*United States Marine Corps*

# Range Environmental Vulnerability Assessment

# Periodic Review Guidance Manual

May 2018

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# NOTICE

The policies and procedures set forth herein are intended solely as guidance to United States Marine Corps (Marine Corps) installations and activities and their contractors. This guidance does not constitute a rulemaking by the Marine Corps and cannot be relied on to create a substantive or procedural right enforceable by any party in litigation with the United States. The Marine Corps may take action that is at variance with the policies and procedures in this manual and may change them at any time without public notice.

Following the date of its publication, this manual is intended to be used as guidance for the Range Environmental Vulnerability Assessment (REVA) program conducted by the Marine Corps in accordance with Department of Defense Instruction (DoDI) 4715.14, *Operational Range Assessment* (Department of Defense (DoD) 2005) as part of the Marine Corps Sustainable Range program. This manual supersedes the *Final Range Environmental Vulnerability Assessment Five-Year Reference Manual* (HQMC, 2010). Issuance of this manual does not invalidate any assessments completed before the publication date that are based on previously released Marine Corps guidance.

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# ACRONYMS

| | |
|---|---|
| AT123D | Analytical Transient 1-, 2-, and 3-Dimensional Simulation of Waste Transport in the Aquifer System |
| AVS | Acid Volatile Sulfide |
| BLM | Biotic Ligand Model |
| BMP | Best Management Practice |
| C.F.R. | Code of Federal Regulations |
| CSM | Conceptual Site Model |
| DO | Dissolved Oxygen |
| DoD | Department of Defense |
| DoDI | Department of Defense Instruction |
| DoDIC | Department of Defense Identification Code |
| DON | Department of the Navy |
| DQO | Data Quality Objective |
| ESCI | Environmental Software Consultants Incorporated |
| FY | Fiscal Year |
| GDM | GEOFidelis Data Model |
| GEOFidelis | Marine Corps Installation Geospatial Information and Services |
| GIS | Geographic Information System |
| HMX | Cyclotetramethylene Tetranitramine |
| HQMC | Headquarters Marine Corps |
| INRMP | Integrated Natural Resources Management Plan |
| ISM | Incremental Sampling Methodology |
| ISQAPP | Installation-Specific Quality Assurance Project Plan |
| ITRC | Interstate Technology & Regulatory Council |
| LOD | Limit of Detection |
| LOQ | Limit of Quantitation |
| MC | Munitions Constituents |
| MCRTAMS | Marine Corps Range and Training Area Management System |
| MCAS | Marine Corps Air Station |
| MCICOM GF-5 | Marine Corps Installation Command-Environmental Management |
| MCO | Marine Corps Order |
| MIDAS | Munitions Items Disposition Action System |

| | |
|---|---|
| MMRP | Military Munitions Response Program |
| MS | Matrix Spike |
| MSD | Matrix Spike Duplicate |
| NAVFAC | Navy Facilities Engineering Command |
| NTUs | Nephelometric Turbidity Units |
| OB | Open Burn |
| OD | Open Detonation |
| OSD | Office of the Secretary of Defense |
| PAO | Public Affairs Officer |
| POC | Point of Contact |
| PQAPP | Programmatic Quality Assurance Project Plan |
| QA | Quality Assurance |
| QAPP | Quality Assurance Project Plan |
| QC | Quality Control |
| QSM | Quality Systems Manual |
| RBSL | Risk Based Screening Level |
| RCRA | Resource Conservation and Recovery Act |
| RDX | Cyclotrimethylene Trinitramine |
| REVA | Range Environmental Vulnerability Assessment |
| RFMSS | Range Facilities Management Support System |
| RPD | Relative Percent Difference |
| SDZ | Surface Danger Zone |
| SEM | Simultaneously Extracted Metals |
| SESOIL | Seasonal Soil |
| SLERA | Screening-Level Ecological Risk Assessment |
| SOP | Standard Operating Procedure |
| SSSHP | Site-Specific Safety and Health Plan |
| TCR | Target Cancer Risk |
| TECOM | Training and Education Command |
| THQ | Target Hazard Quotient |
| TNT | Trinitrotoluene |
| U.S.C. | United States Code |
| UCL | Upper Confidence Limit |

| | |
|---|---|
| USEPA | United States Environmental Protection Agency |
| USACE | United States Army Corps of Engineers |
| USGS | United States Geological Survey |
| UXO | Unexploded Ordnance |

# 1. INTRODUCTION

United States Marine Corps (Marine Corps) operational ranges are essential to the mission of defending the United States. Operational ranges on Marine Corps installations serve as testing and training platforms that provide resources suitable to fulfill Marine Corps Title 10 responsibilities, which include:

- organizing, training, and equipping fleet marine forces of combined arms;
- providing detachments and organizations for service on armed vessels of the navy; and
- providing security detachments for the protection of naval property at naval stations and bases.

