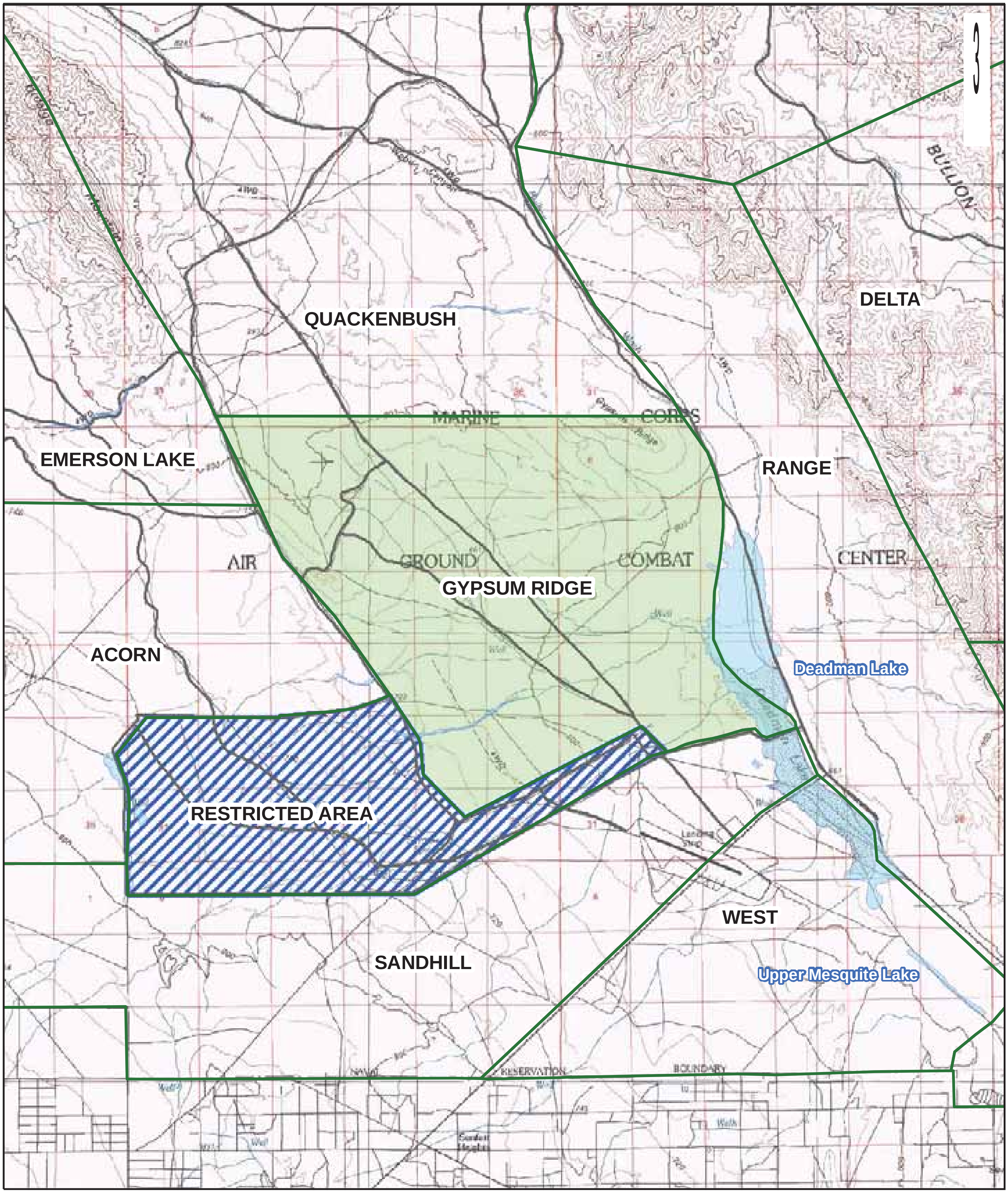
A qualitative groundwater analysis was performed by analyzing the source media, migration mechanisms, and exposure pathways documented in the MCAGCC Twentynine Palms CSM. Based on the results of the qualitative analysis of the groundwater information, limited potential exists for MC migration to groundwater and no groundwater receptors associated with the indicator MC are present. Therefore, a groundwater screening-level analysis was not conducted. Discussions of the qualitative analysis and screening-level analysis are presented in **Section 4**.

7.28.3. Surface Water Analysis Results

Due to the limited amount of training conducted in the East RTA, the MC loading for the RTA was not included as part of the surface water screening transport analysis.

7.29. Gypsum Ridge

The Gypsum Ridge RTA is located on the southwestern portion of MCAGCC Twentynine Palms, west of Mainside (Figure 7.29-1), and covers 17,554 acres (USACE, 2001a). Currently, the Gypsum Ridge RTA is used as a live-fire and maneuver area for air-to-land and land-to-land exercises. Between 1979 and 1997, the RTA covered an area of approximately 34,500 acres, of which 18,600 were considered impact areas. The RTA provided ground-based live fire, aviation exercises, and maneuver exercises. The Field Ammunition Supply Point is located within the RTA and is considered a no-fire area. No fixed ranges are contained within the Gypsum Ridge RTA (USACE, 2001b). Based on interviews with Range Control, an MC loading area was not delineated for the Gypsum Ridge RTA. Therefore, it was assumed that MC were loaded onto an area 10% of the total RTA size.



LEGEND

- GYPSUM RIDGE RTA
- RANGE TRAINING AREA
- SURFACE WATER (INTERMITTENT)
- MAIN SUPPLY ROUTE

2 1 0 2 Miles

SOURCE: MCAGCC/NREA GIS OFFICE 2006; TECOM 2006; USGS, VARIOUS DATES.

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MALCOLM PIRNIE	MCAGCC TWENTYNINE PALMS, CALIFORNIA RANGE ENVIRONMENTAL VULNERABILITY ASSESSMENT	GYPSUM RIDGE RTA	MALCOLM PIRNIE, INC. AUGUST 2008 FIGURE 7.29-1

Military Munitions

The general classes of military munitions expected in this RTA include small arms ammunition and high explosive munitions. Detailed military munitions use data are presented in the PRA (USACE, 2001b), and detailed assumptions for the determination of MC loading rates are provided in the *REVA Reference Manual* (HQMC, 2006).

7.29.1. CSM

7.29.1.1. Estimated MC Loading

An MC loading area of 7,104,000 m^2 was established for the Gypsum Ridge RTA. The MC Loading Rate Calculator was used to estimate the amount of MC loaded on this area over time (Table 7.29-1). The MC loading amounts estimated for the area over each identified time period during which the impact areas were used, Time Periods D and E, were assumed to occur only within the estimated MC loading area. There are no SARs located within the BlackTop RTA; therefore, qualitative assessments to determine the fate and transport of lead were not conducted for this RTA. Expenditure data were extrapolated for time periods for which they were not available.

Table 7.29-1: Estimated Annual MC Loading for the Gypsum Ridge RTA

MC Loading Area	Period	Begin Use	End Use	HMX (kg/m^2)	RDX (kg/m^2)	TNT (kg/m^2)	Perchlorate (kg/m^2)
Gypsum Ridge	D (1977-1988)	1979	1988	7.70E-12	n/a	3.41E-08	n/a
	E (1989-Present)	1989	2005	9.63E-12	n/a	4.27E-08	n/a

7.29.1.2. Geography and Topography

The Gypsum Ridge RTA is located in the southwest portion of MCAGCC Twentynine Palms, in an area characterized as low level rolling terrain. A portion of Deadman Lake playa is located in the southeast corner of the RTA. The elevation of the RTA ranges from 1,703 to 2,661 feet amsl (MCAGCC FMD, 2006).

7.29.1.3. Surface Water Features

There are no perennial surface water features within the Gypsum Ridge RTA. Streambeds are dry, except after infrequent, heavy rainfall (USDA NRCS, 1999). The Gypsum Ridge RTA falls completely within the Deadman Lake surface water drainage basin. Dry washes and ephemeral streams drain to Deadman Lake playa, located southeast of the RTA. Surface water runoff does not leave the installation boundaries (MCAGCC FMD, 2006).

7.29.1.4. Soil Characteristics and Land Cover

The soils at the Gypsum Ridge RTA are generally coarse soils that range from loamy sand to very gravelly sandy loam. The vegetation within the Gypsum Ridge RTA is mainly creosote bush scrub and bare ground (USDA NRCS, 1999).

7.29.1.5. Erosion Potential

The erodibility of the Gypsum Ridge RTA is low to moderate based on the soil types and slopes within the area. The RTA was not included in the surface water screening; therefore, an erodibility factor was not selected for the RTA.

7.29.1.6. Groundwater Characteristics

The Gypsum Ridge RTA overlies the Deadman Lake groundwater subbasin of the Twentynine Palms basin at MCAGCC Twentynine Palms. The basin and subbasin characteristics are described in **Section 7.14.1.6**.

Depth to groundwater ranges from 5 to 400 feet bgs; however, groundwater near the installation's water supply source wells and near Mainside is generally encountered at a depth of 185 to 260 feet bgs (RW Beck, 2002; NEESA, 1999). Groundwater for potable use has been derived from the unconfined portions of the aquifer. Thick clay deposits and perched groundwater tables, ranging in depth from 5 to 75 feet, are present in areas of the playas (Panacea, 2001a and 2001b; ENSR, 1990). These perched aquifers are assumed to be limited in extent based on the available groundwater data and relatively small aerial extent of the playas. It is uncertain if the perched groundwater recharges the deeper aquifer system. Gypsum Ridge is down gradient of the main water supply wells at MCAGCC Twentynine Palms. The direction of groundwater flow underneath the RTA is east toward Deadman Lake. Due to faulting, there is limited hydrogeologic interaction between the Surprise Springs subbasin and the Deadman Lake subbasin.

7.29.1.7. Potential Groundwater and Surface Water Pathways

Groundwater Pathways

MC have the potential to migrate toward the water table at the Gypsum Ridge RTA after dissolution into infiltrating rainwater. This pathway is accentuated by the presence of coarse soils, such as sands and gravel. However, MC have limited potential to migrate vertically based on the infrequent nature of rainfall in the area (less than 5 inches per year), the high evaporative rate, and the depth to the groundwater table. The actual concentration of any MC in groundwater would be highly dependent on many factors, such as its mass loading at the surface, aqueous solubility, and retardation of the MC due to soil characteristics.

Surface Water Pathways

Surface water runoff is the dominant pathway for MC transport at MCAGCC Twentynine Palms. The intense rainfall events produce large volumes of water that rapidly run off the bedrock in mountainous areas and travel downstream through the ephemeral streams and dry washes to the playas. The sparse vegetation on the installation does not dissipate the kinetic energy of the surface water as it travels downstream, increasing the potential for MC migration due to surface water. Runoff drains to the Deadman Lake playa.

7.29.1.8. Potential Groundwater and Surface Water Receptors

Groundwater Receptors

The Gypsum Ridge RTA overlies the Deadman Lake subbasin of the Twentynine Palms basin. The Gypsum Ridge RTA is cross gradient from the main water supply wells of MCAGCC Twentynine Palms. One inactive water supply well is located in the RTA, but it is not considered a potential receptor of groundwater from the RTA. There are no groundwater receptors for MC at this RTA.

Surface Water Receptors

The potential surface water receptors for Gypsum Ridge are ecological (MFTL and desert tortoise). MFTL habitat is located within the RTA. Specific desert tortoise habitat has not been characterized within the RTA. However, these species are unlikely to directly consume surface water from the Deadman Lake playa; therefore, they are not considered surface water receptors.

7.29.2. Groundwater Analysis Results

A qualitative groundwater analysis was performed by analyzing the source media, migration mechanisms, and exposure pathways documented in the MCAGCC Twentynine Palms CSM. Based on the results of the qualitative analysis of the groundwater information, limited potential exists for MC migration to groundwater and no groundwater receptors associated with the indicator MC are present. Therefore, a groundwater screening-level analysis was not conducted. Discussions of the qualitative analysis and screening-level analysis are presented in **Section 4**.

7.29.3. Surface Water Analysis Results

The Gypsum Ridge RTA drains into the Deadman Lake playa, which is fully contained within the boundaries of MCAGCC Twentynine Palms. Because all surface water drainages from the loading area remain within the boundaries of the installation, no off-range release of MC is likely to occur for this RTA. There are no human receptors that consume or use the limited surface water collected within the playas for any beneficial use. Although ecological receptors (MFTL and desert tortoise) might be present, they are unlikely to consume surface water (Appendix A). Therefore, based on the lack of potential off-site receptors, surface water screening was not conducted for the Gypsum Ridge RTA.

7.30. Sand Hill

The Sand Hill RTA is located on the southwestern corner of MCAGCC Twentynine Palms, forms the southern boundary of the installation (Figure 7.30-1), and covers an area of 16,794 acres (USACE, 2001a). The RTA has been used since 1979 as a maneuver area for blank ammunition and pyrotechnic items only. The RTA contains the Exercise Support Base, Camp Wilson, the Expeditionary Air Field, and the Assault Landing Zone. There are no fixed ranges within the RTA. A desert tortoise study area is present across the northern boundary of the RTA (USACE, 2001b; MCAGCC, 2006).

Based on interviews with Range Control, a primary MC loading area was not delineated for the Sand Hill RTA due to its use as a non-live-fire maneuver area.

Military Munitions

The general classes of military munitions expected in this RTA include small arms ammunition and pyrotechnics. Detailed military munitions use data are presented in the PRA (USACE, 2001b), and detailed assumptions for the determination of MC loading rates are provided in the *REVA Reference Manual* (HQMC, 2006).

7.30.1. CSM

7.30.1.1. Estimated MC Loading

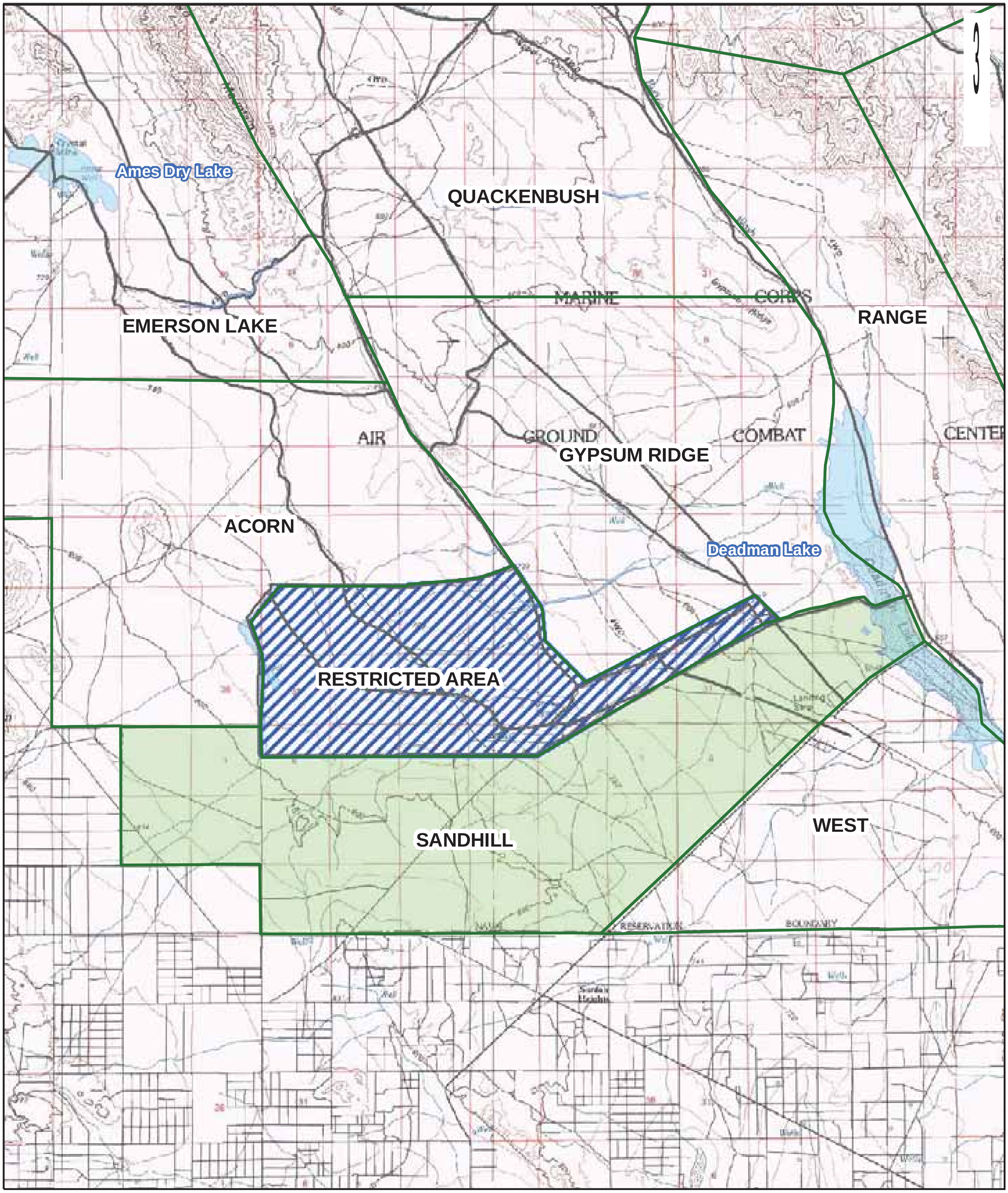
No primary MC loading area was identified within the Sand Hill RTA. In addition, Range Control recorded no military munitions expenditures for the RTA between 2001 and 2005. Because of the lack of expenditure data and the use of this RTA as a strict non-live-fire maneuver area, no MC loading estimation was performed. Historical use MC loading for the Sand Hill RTA area is captured under the Alpha and X-Ray RTAs (from 1969 to 1979) and the Emerson Lake RTA (from 1979 to 1997). There are no SARs located within the Sand Hill RTA; therefore, qualitative assessments to determine the fate and transport of lead were not conducted for this RTA.

7.30.1.2. Geography and Topography

The Sand Hill RTA is located in the southwest corner of MCAGCC Twentynine Palms and is generally characterized as a plateau that slopes east toward Deadman Lake. The elevation of the RTA ranges from 1,763 to 2,743 feet amsl (MCAGCC FMD, 2006).