Operational ranges include all military ranges that are under the jurisdiction, custody, or control of the Secretary of a military department that are (1) used for range activities (i.e., the use and handling of military munitions, other ordnance, and weapons systems) or (2) although not currently being used for range activities, are still considered by the Secretary as a range and have not been put to a new use incompatible with range activities (10 United States Code [U.S.C.] § 101(e)(3)). The Marine Corps operates training ranges on installations around the world. These ranges include live-fire ranges (e.g., small arms ranges, medium and large caliber ranges, demolition ranges, and dudded and non-dudded impact areas), maneuver training areas, and many other training facilities (e.g., landing zones) dedicated to individual and collective combined arms training.

The Range Environmental Vulnerability Assessment (REVA) program is a non-regulatory, proactive, and comprehensive approach for ensuring the environmental sustainability of Marine Corps operational ranges and meets the requirements established by Department of Defense (DoD) Instruction (DoDI) 4715.14, *Operational Range Assessments* (DoD ,2005). DoDI 4715.14 establishes policies and procedures to ensure the long-term sustainability of operational ranges while being protective of the environment. In doing so, the DODI 4715.14 provides instruction to aid in the determination of whether a release or substantial threat of a release of munitions constituents (MC) from an operational range to an off-range area creates an unacceptable risk to human health or the environment. MCs are any materials originating from unexploded ordnance (UXO) or other military munitions, including explosive and non-explosive materials, and emission, degradation, or breakdown elements of such ordnance or munitions (10 U.S.C. § 2710(e)(4)).

REVA baseline assessments were conducted between fiscal year (FY) 04 and FY08, with subsequent five-year review assessments conducted between FY10 and FY14. In accordance with this REVA Periodic Review Guidance Manual, the Marine Corps will conduct REVA Periodic Reviews every five years, or sooner if changes in range use or conditions warrant.

## 1.1 Purpose

The REVA Guidance Manual supports the sustainable use of Marine Corps ranges and implements DoDI 4715.14. The REVA Guidance Manual sets forth processes and procedures for conducting periodic reviews of operational ranges at Marine Corps installations to fulfill the primary REVA purpose of:

> *Determining whether there has been a release or substantial threat of release of MC from an operational range or range complex to off-range areas that creates an unacceptable risk to human health and the environment*.

This manual incorporates changes to the REVA process established in previous guidance documents and lessons learned from previous assessments. Specifically, this manual contains updates to:

- methods applied to assess various types of ranges;
- roles and responsibilities of involved commands and other stakeholders;
- quantity and types of data necessary for the assessment;
- sequence of the assessment process with emphasis placed on the conceptual site model (CSM) during decision making;
- whether fate and transport modeling or sampling is conducted; and
- decision criteria for drawing conclusions or continued monitoring of sampling locations.

The subjects covered in this manual are intended to inform the user about the applicable requirements under the Marine Corps REVA program and to provide information on the processes and materials necessary to assess off-range environmental impacts from training. Note that each portion of this manual may not be applicable to every installation and activities covered within are subject to installation-specific situations and needs.

## 1.2 Program Goals and Objectives

The primary goals of the REVA program are to:

- extend the long-term viability and utility of operational ranges to meet the National Defense mission; and
- protect human health and the environment.

In order to achieve these goals, the REVA assessments must answer the following primary study question: *Is there MC migration from the operational range to an off-range area that creates an unacceptable risk to human health or the environment?*

In order to answer this primary study question, this manual provides guidance and processes for accomplishing the following objectives:

- create a CSM that identifies sources of MC, potential migration pathways, and receptors and determine source-receptor interactions;
- evaluate the concentration of MC in the environmental media (e.g., surface water, groundwater, and sediment) of potential migration pathways between identified MC sources and off-range receptors; and
- assess whether MC in environmental media off-range creates an unacceptable risk to the identified receptors.

In addition, the REVA Guidance Manual contains procedures for:

- reporting assessment results internally within the Marine Corps and DoD and externally to state or federal regulatory agencies and the public; and
- recommending and implementing actions required to mitigate MC migration that may pose an unacceptable risk to human health or the environment.

The information obtained under the REVA program, regarding the migration of MC from an operational range to an off-range area, will assist Marine Corps decision-makers in ensuring environmental compliance and enhancing the long-term sustainability of Marine Corps operational ranges.

## 1.3 Roles and Responsibilities

The execution of REVA requires a cooperative approach among various organizations comprising the REVA Management Team. A cooperative approach can minimize the impact on facility resources while effectively streamlining data collection and evaluation to achieve assessment goals. The REVA Management Team has been established to assist in the development of REVA guidance, policy, documentation, and other products and guide and enhance communication at all levels. The REVA Management Team includes Headquarters Marine Corp (HQMC)/Marine Corps Installation Command (MCICOM) Environmental Management (HQMC (LF)/(MCICOM (GF-5)), MCICOM Range (MCICOM G-3), Training and Education Command (TECOM), Installation Environmental office, Installation Range Managers, Navy Facilities Engineering Command (NAVFAC), and the REVA Technical Support Team. The REVA Management Team lines of communication are presented on Figure 1. The overall REVA responsibilities for each role are listed in Table 1.