7.30.1.3. Surface Water Features

There are no perennial surface water features within the Sand Hill RTA. Streambeds are dry, except after infrequent, heavy rainfall (USDA NRCS, 1999). The Sand Hill RTA falls mostly within the Deadman Lake (85%) surface water drainage basin and Goat



LEGEND

- SAND HILL RTA
- RANGE TRAINING AREA
- RESTRICTED AREA
- SURFACE WATER (INTERMITTENT)
- MAIN SUPPLY ROUTE

2 1 0 2 Miles

SOURCE: MCAGCC/NREA GIS OFFICE 2006; TECOM 2006; USGS, VARIOUS DATES.

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SAND HILL RTA

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AUGUST 2008

FIGURE 7.30-1

Mountain (15%) drainage basin. Both drainage basins drain to Deadman Lake and Miller Dry Lake within the installation boundaries (MCAGCC FMD, 2006).

7.30.1.4. Soil Characteristics and Land Cover

The soils at the Sand Hill RTA are generally coarse-grained with some fine-grained soils that range from sandy loam to gravelly loamy coarse sand. The vegetation within the Sand Hill RTA is mainly creosote bush scrub and bare ground. Vegetation is typically denser near the playas (USDA NRCS, 1999; MCAGCC FMD, 2006).

7.30.1.5. Erosion Potential

The erodibility of the Sand Hill RTA is low to moderate based on the soil types and slopes within the area. The RTA was not included in the surface water screening; therefore, an erodibility factor was not selected for the RTA.

7.30.1.6. Groundwater Characteristics

The Sand Hill RTA overlies the Surprise Springs and Deadman Lake groundwater subbasins of the Twentynine Palms basins. The basin and subbasin characteristics are described in **Section 7.14.1.6**.

Portions of the Sand Hill RTA are up gradient, cross gradient, and down gradient of the main water supply wells at MCAGCC Twentynine Palms. The eastern portion of the RTA is within the Deadman Lake subbasin, which is down gradient of the water supply wells. Deadman Lake subbasin is not considered interconnected within the Surprise Springs subbasin.

7.30.1.7. Potential Groundwater and Surface Water Pathways

Groundwater Pathways

MC have the potential to migrate toward the water table at the Sand Hill RTA after dissolution into infiltrating rainwater. This pathway is accentuated by the presence of coarse soils, such as sands and gravel. However, MC have limited potential to migrate vertically due to the infrequent nature of rainfall in the area (less than 5 inches per year), the high evaporative rate, and the depth to the groundwater table. In addition, MC loading is not presently occurring at this RTA and was greatly limited in the past due to its proximity to the installation boundary and the water supply wells.

Surface Water Pathways

Surface water runoff is the dominant pathway for MC transport at MCAGCC Twentynine Palms. The intense rainfall events produce large volumes of water that rapidly run off the bedrock in mountainous areas and travel downstream through the ephemeral streams and dry washes to the playas. The sparse vegetation on the installation does not dissipate the kinetic energy of the surface water as it travels downstream, increasing the potential for

MC migration due to surface water. Runoff collects within the Deadman Lake and Miller Dry Lake playas.

7.30.1.8. Potential Groundwater and Surface Water Receptors

Groundwater Receptors

The Sand Hill RTA overlies the Surprise Springs and Deadman Lake subbasins of the Twentynine Palms basin. Portions of the Sand Hill RTA located on the western boundary of the installation are up gradient of the main water supply wells. The supply wells are considered potential groundwater receptors to the Sand Hill RTA. However, as MC loading is not occurring on this RTA and given the depth to groundwater, it unlikely that detectable concentrations of MC can migrate vertically to groundwater.

Surface Water Receptors

The potential receptors for MC deposited within the RTA are ecological (MFTL and the desert tortoise). MFTL habitat is located in the western portion of the RTA, along the installation boundary, and desert tortoise habitat is located throughout the RTA. However, these receptors are located on range and are unlikely to consume surface water. There are no human receptors for surface water exposure pathways.

7.30.2. Groundwater Analysis Results

A qualitative groundwater analysis was performed by analyzing the source media, migration mechanisms, and exposure pathways documented in the MCAGCC Twentynine Palms CSM. Based on the results of the qualitative analysis of the groundwater information, limited potential exists for MC migration to groundwater and no groundwater receptors associated with the indicator MC are present. Therefore, a groundwater screening-level analysis was not conducted. Discussions of the qualitative analysis and screening-level analysis are presented in **Section 4**.

7.30.3. Surface Water Analysis Results

Since all surface water drainages from the loading area remain within the boundaries of the installation, no off-range release of MC is likely to occur for this RTA. There are no human receptors that consume or use the limited surface water collected within the playas. Although ecological receptors (MFTL and desert tortoise) might be present, they are unlikely to consume surface water (Appendix A). Therefore, based on the lack of potential off-site receptors, surface water screening was not conducted for the Sand Hill RTA.

7.31. West

The West RTA is located on the southern boundary of MCAGCC Twentynine Palms, west of Mainside (Figure 7.31-1). The West RTA covers an area of 10,626 acres and is used as non-live-fire maneuver area (USACE, 2001a). Munitions use is limited to blank ammunition and pyrotechnics. Portions of the Expeditionary Air Field and the Exercise Support Base are contained within the RTA. Range 102 (land navigation range), a non-live-fire range, is contained within the RTA (USACE, 2001b) (Table 7.31-1).

Table 7.31-1: Fixed Ranges within the West RTA

Fixed Range	Range Type	Area (1,000 m^2)
NON-LIVE-FIRE RANGES		
Range 102	Land navigation range	2,454.34

Based on interviews with Range Control, a primary MC loading area was not delineated for the West RTA due to its use as a non-live-fire maneuver area.

Military Munitions

The general classes of military munitions expected in this RTA include blank small arms ammunition and pyrotechnics. Detailed military munitions use data are presented in the PRA (USACE, 2001b), and detailed assumptions for the determination of MC loading rates are provided in the *REVA Reference Manual* (HQMC, 2006).

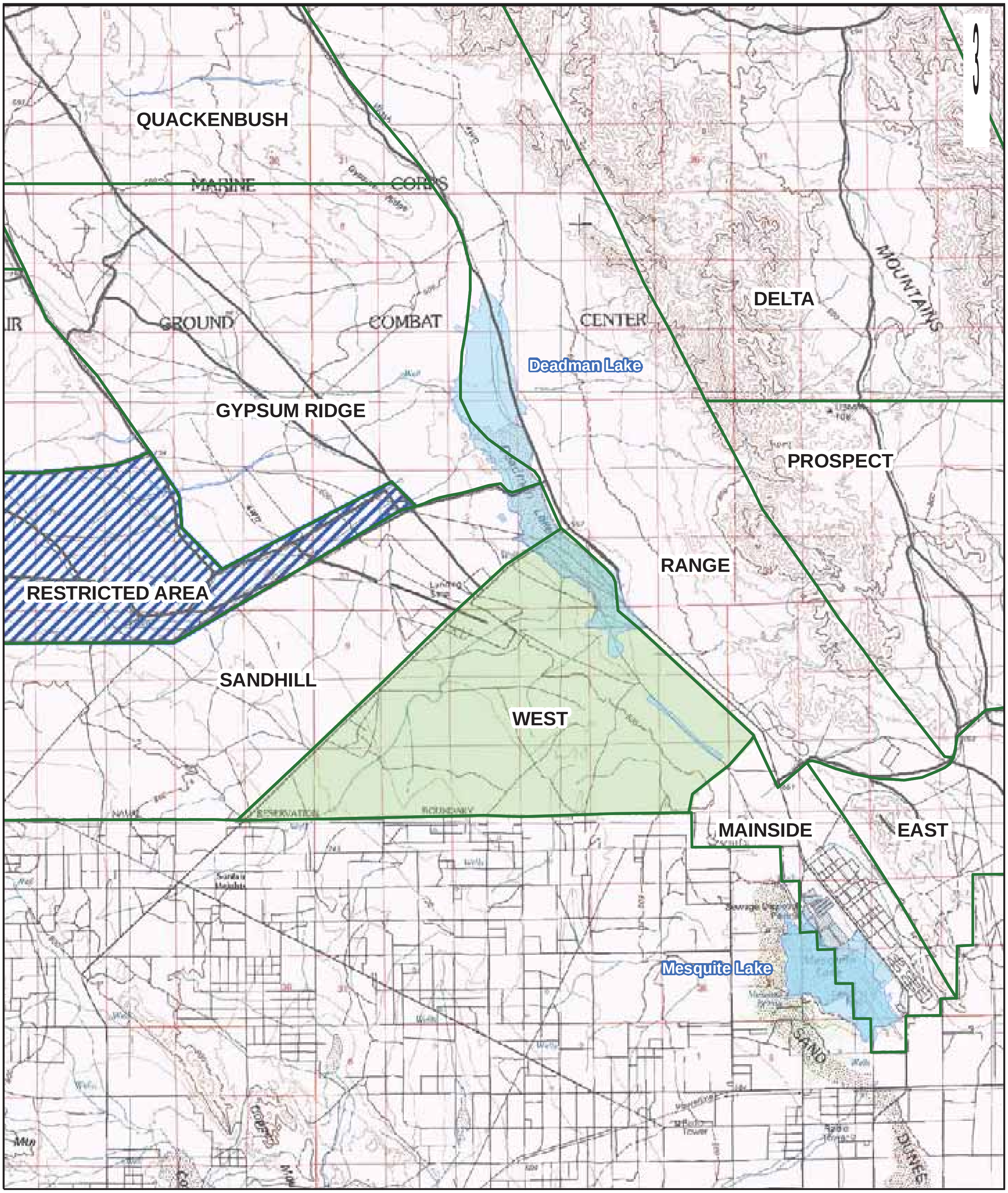
7.31.1. CSM

7.31.1.1. Estimated MC Loading

No primary MC loading area was identified within the West RTA. In addition, Range Control recorded no military munitions expenditures for the RTA between 2001 and 2005. Because of the lack of expenditure data and the use of this RTA as a strict non-live-fire maneuver area, no MC loading estimation was performed. Historical use MC loading for the West RTA was captured under the X-Ray RTA (1969–1979). There are no SARs located within the West RTA; therefore, qualitative assessments to determine the fate and transport of lead were not conducted for this RTA.

7.31.1.2. Geography and Topography

The West RTA is located in the southwest section of MCAGCC Twentynine Palms, in an area characterized by a plateau that slopes east toward Deadman Lake. The elevation of the RTA ranges from 1,706 to 2,507 feet amsl (MCAGCC FMD, 2006).



LEGEND

- WEST RTA
- RANGE TRAINING AREA
- RESTRICTED AREA
- SURFACE WATER (INTERMITTENT)
- MAIN SUPPLY ROUTE

2 1 0 2 Miles

SOURCE: MCAGCC/NREA GIS OFFICE 2006; TECOM 2006; USGS, VARIOUS DATES.

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RANGE ENVIRONMENTAL VULNERABILITY ASSESSMENT

WEST RTA

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FIGURE 7.31-1

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7.31.1.3. Surface Water Features

There are no perennial surface water features within the West RTA. Streambeds are dry, except after infrequent, heavy rainfall (USDA NRCS, 1999). The West RTA falls mostly within the Deadman Lake surface water drainage basin (88%), with a smaller portion drained by the Mesquite Dry Lake drainage basin (12%). The Deadman Lake playa is wholly contained within the installation boundaries of MCAGCC Twentynine Palms. Mesquite Lake is located within Mainside, along the installation boundary. A portion of Mesquite Lake is located outside the boundaries of MCAGCC Twentynine Palms (MCAGCC FMD, 2006).

7.31.1.4. Soil Characteristics and Land Cover

The soils at the West RTA are generally loamy soils with some that range from sandy loam to loamy coarse sand. The vegetation within the West RTA is mainly creosote bush scrub and bare ground (USDA NRCS, 1999).

7.31.1.5. Erosion Potential

The erodibility of the West RTA is low to moderate based on the soil types and slopes within the area. The RTA was not modeled for surface water screening; therefore, an erodibility factor was not selected for the RTA.

7.31.1.6. Groundwater Characteristics

The West RTA lies over the Twentynine Palms Valley and Deadman Lake groundwater subbasins of the Twentynine Palms basin. The basin and subbasin characteristics are described in **Section 7.14.1.6**.

The West RTA is generally down gradient of the main water supply wells at MCAGCC Twentynine Palms. The groundwater flow direction in the Twentynine Palms Valley subbasin is to the south.

7.31.1.7. Potential Groundwater and Surface Water Pathways

Groundwater Pathways

MC have the potential to migrate toward the water table at the West RTA after dissolution into infiltrating rainwater. This pathway is enhanced by the presence of coarse soils, such as sands and gravel. However, MC have limited potential to migrate vertically due to the infrequent nature of rainfall in the area (less than 5 inches per year), the high evaporative rate, and the depth to the groundwater table. In addition, MC loading is not occurring at this RTA, reducing the amount of material potentially available to this migration pathway.

Surface Water Pathways

Surface water runoff is the dominant pathway for MC transport at MCAGCC Twentynine Palms. The intense rainfall events produce large volumes of water that rapidly run off the bedrock in mountainous areas and travel downstream through the ephemeral streams and dry washes to the playas. The sparse vegetation on the installation does not dissipate the kinetic energy of the surface water as it travels downstream, increasing the potential for MC migration due to surface water. Runoff drains to the Deadman Lake and Mesquite Lake playas.

7.31.1.8. Potential Groundwater and Surface Water Receptors

Groundwater Receptors

Because the West RTA is down gradient of the water supply wells, there are no identified groundwater receptors for this RTA.

Surface Water Receptors

The potential receptors for MC deposited within the RTA are ecological receptors (MFTL and the desert tortoise). However, these receptors are located on range and are unlikely to consume surface water. There are no human receptors for surface water exposure pathways.

7.31.2. Groundwater Analysis Results

A qualitative groundwater analysis was performed by analyzing the source media, migration mechanisms, and exposure pathways documented in the MCAGCC Twentynine Palms CSM. Based on the results of the qualitative analysis of the groundwater information, limited potential exists for MC migration to groundwater and no groundwater receptors associated with the indicator MC are present. Therefore, a groundwater screening-level analysis was not conducted. Discussions of the qualitative analysis and screening-level analysis are presented in **Section 4**.

7.31.3. Surface Water Analysis Results

The West RTA drains into the Deadman Lake and Mesquite Lake playas. There are no human receptors that consume or use the limited surface water collected within the playas for any beneficial use. Although ecological receptors (MFTL and desert tortoise) might be present, they are unlikely to consume surface water (Appendix A). Therefore, based on the lack of potential off-site receptors, surface water screening was not conducted for the West RTA.

8. Small Arms Range Assessments

The REVA indicator MC for SARs is lead, as it is the most prevalent (by weight) potentially hazardous constituent associated with small arms ammunition. As described in previous sections, fate and transport parameters for lead at SARs are dependent on site-specific geochemical properties, which cannot be determined solely by physical observation. Therefore, ranges that solely utilize small arms ammunition (defined as nonexplosive ammunition, .50-cal or smaller) for training purposes are qualitatively assessed under the REVA program. Ranges that perform joint small arms and live-fire training with high explosive munitions are not qualitatively assessed through this process; rather, they are assessed through the MC loading process previously described, and no lead loading is performed. In addition, only operational SARs are addressed in this protocol; historical use SARs that are no longer used are not assessed due to lack of information to adequately perform an assessment.

Existing data characterizing range operations, the physical environment, transport mechanisms, and potential receptors were gathered to complete the SAR assessments. The data were used to populate the SAR Assessment Protocol tables, which produce scores for specific factors that may influence potential MC transport and exposure to receptors. The scores are aggregated to determine the overall environmental concern evaluation rankings for surface water and groundwater conditions. The scoring system assigns minimal, moderate, and high values for both environmental concern categories:

- Minimal (0 to 29 points)
- Moderate (30 to 49 points)
- High (50 to 65 points)

The protocol tables for the 12 SARs at MCAGCC Twentynine Palms are provided in Appendix B. A summary of the results of these range assessments is provided in the following sections. Table 8-1 provides a summary of the assessment of each range.

Table 8-1: Summary of SAR Prioritizations

Range Number	Range Type	Surface Water Environmental Concern	Groundwater Environmental Concern
Range 1	Known distance rifle range	Minimal	Minimal*
Range 1A	Unknown distance rifle range	Minimal	Minimal
Range 2	Known distance pistol range	Minimal	Minimal
Range 2A	Combat pistol range	Minimal	Minimal
Range 3	BZO grouping range	Minimal	Minimal
Range 3A	BZO grouping range	Minimal	Minimal*
Range 4	Multipurpose range	Minimal	Minimal*
Range 101	Armor, gun training range (subcaliber)	Minimal	Minimal
Range 101A	Small arms BZO	Minimal	Minimal*
Range 105A	Small arms BZO	Minimal	Minimal*
Range 113	Multipurpose machine gun range	Minimal	Minimal*
Range 113A	Machine gun BZO	Minimal	Minimal*