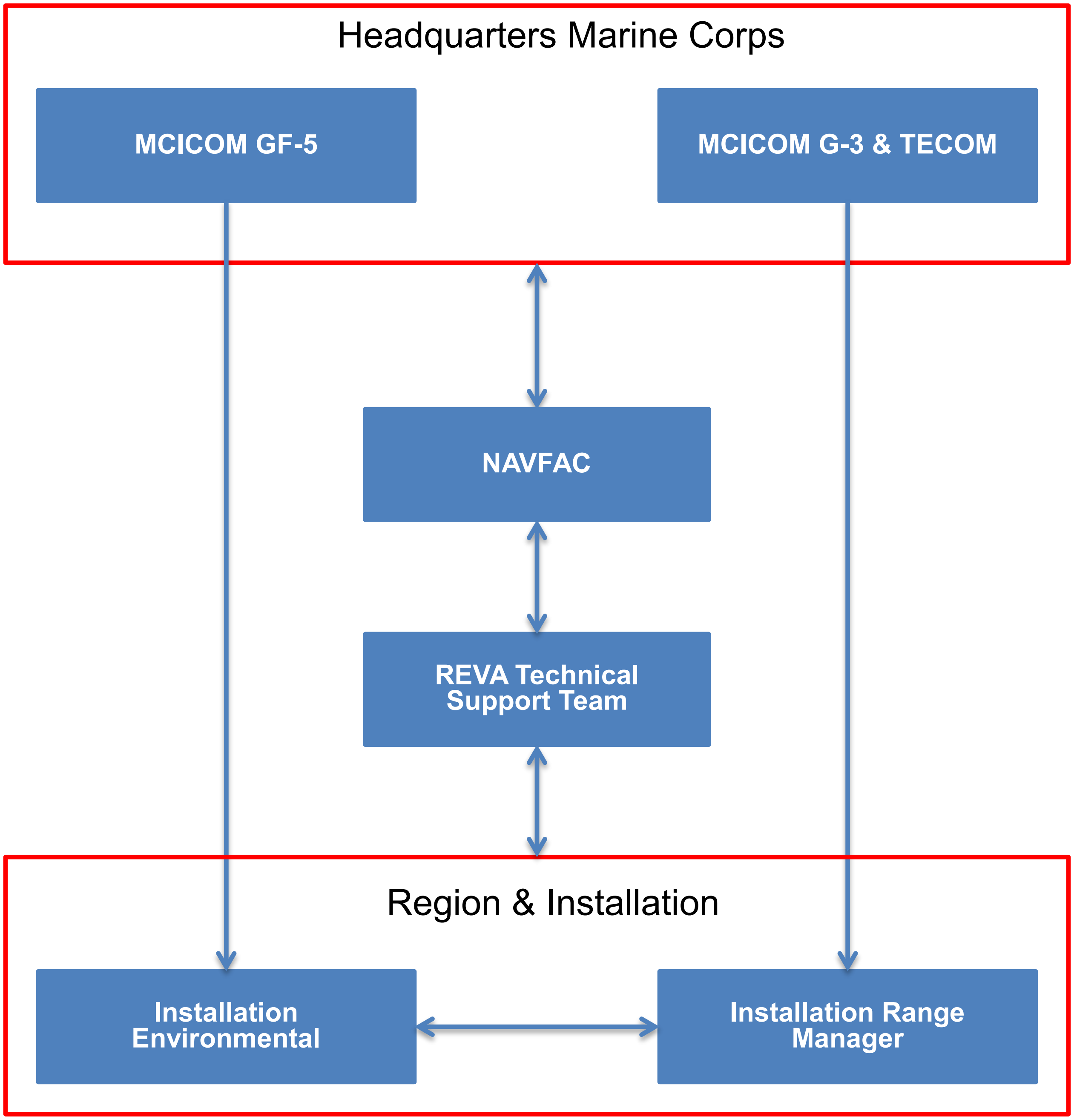


**Figure 1. Range Environmental Vulnerability Assessment Management Team**

**Table 1. Range Environmental Vulnerability Assessment (REVA) Organizational Responsibilities**

| Office Name | REVA Responsibilities |
|---|---|
| REVA Management Team | • Serve as the oversight body to support the development and review of REVA policies, guidance, documentation and other information. Decisions should be made by consensus to the extent possible.<br>• Support communication of information to appropriate stakeholders |
| HQMC LF/MCICOM GF-5 | • Manage and maintain the REVA program; monitor changes to applicable statutes, regulations, instructions, manuals, or other guidance and polices that affect the content of the REVA program; and update this REVA Guidance Manual when significant changes occur.<br>• Identify, plan, program, and budget resources for REVA activities.<br>• Notify the appropriate Marine Corps, Department of the Navy (DON), and Office of the Secretary of Defense (OSD) offices of any discovery of a release or substantial threat of release of MC from an operational range or range complex to an off-range area that creates an unacceptable risk to human health or the environment.<br>• Prepare and submit documentation and provide briefings, as requested to OSD indicating the progress made in implementing the REVA program.<br>• Facilitate coordination and information collection with TECOM, installation environmental personnel, Installation Range Manager, NAVFAC, and the REVA Technical Support Team to support execution of REVA while minimizing negative effects on range operations.<br>• Serve as a member of the REVA Management Team.<br>• Review and respond to REVA Periodic Review documents generated by the REVA Technical Support Team throughout the assessment process.<br>• Support installation coordination with regulatory agencies and the public before, during, and after REVA periodic reviews, as appropriate.<br>• Attend site visits and conduct project status briefings. |
| MCICOM G-3 & TECOM | • Serve as members of the REVA Management Team and a liaison to the Installation Range Manager offices to facilitate implementation of the REVA program.<br>• Protect operational range interests by ensuring proper procedures and protocols are developed and followed for accessing and using range data.<br>• Facilitate coordination with Installation Range Managers to support data collection and execution of REVA with minimal effect on range operations.<br>• Assist with the retrieval of Range Facilities Management Support System (RFMSS) data and range standard operating procedures (SOPs).<br>• Coordinate with range points of contact (POCs) for scheduling range tours, as needed.<br>• Assist in the coordination of and attend site visits and REVA status briefings.<br>• Review and contribute to REVA documents.<br>• Assist in ensuring the operational range inventory identified in the REVA accurately reflects all operational ranges used by the Marine Corps. |
| NAVFAC | • Issue and manage REVA technical support contracts.<br>• Serve as a member of the REVA Management Team to facilitate gathering and generating REVA data and deliverables.<br>• Attend and participate in site visits and REVA status briefings.<br>• Review and contribute to REVA documents. |

| Office Name | REVA Responsibilities |
|---|---|
| Installation Environmental Office | • Respond to requests for installation POCs information and facilitate base access, if needed.<br>• Facilitate the collection of installation-specific data by the REVA Technical Team.<br>• Notify HQMC LF/MCICOM GF-5 and REVA Technical Support Team of updates to critical REVA data (e.g., new uses of water resources, new development adjacent to installations, and new analytical data for MC in environmental media) during review and upon request.<br>• Manage stakeholder involvement and environmental risk communication support for HQMC LF/MCICOM GF-5 and installations.<br>• Review and contribute to REVA documents.<br>• Participate in REVA implementation meetings and briefings for their respective installations.<br>• Serve as a POC for liaison activities with state and federal regulatory agencies for range assessments. This includes providing assistance with notifying regulatory authorities of REVA results, in coordination with HQMC/MCICOM and TECOM. |
| Installation Range Manager | • Maintain an accurate installation operational range inventory.<br>• Identify new/modified activities on ranges that may impact REVA.<br>• Designate a POC to coordinate necessary personnel, safety procedures, range access, and actions to implement the REVA.<br>• Respond to requests for installation-specific data by the REVA Technical Support Team.<br>• Review and contribute to REVA documents.<br>• Participate in REVA implementation meetings and briefings for their respective installations. |
| REVA Technical Support Team<br><br>(contractor) | • Serve as a member of the REVA Management Team and technical liaison to the Installation Range Manager and environmental offices to facilitate implementation of the REVA program.<br>• Coordinate with identified environmental and range installation contacts to facilitate data collection and schedule on-site activities. Conduct research, collect data, and perform data analysis in accordance with this REVA Guidance Manual.<br>• Develop draft REVA documentation of findings and factsheets.<br>• Coordinate draft deliverables with all REVA Management Team members. |

# 2. APPLICABILITY

This chapter presents information on operational ranges that will be assessed in accordance with the requirements of this REVA Guidance Manual and ranges that are excluded from REVA. The REVA program applies to all Marine Corps operational ranges; however, each portion of this manual may not be applicable to every installation. The organizational structure and range types vary across installations. The subject areas covered in this guidance manual are intended to inform the user about the applicable requirements and provide the processes and materials used to perform a thorough analysis under the REVA program.

## 2.1 Eligible Ranges

The scope of the REVA program includes Marine Corps operational land and water ranges located within the United States.

An operational range (10 U.S.C. § 101(e)(3)) is a range that is under the jurisdiction, custody, or control of the Secretary of a military department and:

- is used for range activities (i.e., the use and handling of military munitions, other ordnance, and weapons systems); or
- although not currently being used for range activities, is still considered by the Secretary to be a range and has not been put to a new use that is incompatible with range activities.