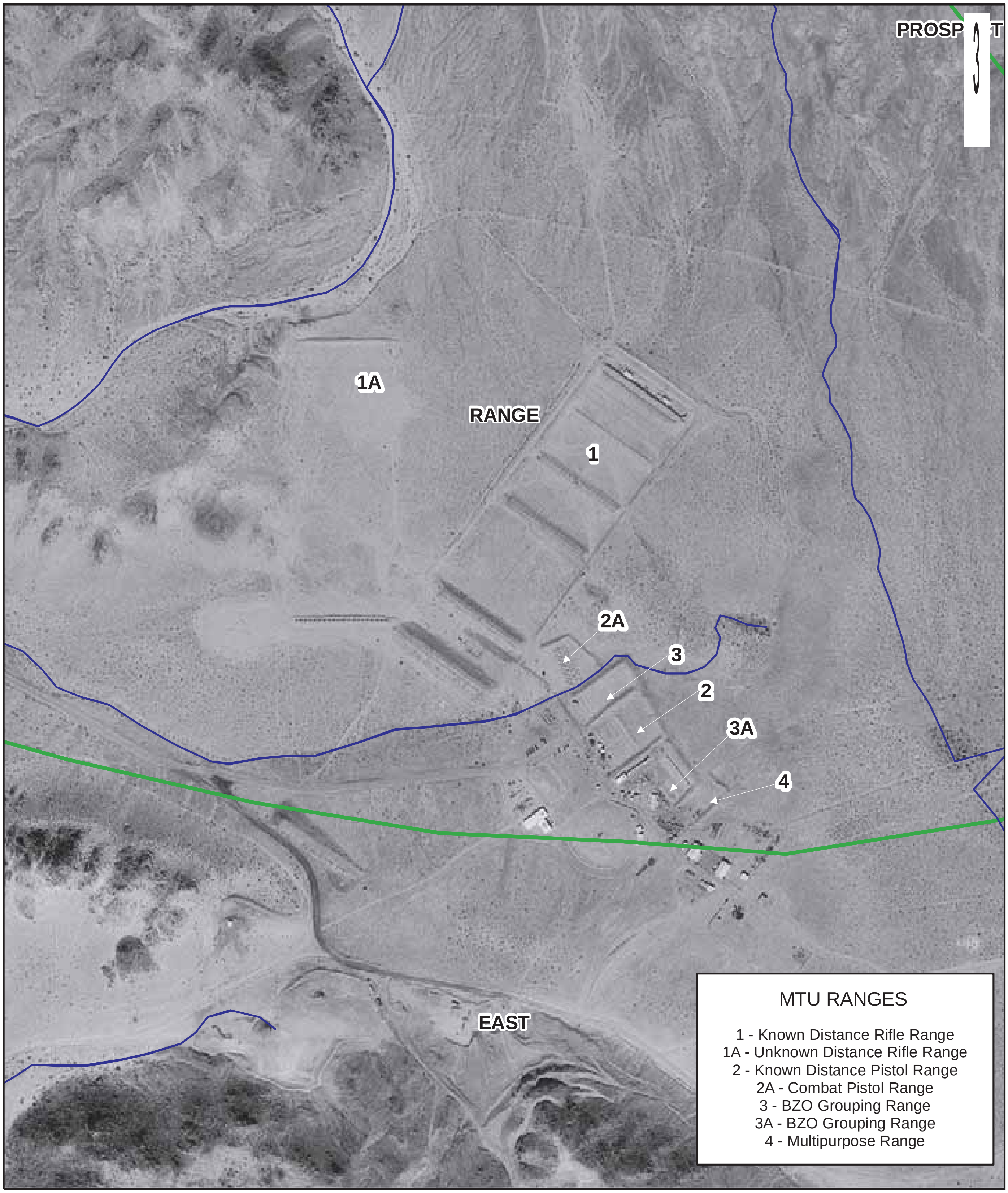
* Original protocol evaluation ranking was moderate; ranking was adjusted based on professional judgment.

8.1. MTU Range 1 – Known Distance Rifle Range

8.1.1. Site Background

The MTU oversees the small arms training and requalification of Marines at MCAGCC Twentynine Palms. The MTU ranges consist of seven SARs located in the Range RTA (Figure 8.1-1). Expenditure data at each range for 2004 and 2005 were obtained from the MTU for use in estimating lead loading. Although only two years of expenditure data were available, it was assumed that this expenditure rate is characteristic of use through the 2000s, given the higher rate of training at the base due to current theater operations.

Range 1 is used by the MTU for rifle proficiency and requalification at known distances. The range consists of several firing lines, earthen side containment berms, and an earthen rear impact berm for bullet containment. Marines behind the rear impact berm raise stationary targets for the shooters on the firing lines during training operations. The range has been used heavily in recent years, with approximately 5,000 to 7,000 pounds of lead estimated to have been deposited in the rear impact berm in both 2004 and 2005 (no data prior to 2004 were available).



LEGEND
RANGE TRAINING AREA
SURFACE DRAINAGE

500 250 0 500 Feet

SOURCE: MCAGCC/NREA GIS OFFICE 2006, TECOM 2006; USGS, VARIOUS DATES.

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MALCOLM PIRNIE	MCAGCC TWENTYNINE PALMS, CALIFORNIA RANGE ENVIRONMENTAL VULNERABILITY ASSESSMENT	MARKSMANSHIP TRAINING UNIT RANGES	MALCOLM PIRNIE, INC. AUGUST 2008 FIGURE 8.1-1

Due to the high training use of this SAR, a bullet trap was installed in 2000/2001 for greater capture and containment of lead fragments. However, the bullet trap was removed within two years of its installation due to range safety concerns; an increased rate of ricochet of expended rounds was observed when the trap was in place. Currently, sand is spread periodically across the face of the impact berm to minimize the formation of deep bullet pockets.

Soil sampling was conducted in 1998 as part of a Small Arms Range Maintenance and Repair Project for the MTU (Battelle, 1998). Results of the sampling effort indicate that, although lead was present in soil up to 1,000 feet from the ranges, the majority of the lead was concentrated within the impact berms. In addition, soil sampling in areas outside of the range footprint and berm areas indicates very limited migration of lead in the subsurface. Soil samples collected from a depth of 4 to 8 inches bgs were within the acceptable limits for lead in soil. These results are applicable for the SAR assessments for all of the MTU ranges because the soil types are similar across all seven ranges.

Surface runoff generated during storm events flows south from Range 1, then southwest for eventual discharge in the Mesquite Dry Lake playa, approximately 2.5 miles from the range. An earthen berm located behind the rear impact berm appears to serve as a partial engineered control by redirecting surface runoff away from the range. Most surface water quickly evaporates due to the high temperatures in the region; only limited infiltration occurs along the courses of surface drainages and less so through low permeability playa soils.

Groundwater depths on the MTU are not known, but the depth to groundwater is expected to be up to 400 feet bgs, given the elevation at the MTU (Battelle, 1998). There are no water supply wells in proximity to the MTU ranges.

Additional site-specific data used to complete the qualitative evaluation of Range 1 are provided in the SAR Assessment Protocol tables in Appendix B.

8.1.2. Assessment Results

Surface Water

The Surface Water Environmental Concern Evaluation Ranking resulted in a Minimal score (27 points). Limited precipitation rates and partial engineered controls (earthen berms) reduce the potential for lead transport. Although intense storms in the winter might cause runoff to act as a transport mechanism, lead from this range would not be expected to reach Mesquite Dry Lake (2.5 miles down gradient) in high concentrations or quantities. On the basis of the SAR Assessment Protocol, there is minimal potential for lead migration and impact to surface water.

Groundwater

The Groundwater Environmental Concern Evaluation Ranking resulted in a Moderate score (32 points). However, it is the professional judgment of the REVA assessment team that the overall concern for lead migration and exposure to groundwater receptors is more accurately categorized as a Minimal level. The groundwater pathway score is biased high by the sandy nature of the soils and the lack of clay in the soil unit. Previous sampling data indicate that lead migration on this range is limited to a maximum of 8 inches from the soil surface. In addition, the depth to groundwater and the lack of groundwater receptors in the area likely preclude any significant groundwater impacts. Therefore, on the basis of professional judgment, there is minimal potential for lead migration and impact to groundwater resources.

8.2. MTU Range 1A – Unknown Distance Rifle Range

8.2.1. Site Background

Range 1A is used to train Marines in long-range rifle firing at targets of unknown or variable distance. The range is the westernmost of the MTU ranges and extends from the south (location of the firing points) to the north (location of the rear targets and rear earthen impact berm) (Figure 8.1-1). The range was constructed in the early 2000s and has received a high level of use in recent years. The estimated annual lead deposition in the rear impact berm at this range is between 3,600 and 6,600 pounds per year.

Surface runoff generated during storm events flows south from Range 1A, then southwest for eventual discharge in the Mesquite Dry Lake playa, approximately 2.5 miles from the range. An earthen berm located behind the rear impact berm appears to serve as a partial engineered control by redirecting surface runoff away from the range. Most surface water quickly evaporates due to the high temperatures in the region; only limited infiltration occurs along the courses of surface drainages and less so through low permeability playa soils.

Groundwater depths on the MTU are not known, but the depth to groundwater is expected to be up to 400 feet bgs, given the elevation at the MTU (Battelle, 1998). There are no water supply wells in proximity to the MTU ranges.

Additional site-specific data used to complete the qualitative evaluation of Range 1A are provided in the SAR Assessment Protocol tables in Appendix B.

8.2.2. Assessment Results

Surface Water

The Surface Water Environmental Concern Evaluation Ranking resulted in a Minimal score for this range (23 points). The range has been in use for a short period of time (less than 10 years), and the distance to the nearest intermittent surface water body (2.5 miles) makes it unlikely that lead from range operations will reach this point of exposure in significant concentrations or quantities. Therefore, there is minimal potential for lead migration and impact to surface water.

Groundwater

The Groundwater Environmental Concern Evaluation Ranking resulted in a Minimal score (28 points), primarily due to the depth to groundwater and the lack of groundwater receptors. In addition, soil sampling results at other MTU ranges indicate the vertical migration of lead is limited to a maximum of 8 inches from the soil surface. Therefore, there is minimal potential for lead migration and impact to groundwater from Range 1A.