Operational ranges include, but are not limited to, fixed ranges, live-fire maneuver areas, small arms ranges, buffer areas, and training areas where military munitions are known to be or suspected to have been used (see definition of military range in the glossary). For REVA, the term operational range includes both firing ranges and training areas. For definitions of terms and abbreviations used throughout this document, see the Glossary.

Marine Corps operational ranges are subject to the requirements of the REVA program unless specifically excluded (see Section 2.2).

Operational ranges owned by the Marine Corps (even if used or leased by other military services or law enforcement) are subject to the requirements of REVA. Operational ranges operated by the Marine Corps, but owned or leased by other military services, are subject to the operational range assessment program of the owning military service. The military service with real property ownership of the range shall conduct the assessment, unless an alternate agreement is prepared in writing for the operator of the range to conduct the assessment.

## 2.2 Excluded Ranges

Some range types are specifically excluded from DoDI 4715.14 and are not assessed as part of the REVA program (DoD, 2005). Operational ranges excluded from the REVA program are listed below.

- Ranges located entirely indoors with no exposure to the elements or the outdoors; MC associated with the aforementioned ranges is presumed to be contained and not transportable to the outdoor environment.

- Operational ranges permitted under an already established regulatory program (i.e., Resource Conservation and Recovery Act [RCRA] Subpart X permits). The Marine Corps currently has two such ranges—at Marine Corps Air Station (MCAS) Yuma and MCAS Beaufort that will continue to be evaluated as part of RCRA compliance and not within REVA.
- Closed ranges. Ranges in the process of closure will undergo one final REVA review after the date of closure.
- Ranges outside the United States and its territories.

The following facilities do not meet the definition of an operational range and are not subject to the REVA program:

- Munitions manufacturing, logistics, or storage facilities.
- Munitions demilitarization or treatment facilities, such as permitted open burn (OB)/open detonation (OD) sites, unless they are co-located on operational ranges or are also set aside, managed, and used for munitions training activities.
- Areas taken out of service as an operational range and officially determined to be permanently removed from operational range inventory or put to a use incompatible with range activities.
- Former military ranges (e.g., other than operational ranges) that are subject to the Defense Environmental Restoration Program.
- Munitions Response Sites addressed in the Military Munitions Response Program (MMRP), as they are no longer set aside, managed, and used for military test and training activities. Additionally, the management and funding of MMRP sites are conducted under a separate DoD program.

# 3. METHODOLOGY

The REVA methodology focuses on answering the primary question: *Is there MC migration from the operational range to an off-range area that creates an unacceptable risk to human health or the environment?* The methodology also assists in identifying any necessary management actions to sustain the long-term use of operational ranges. The following actions are addressed within this chapter:

- overview of the methodology for assessment (Section 3.1.)
- review of available site information for developing or updating the CSM (Section 3.2.)
- conducting installation site visit (Section 3.2.2.)
- sampling for MC and required quality assurance (QA) and quality control (QC) measures (Section 3.3.)
- modeling MC migration (Section 3.4.)
- preliminary identification of potential human and ecological receptors, exposure pathways, and potential for risk (Section 3.5.2.)
- interim technical memoranda for communicating to decision makers (Sections 0 and 3.6)

## 3.1 Overview of the REVA Process

Figure 2 is a graphical representation of the REVA process. The process begins with the development (or update) of the CSM, where existing site data are collected and assessed to identify potential MC sources, migration pathways, and receptors. The CSM results are documented in an interim technical memorandum (Section 0). At any point in the process where there is sufficient evidence to conclude there is no source-receptor interaction, the findings are documented, and the assessment is complete. Pathways identified as complete or inconclusive may require further assessment through MC fate and transport modeling or MC sampling and analysis. The sampling and modeling procedures are designed and executed to quantify MC migration for complete pathways and fill any data gaps associated with inconclusive pathways in the CSM. The results of the sampling, modeling, or other investigation are documented in a second interim technical memorandum (Section 3.6). In instances where this investigation indicates MC are migrating off the operational range complex at concentrations greater than or equal to an applicable state or federal screening value (Section 3.5.2.4), a preliminary or screening level risk assessment is performed to determine whether MC migration creates an unacceptable risk to the receptors (e.g., human health or ecological) identified in the CSM. The risk evaluation is captured in the third interim technical memorandum (Section 4.4). If the MC migration presents an unacceptable risk to human health or the environment, the site is managed within the appropriate range management and/or environmental restoration program as applicable for response and risk management. REVA Periodic Review findings are documented in accordance with Chapter 6.