8.3. MTU Range 2 – Known Distance Pistol Range

8.3.1. Site Background

Range 2 is the primary pistol proficiency and requalification SAR at the MTU. The range is located in the center of the MTU range complex, between Ranges 3 and 3A (Figure 8.1-1). The range was one of the original three SARs established at the MTU in 1955. The range contains 5-, 15-, and 25-yard firing lines and is bounded laterally with earthen protective berms. The original earthen rear impact berm was replaced by a bullet trap in 2000/2001. Lead was recovered from the original impact berm prior to the installation of the bullet trap.

The estimated deposition of lead at this range is between 3,800 and 7,100 pounds per year. However, the majority of the rounds fired downrange are captured by the bullet trap. Maintenance personnel recover and recycle the lead fragments every three months.

All surface water that falls on the range is captured by a collection system located between the bullet trap and a rear earthen berm. The water is diverted to an existing natural drainage feature that runs between Ranges 2A and 3 and eventually discharges to the Mesquite Dry Lake, approximately 2.5 miles to the southwest. Surface water run-on to Range 2 is prevented by the rear and side berms. The majority of surface water evaporates due to the arid environment.

Groundwater depths on the MTU are not known, but the depth to groundwater is expected to be up to 400 feet bgs, given the elevation at the MTU (Battelle, 1998). There are no water supply wells in proximity to the MTU ranges.

Additional site-specific data used to complete the qualitative evaluation of Range 2 are provided in the SAR Assessment Protocol tables in Appendix B.

8.3.2. Assessment Results

Surface Water

The Surface Water Environmental Concern Evaluation Ranking resulted in a Minimal score (18 points). The presence of a bullet trap on this range greatly limits the potential for lead deposition and migration, as the majority of the lead is captured. Limited precipitation rates reduce the potential for lead transport, and there are no surface water receptors identified in proximity to the range. Therefore, there is minimal potential for lead migration and impact to surface water.

Groundwater

The Groundwater Environmental Concern Evaluation Ranking resulted in a Minimal score (28 points), primarily due to the depth to groundwater and the lack of groundwater receptors. Therefore, there is minimal potential for lead migration and impact to groundwater.

8.4. MTU Range 2A – Combat Pistol Range

8.4.1. Site Background

Range 2A, located between MTU Ranges 1 and 3, is used for training Marines in close-combat handgun operations. The range was established at the MTU at an unknown date; however, the ASR suggests that it was established between 10 and 30 years ago. The range contains several dozen target locations, with small earthen berms at the base of each target. A side berm is present on the northwest side for containment of fired rounds, as is a rear earthen impact berm. Training activities at this range generally result in less firing as compared to other ranges; this is reflected in the expenditure data obtained from the MTU. The estimated deposition of lead at this range is between 140 and 225 pounds per year.

Surface water runoff on the range drains to the southwest through an existing natural drainage feature that eventually discharges to the Mesquite Dry Lake, approximately 2.5 miles to the southwest. Surface water run-on to Range 2A is prevented by the rear and side berms. The majority of surface water evaporates due to the arid environment.

Groundwater depths on the MTU are not known, but the depth to groundwater is expected to be up to 400 feet bgs, given the elevation at the MTU (Battelle, 1998). There are no water supply wells in proximity to the MTU ranges.

Additional site-specific data used to complete the qualitative evaluation of Range 2A are provided in the SAR Assessment Protocol tables in Appendix B.

8.4.2. Assessment Results

Surface Water

The Surface Water Environmental Concern Evaluation Ranking resulted in a Minimal score (23 points). This range has been operational for a shorter period of time compared to some of the other MTU ranges, and training activities result in only marginal deposition of lead in the impact berm. Limited precipitation rates and partial engineered controls (earthen berms) reduce the potential for lead transport, and there are no surface water receptors identified in proximity to the range. Therefore, there is minimal potential for lead migration and impact to surface water.

Groundwater

The Groundwater Environmental Concern Evaluation Ranking resulted in a Minimal score (28 points), primarily due to the depth to groundwater and the lack of groundwater receptors. Therefore, there is minimal potential for lead migration and impact to groundwater.

8.5. MTU Range 3 – BZO Grouping Range

8.5.1. Site Background

Range 3 is used by Marine training units for adjustment of sighting scopes on rifles. The range, located between Ranges 2 and 2A in the center of the MTU range complex, was established as a SAR in 1974 (Figure 8.1-1). Operations at this range generally result in a lower level of expenditures; an estimated 35 to 50 pounds of lead are deposited annually at this range. The range consists of two firing lines, two side impact berms, and a rear bullet trap for capture and containment of fired rounds. The bullet trap was installed in 2000/2001; previously, an earthen impact berm was in place for bullet capture.

All surface water that falls on the range is captured by a collection system located between the bullet trap and a rear earthen berm. The water is diverted to an existing natural drainage feature that runs along the north edge of the range’s side berm and eventually discharges to the Mesquite Dry Lake, approximately 2.5 miles to the southwest. Surface water run-on to Range 3 is prevented by the rear and side berms. The majority of surface water evaporates due to the arid environment.

Groundwater depths on the MTU are not known, but the depth to groundwater is expected to be up to 400 feet bgs, given the elevation at the MTU (Battelle, 1998). There are no water supply wells in proximity to the MTU ranges.

Additional site-specific data used to complete the qualitative evaluation of Range 3 are provided in the SAR Assessment Protocol tables in Appendix B.

8.5.2. Assessment Results

Surface Water

The Surface Water Environmental Concern Evaluation Ranking resulted in a Minimal score (21 points). The presence of a bullet trap on this range greatly limits the potential for lead deposition and migration, as the majority of the lead is captured. In addition, very limited loading of lead is occurring at this range, given the activities conducted at a BZO range. Limited precipitation rates and the presence of the earthen berms reduce the potential for lead transport, and there are no surface water receptors identified in proximity to the range. Therefore, there is minimal potential for lead migration and impact to surface water.

Groundwater

The Groundwater Environmental Concern Evaluation Ranking resulted in a Minimal score (22 points), primarily due to the depth to groundwater and the lack of groundwater receptors. Therefore, there is minimal potential for lead migration and impact to groundwater.

8.6. MTU Range 3A – BZO Grouping Range

8.6.1. Site Background

Range 3A is also designated as a BZO range for use in setting rifle scopes. Range 3A was established as a SAR in 1969. The range is located between MTU Ranges 2 and 4 and shares a side berm with Range 4 to the east (Figure 8.1-1). A rear impact berm is present on the northeast side. Ammunition expenditures at this range are much greater than at the Range 3 BZO; approximately 1,500 to 2,900 pounds of lead are estimated to be deposited annually.

Surface water runoff from precipitation that falls directly on the range appears to collect at a low elevation point on the northwest side of the range. Surface water here likely evaporates quickly due to the arid environment, although some infiltration into the well-drained sandy soils likely occurs as well. Runoff from intense storms that falls on the range may drain to the southwest and eventually discharge to the Mesquite Dry Lake, approximately 2.5 miles to the southwest. Surface water run-on to Range 3A is prevented by the rear impact berm.

Groundwater depths on the MTU are not known, but the depth to groundwater is expected to be up to 400 feet bgs, given the elevation at the MTU (Battelle, 1998). There are no water supply wells in proximity to the MTU ranges.

Additional site-specific data used to complete the qualitative evaluation of Range 3A are provided in the SAR Assessment Protocol tables in Appendix B.

8.6.2. Assessment Results

Surface Water

The Surface Water Environmental Concern Evaluation Ranking resulted in a Minimal score (27 points). Limited precipitation rates and partial engineered controls (earthen berms) reduce the potential for lead transport. Although intense storms in the winter might cause runoff to act as a transport mechanism, lead from this range would not be expected to reach Mesquite Dry Lake (2.5 miles down gradient) in high concentrations or quantities. Therefore, there is minimal potential for lead migration and impact to surface water.

Groundwater

The Groundwater Environmental Concern Evaluation Ranking resulted in a Moderate score (32 points). However, it is the professional judgment of the REVA assessment team that the overall concern for lead migration and exposure to groundwater receptors is more accurately categorized as a Minimal level. The groundwater pathway score is biased high based on the sandy nature of the soils and lack of clay in the soil unit. Previous sampling data from nearby MTU ranges indicate that lead migration on this range is limited to a maximum of 8 inches from the soil surface. In addition, the depth to groundwater and the lack of groundwater receptors in the area likely preclude any significant groundwater impacts. Therefore, on the basis of professional judgment, there is minimal potential for lead migration and impact to groundwater resources.

8.7. MTU Range 4 – Multipurpose Range

8.7.1. Site Background

Range 4 is used for various purposes and weaponry, including pistol, shotgun, and rifle training. The exact date the range was established is not known; however, information provided in the ASR suggests the range is between 10 and 30 years old. Range 4 is the easternmost range at the MTU complex (Figure 8.1-1). The range contains a single firing line, two side containment berms (sharing the western berm with Range 3A), and a rear earthen impact berm. Expenditures at this range result in an estimated deposition of between 1,600 and 3,000 pounds of lead per year.

Surface water runoff on the range collects at a low elevation point on the northern end of the range floor at the base of the western berm. The surface water at this location infiltrates due to the sandy, well-drained soils or evaporates. Ephemeral washes near Range 4 drain to the southeast and eventually discharge to Dale Lake, located off of the installation approximately 18 miles to the southeast. Surface water run-on to Range 4 is prevented by the rear impact berm. The majority of surface water evaporates due to the arid environment.