The REVA process focuses on assessing MC migration off the range complex. For REVA, operational ranges include firing ranges and training areas (see the perimeter formed by the blue line on Figure 3). Off-range areas are outside the boundaries of an operational range complex or outside a single operational range where there is only one range in the area. The off-range area closest to an operational range may be outside the installation boundary or on installation property, such as cantonment areas adjacent to the range complex. Off-range migration means that MC has moved outside the defined operational range boundary via a migration pathway through environmental media (e.g., surface water, sediment, soil, or groundwater).

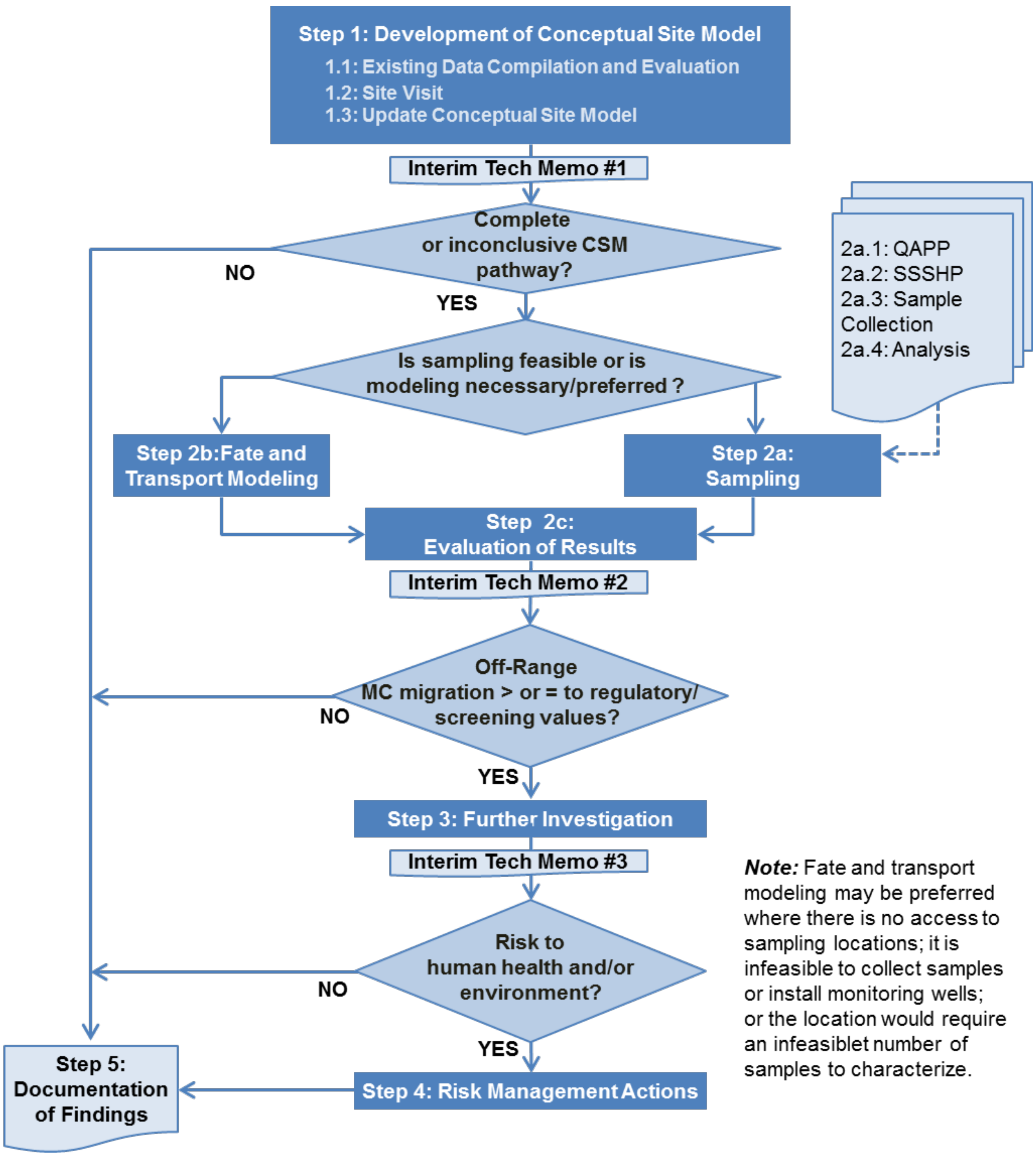


**Figure 2. REVA Process**

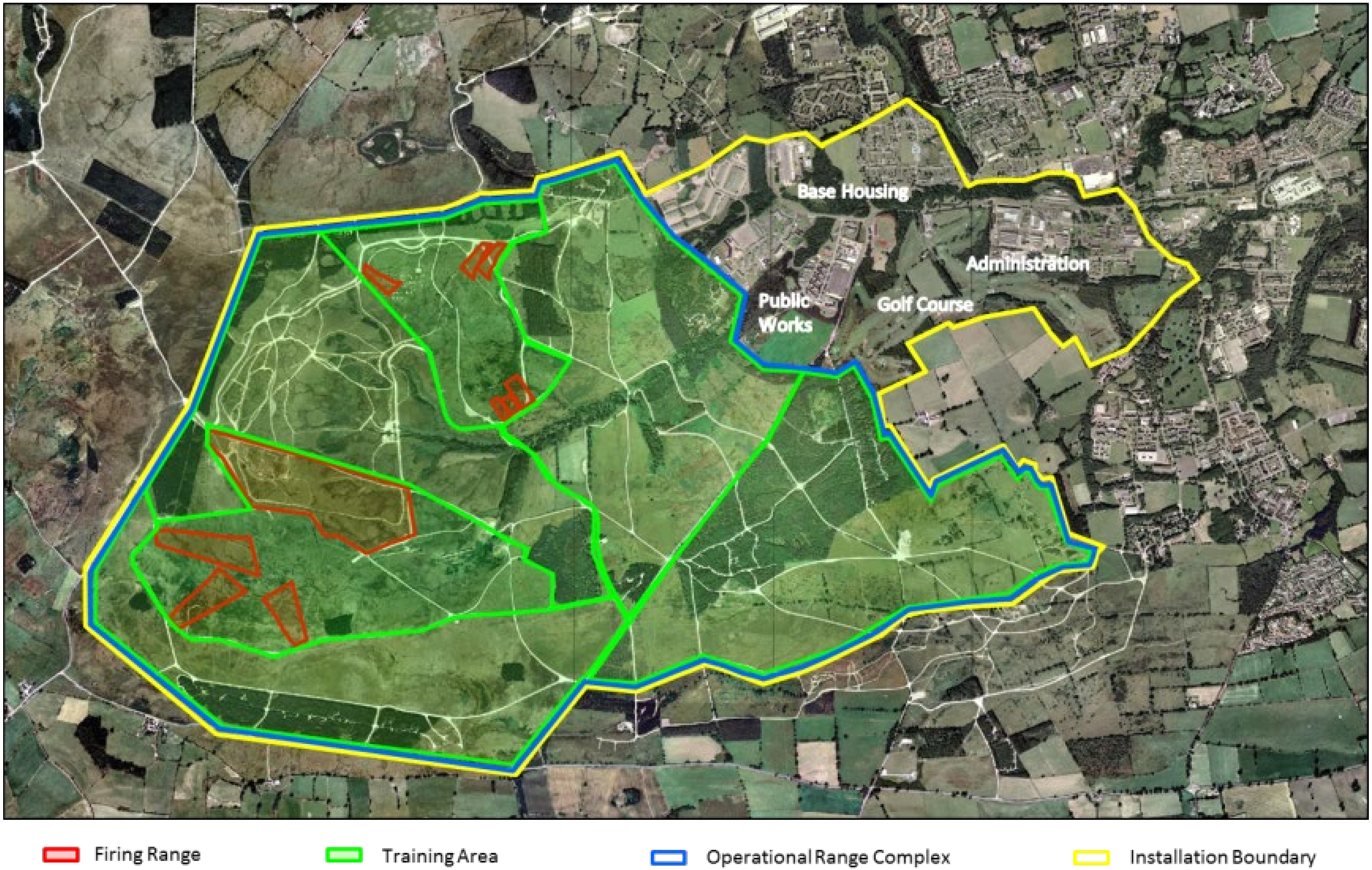


**Figure 3. Illustration of Range, Range Complex, and Installation Boundaries**

## 3.2 Development/Update of Conceptual Site Model

This section presents the data requirements and process for creating or updating a CSM. A REVA CSM may be tabular or graphical and provides a description of the physical conditions of the installation's operational range complex, military munitions and corresponding MC loading (deposition), MC migration pathways, and receptors. A CSM is a standard way to document information, assumptions, or initial data interpretation. A CSM will be developed for each range or group of ranges—based on similar migration pathways—and will become more focused as the REVA project proceeds. Independent CSMs should be created for land and water ranges that identify each MC migration and exposure pathway as:

- Complete – The pathway includes viable MC sources, migration pathways, and receptors and data indicate there is source-receptor interaction.
- Incomplete – The pathway lacks a viable MC source, migration pathway, or receptors OR the data indicate there is no source-receptor interaction.
- Inconclusive – The pathway includes viable MC sources, migration pathways, and receptors but there is insufficient data to conclude the pathway is either complete or incomplete.

The REVA Technical Support Team may decide to develop multiple CSMs when the site contains multiple physically distinct MC source areas or source areas within distinct watersheds.