Groundwater depths on the MTU are not known, but the depth to groundwater is expected to be up to 400 feet bgs, given the elevation at the MTU (Battelle, 1998). There are no water supply wells in proximity to the MTU ranges.

Additional site-specific data used to complete the qualitative evaluation of Range 4 are provided in the SAR Assessment Protocol tables in Appendix B.

8.7.2. Assessment Results

Surface Water

The Surface Water Environmental Concern Evaluation Ranking resulted in a Minimal score (25 points). Limited precipitation rates and partial engineered controls (earthen berms) reduce the potential for lead transport. Although intense storms in the winter might cause runoff to act as a transport mechanism, most surface water evaporates on range; any lead washed from this range by flood events would not be expected to reach Dale Lake (18 miles down gradient) in high concentrations or quantities. Therefore, there is minimal potential for lead migration and impact to surface water.

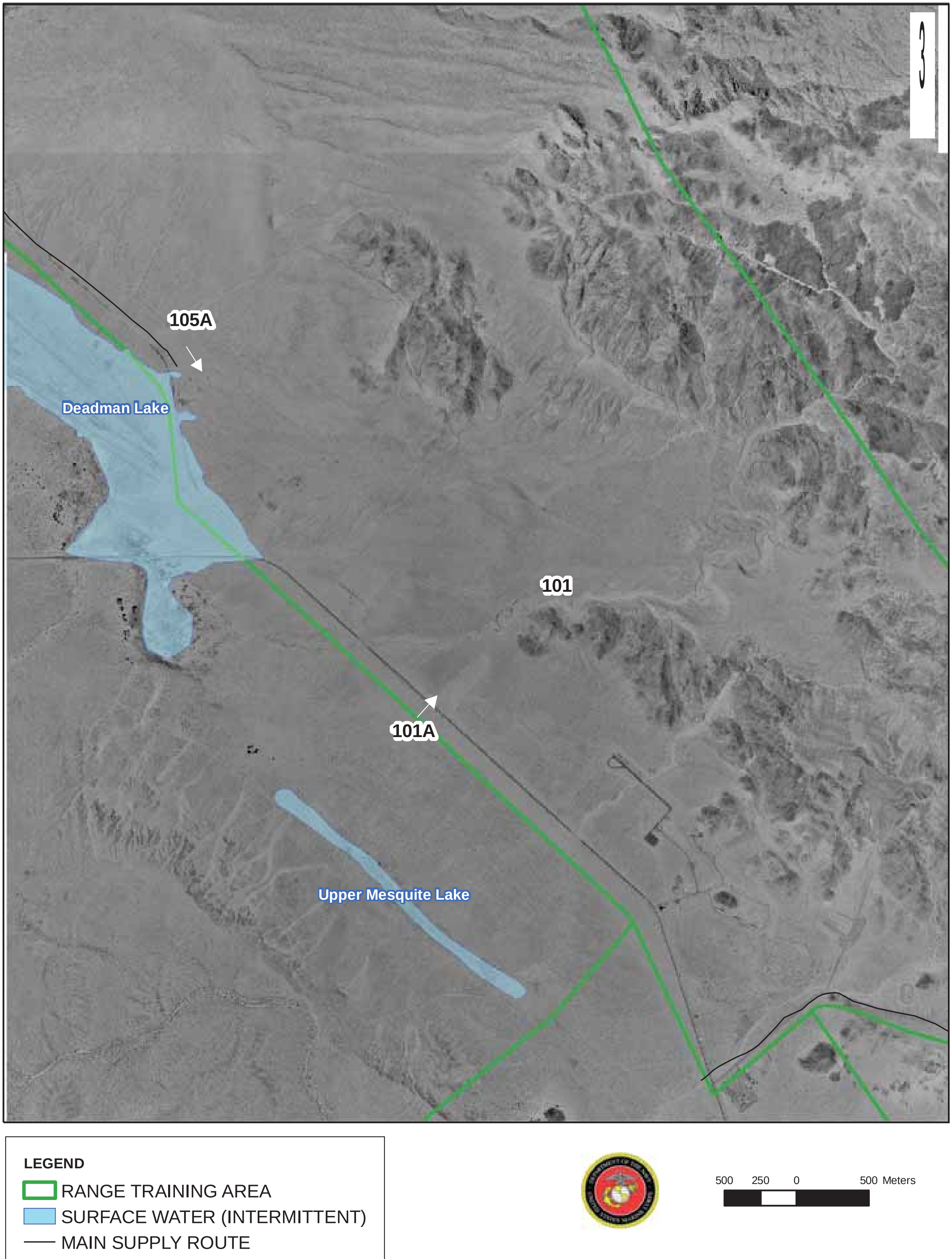
Groundwater

The Groundwater Environmental Concern Evaluation Ranking resulted in a Moderate score (30 points). However, it is the professional judgment of the REVA assessment team that the overall concern for lead migration and exposure to groundwater receptors is more accurately categorized as a Minimal level. The groundwater pathway score is biased high based on the sandy nature of the soils and lack of clay in the soil unit. Previous sampling data indicate that lead migration on this range is limited to a maximum of 8 inches from the soil surface. In addition, the depth to groundwater and the lack of groundwater receptors in the area likely preclude any significant groundwater impacts. Therefore, on the basis of professional judgment, there is minimal potential for lead migration and impact to groundwater resources.

8.8. Range 101 – Armor, Gun Training Range (Subcaliber)

8.8.1. Site Background

Range 101 is located on the southern end of the Range RTA (Figure 8.8-1). The range was first noted in the 1984 Range Standard Operating Procedure for the installation. The range is used for training of small caliber and subcaliber weapons on armor units (USACE, 2001a). A boresighting range capable of accommodating three tanks is located adjacent to the range (Range 101A). Arms fire is directed from the firing line to the northeast toward the base of the Bullion Mountains. There is no rear impact berm at the back of the range for collection of small arms projectiles.



SOURCE: MCAGCC/NREA GIS OFFICE 2006, TECOM 2006; USGS, VARIOUS DATES.

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MALCOLM PIRNIE	MCAGCC TWENTYNINE PALMS, CALIFORNIA RANGE ENVIRONMENTAL VULNERABILITY ASSESSMENT	RANGES 101, 101A AND 105A	MALCOLM PIRNIE, INC. AUGUST 2008 FIGURE 8.8-1

Expenditure data for the years 2001 through 2005 were obtained from Range Control to estimate the amount of lead loading occurring at the range. Low rates of expenditure are noted for 2001, 2003, and 2004 (less than 100 pounds of lead loaded per year). No expenditures were noted in 2002 and 2005.

Range 101 drains to the west through gullies that are dry except after heavy rains. Two large surface drainages bisect the northern and central sections of the range fan. Drainages discharge to Deadman Lake within the Range RTA, approximately 1.25 miles to the northwest. The majority of surface water evaporates due to the arid environment.

The depth to water at a well southwest of Deadman Lake is approximately 134 feet bgs; it is likely that the depth to water is greater where the range is located. The installation drinking water wells are located up gradient of the range and are hydrogeologically separated from the range by a large fault. The down gradient groundwater basin, Mesquite basin, is not used as a drinking water source because of high mineral content.

Additional site-specific data used to complete the qualitative evaluation of Range 101 are provided in the SAR Assessment Protocol tables in Appendix B.

8.8.2. Assessment Results

Surface Water

The Surface Water Environmental Concern Evaluation Ranking resulted in a Minimal score (22 points) for this range. The range has been in use for a short period of time, minimal lead loading is occurring, and the distance to the nearest intermittent surface water body makes it unlikely that lead from range operations will migrate to this point of exposure in high concentrations or quantities. In addition, Deadman Lake, the ultimate surface water exposure point, is considered to be completely contained on range. As the REVA considers potential MC releases and exposures to off-range receptors only, there are no surface water receptors for this SAR. Therefore, there is minimal potential for lead migration and impact to surface water.

Groundwater

The Groundwater Environmental Concern Evaluation Ranking resulted in a Minimal score (29 points), primarily due to the depth to groundwater and the lack of groundwater receptors. Therefore, there is minimal potential for lead migration and impact to groundwater.

8.9. Range 101A – Small Arms BZO Range

8.9.1. Site Background

Range 101A is a boresighting range located immediately adjacent to Range 101 (Figure 8.8-1). The range consists of a firing line, side impact berms, and a rear earthen impact berm that absorbs the small arms projectiles. Small arms expenditures were noted to be minimal between 2001 and 2003 (between 10 and 340 pounds of lead deposited per year), but increased greatly in 2004 and 2005 (between 700 and 1,200 pounds per year). The exact date of establishment of this range is not known, but it is assumed it was constructed at the same time as Range 101.

Range 101A drains to the west through gullies that are dry except after heavy rains. A large natural drainage feature is present west of the range. Drainages discharge to the southern end of Deadman Lake within the Range RTA, approximately 1.25 miles to the northwest. The majority of surface water evaporates due to the arid environment.

Groundwater conditions at Range 101A are similar to those described for Range 101. The down gradient groundwater basin, Mesquite basin, is not used as a drinking water source because of high mineral content.

Additional site-specific data used to complete the qualitative evaluation of Range 101A are provided in the SAR Assessment Protocol tables in AppendixB.

8.9.2. Assessment Results

Surface Water

The Surface Water Environmental Concern Evaluation Ranking resulted in a Minimal score (25 points). The infrequent precipitation and distance to the nearest intermittent surface water body (Deadman Lake, 1.25 miles to the northwest) make it unlikely that lead from range operations will migrate to this point of exposure in high concentrations or quantities. In addition, there are no surface water receptors at Deadman Lake, as described previously for Range 101. Therefore, there is minimal potential for lead migration and impact to surface water.

Groundwater

The Groundwater Environmental Concern Evaluation Ranking resulted in a Moderate score (33 points). However, it is the professional judgment of the REVA assessment team that the overall concern for lead migration and exposure to groundwater receptors is more accurately categorized as a Minimal level. The groundwater pathway score is biased high based on the sandy nature of the soils and lack of clay in the soil unit. Previous sampling data at a similar range location (MTU ranges) indicate that lead migration is limited to a maximum of 8 inches from the soil surface. In addition, the depth to groundwater and the lack of groundwater receptors in the area likely preclude any significant groundwater impacts. Therefore, on the basis of professional judgment, there is minimal potential for lead migration and impact to groundwater resources.

8.10. Range 105A – Small Arms BZO Range

8.10.1. Site Background

Range 105A, located immediately adjacent to Range 105 (a gas chamber), is used as a gun scope sighting range (Figure 8.8-1). The range is not listed in the 2001 ASR and is assumed to have been present for only a short period of time (less than 10 years). The range contains a firing line, side berms, and rear earthen impact berm for projectile containment. Similar to Range 101A, expenditures at this range were moderate between 2001 and 2003 (140 to 360 pounds lead deposited annually) and then increased greatly in 2004 and 2005 (1,300 to 4,100 pounds of lead annually).

Range 105A drains to the southwest through gullies that are dry except after heavy rains. Deadman Lake is the closest surface body, located downstream of the range less than one-quarter of a mile to the west. The lake does not drain off the installation. The majority of surface water evaporates due to the arid environment.

The depth to water at a well southwest of Deadman Lake is approximately 25 feet bgs; given the higher elevation at Range 105A, it is likely the depth to water is greater where the range is located. Groundwater wells are located approximately 6.5 miles from Range 105A.

Additional site-specific data used to complete the qualitative evaluation of Range 105A are provided in the SAR Assessment Protocol tables in Appendix B.

8.10.2. Assessment Results

Surface Water

The Surface Water Environmental Concern Evaluation Ranking resulted in a Minimal score (20 points). This score is predominantly based on the short period of use and moderate level of lead loading occurring at the range. In addition, the earthen berms at the range serve as a partial engineered control to prevent run-on from entering the range. Transport of lead is likely minimized by the limited precipitation and high rate of evaporation in the area. There are no off-range surface water receptors for this range, as described previously.

Groundwater

The Groundwater Environmental Concern Evaluation Ranking resulted in a Moderate score (30 points). The groundwater pathway score is based mostly on the sandy nature of the soils, lack of clay in the soil unit, and the estimated depth to groundwater. While the depth to groundwater east of Deadman Lake is not known, groundwater depths tend to become shallower as the local topography flattens toward a playa. It is noted that previous sampling data at a similar range location (MTU ranges) indicate that lead migration is limited to a maximum of 8 inches from the soil surface. As such, it is the professional judgment of the REVA assessment team that the ranking is more accurately described as a Minimal level, given the very limited potential for lead migration through the vadose zone.

8.11. Range 113 – Multipurpose Machine Gun Range

8.11.1. Site Background

Range 113 was established in the early 1980s as a tank combat course, but has since been modified exclusively for small arms use (Figure 8.11-1). The range provides computer-controlled targets from 100 to 1,000 m for machine gun training (USACE, 2001a). The targets are set up in 10 lanes, with each pair of lanes in a different configuration. The range contains a 260-meter-long firing line, with fire directed to the northeast toward the Bullion Mountains. Small arms expenditures were high for all years except 2003, in which a moderate degree of loading occurred (approximately 600 pounds of lead deposited). The highest expenditure rates to date occurred in 2005, with approximately 8,500 pounds of lead estimated to have been deposited on the range.

Range 113 drains to the southeast through gullies that are dry except after heavy rains. Deadman Lake is the closest surface body, located 2.5 miles to the south-southeast of the range. The majority of surface water evaporates due to the arid environment. Based on aerial photographs, a surface drainage control (either a ditch or berm) is in place in the center of the range fan to divert surface runoff and prevent run-on from entering the range.

The depth to water at a well southwest of Deadman Lake is 100 feet bgs; given the higher elevation at Range 113, it is likely the depth to water is greater where the range is located. Water supply wells are approximately 7 miles form the range.

Additional site-specific data used to complete the qualitative evaluation of Range 113 are provided in the SAR Assessment Protocol tables in Appendix B.

8.11.2. Assessment Results

Surface Water

The Surface Water Environmental Concern Evaluation Ranking resulted in a Minimal score (21 points). The range has been in use for a moderate period of time and partial engineered controls help to minimize surface runoff from entering the range floor. In

LEGEND

RANGE TRAINING AREA

MAIN SUPPLY ROUTE

500 250 0 500 Meters

SOURCE: MCAGCC/NREA GIS OFFICE 2006, TECOM 2006; USUGS, VARIOUS DATES.

MALCOLM PIRNIE

MCAGCC TWENTYNINE PALMS, CALIFORNIA

RANGE ENVIRONMENTAL VULNERABILITY ASSESSMENT

RANGES 113 AND 113A

MALCOLM PIRNIE, INC.

AUGUST 2008

FIGURE 8.11-1

Map Document: (S:\GIS_Resources\Standards_Guidelines\MapTemplates\GIS_TEMPLATES_2005\11X8.5_Portrait.mxt)
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addition, the large distance to the nearest intermittent surface water body makes it unlikely that lead from this range will migrate to this point of exposure in elevated concentrations. There are no off-range surface water receptors associated with this range. Therefore, there is minimal potential for lead migration and impact to surface water.

Groundwater

The Groundwater Environmental Concern Evaluation Ranking resulted in a Moderate score (33 points). However, it is the professional judgment of the REVA assessment team that the overall concern for lead migration and exposure to groundwater receptors is more accurately categorized as a Minimal level. The groundwater pathway score is biased high by the sandy nature of the soils and lack of clay in the soil unit. Previous sampling data at a similar range location (MTU ranges) indicate that lead migration is limited to a maximum of 8 inches from the soil surface. In addition, the depth to groundwater and the lack of groundwater receptors in the area likely preclude any significant groundwater impacts. Therefore, on the basis of professional judgment, there is minimal potential for lead migration and impact to groundwater resources.

8.12. Range 113A – Machine Gun BZO Range

8.12.1. Site Background

Range 113A is a boresighting range for machine guns located west of Range 113 (Figure 8.11-1). Range 113A was established at an unknown date. Given its use as a BZO range in support of training activities at the adjacent Range 113, it is likely that the range is between 10 and 30 years old. The range is constructed similar to other BZO ranges. Bullets concentrate within the rear earthen impact berm. Small arms expenditures were moderate in 2001 (approximately 260 pounds of lead deposited), minimal in 2002 and 2003 (between 50 and 100 pounds per year), and high in 2004 and 2005 (between 1,100 and 3,000 pounds per year).

Similar to Range 113, Range 113A drains to the southeast through gullies that are dry except after heavy rains. Deadman Lake is the closest surface water body, located 3.5 miles to the south-southeast of the range. The majority of surface water evaporates due to the arid environment.

The depth to water at a well approximately 6 miles southwest of Deadman Lake is 100 feet bgs; given the higher elevation at Range 113A, it is likely the depth to water is greater where the range is located. Water supply wells are located approximately 7.5 miles from the range.

Additional site-specific data used to complete the qualitative evaluation of Range 113A are provided in the SAR Assessment Protocol tables in Appendix B.

8.12.2. Assessment Results

Surface Water

The Surface Water Environmental Concern Evaluation Ranking resulted in a Minimal score (23 points). Range use has been estimated for a moderate period of time, and partial engineered controls help to minimize surface runoff from entering the range floor. In addition, the distance to the nearest intermittent surface water body makes it unlikely that lead from range operations will migrate to this point of exposure. There are no off-range receptors associated with this range. As such, there is minimal potential for lead migration and impact to surface water.

Groundwater

The Groundwater Environmental Concern Evaluation Ranking resulted in a Moderate score (31 points). However, it is the professional judgment of the REVA assessment team that the overall concern for lead migration and exposure to groundwater receptors is more accurately categorized as a Minimal level. The groundwater pathway score is biased high by the sandy nature of the soils and lack of clay in the soil unit. Previous sampling data at a similar range location (MTU ranges) indicate that lead migration is limited to a maximum of 8 inches from the soil surface. In addition, the depth to groundwater and the lack of groundwater receptors in the area likely preclude any significant groundwater impacts. Therefore, on the basis of professional judgment, there is minimal potential for lead migration and impact to groundwater resources.

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