### 3.2.1 Existing Data Compilation and Evaluation

During this step, the REVA Technical Support Team gathers and evaluates information to develop a preliminary CSM or update a previously developed CSM. This step requires gathering available site information about MC source areas, migration pathways, and receptors. A CSM will be based on site-specific characterization data that describe the dominant transport processes as accurately as possible. The information needed for each CSM element is listed in Table 2. When performing a periodic review of an installation that has undergone a previous REVA evaluation, the prior CSM information compiled within the previous REVA documents (e.g., Baseline, Five-Year, or Periodic Reviews) will be reviewed to determine whether it is still applicable. Supplemental data compilation for updating the REVA CSM should focus on identifying any changes in:

- range management practices;
- range uses;
- munitions expenditures;
- range design, construction, orientation, and footprints;
- natural resource uses;
- development on or surrounding the installation or encroachment;
- off-range human or ecological receptors;
- MC sampling/monitoring executed from the time of the last assessment to present (if any); and
- status and effectiveness of any protective measures or best management practices (BMPs) implemented.

| Table 2. Information Needed for CSM | |
|---|---|
| **Elements** | **Information Needed** |
| Installation | • Installation location<br>• Date of installation establishment<br>• Installation area and layout<br>• Installation mission |
| Operational Range | • Range names<br>• Range boundaries<br>• Date of range establishment<br>• Range design and use<br>• Target and/or impact areas<br>• Munitions expenditures<br>• MC types<br>• Maintenance<br>• Engineered controls |
| Physical | • Climate<br>• Elevation<br>• Topography<br>• Stratigraphy<br>• Hydrostratigraphic units<br>• Soil and vadose zone characteristics<br>• Erosion potential |
| Surface Water | • Surface water and drainage<br>• Hydrological unit and watershed areas<br>• Designated drinking water sources<br>• Designated agricultural or other beneficial uses<br>• Floodplains<br>• Lakes, ponds, and reservoirs |
| Groundwater | • Groundwater aquifers<br>• Groundwater supply wells<br>• Designated agricultural or other beneficial uses<br>• Recharge source(s)<br>• Porous or fracture flow/depth to groundwater<br>• Gradient and flow velocity<br>• Discharge location(s) |
| Human Use and Exposure | • Current and planned land use (including main cantonment area)<br>• Consumption of fish or shellfish<br>• Current human receptors<br>• Land use restrictions |
| Natural Resources | • Ecosystems<br>• Vegetation<br>• Fauna<br>• Sensitive species habitat and threatened or endangered species |

The REVA Technical Support Team will collect as much of the required data as possible through accessible databases and centrally managed sources (e.g., HQMC Environmental Management Portal, GEOFidelis). These data will be supplemented with data and documents collected directly from installation personnel through a combination of electronic file transfer, telephone interviews, and site visits.

A separate coordination effort must be conducted through MCICOM G3 and TECOM to support range-related data collection. The REVA Support Technical Team will develop a list of range-related data needs and a list of ranges that they plan to tour, if a site visit is needed. MCICOM G3 and TECOM will work through the Installation Range Manager's office to obtain the data and to schedule a site visit, including range tours. The data typically requested will include:

- range SOPs;
- the range complex master plan;
- munitions expenditure data from RFMSS;
- range clearance after action reports;
- range-related geographic information system (GIS) layers including range boundaries, targets, and firing points;
- range maintenance data;
- Range Safety Officer handouts; and
- any other exercise-related information pertaining to munitions target/impact areas.

#### *3.2.1.1 Indicator Munitions Constituents*

The REVA program assesses potential migration of MC found on Marine Corps ranges, which includes explosives constituents, ammonium and potassium perchlorate, and metals. REVA focuses on the most common and mobile of these MC, referred to as indicator MC, and include:

- Lead
- cyclotetramethylene tetranitramine (HMX)
- cyclotrimethylene trinitramine (RDX)
- trinitrotoluene (TNT)
- 1,3,5-TNB*
- 1,3-DNB*
- 2A-4,6-DNT*
- 4A-2,6-DNT*
- DNT-mixture 2,4/2,6*
- 2,6-DNT*
- 2,4-DNT*
- 2-NT (o-)*
- 3-NT (m-)*
- 4-NT (p-)*
- Perchlorate

*Explosives degradation or breakdown products

Among the explosives MC, REVA focuses on TNT, HMX, RDX, and their respective degradation and breakdown products. TNT and RDX have been detected in studies on the occurrence of MC in soil and groundwater at ranges, and TNT, RDX, HMX, and perchlorate can persist in the environment (Jenkins, Bartolini and Ranney, 2003). Studies have also shown that high explosive components RDX, HMX, and perchlorate are mobile within the environment and have the highest potential to migrate off range (Jenkins, 2005).

Metals associated with ammunition commonly used at operational ranges include lead, antimony, copper, and zinc. REVA focuses on lead as the MC indicator. Lead is primarily associated with small arms military munitions and is the most prevalent metal found in soils on operational ranges. Lead has been shown to have limited vertical migration potential through soil matrices; however, like many contaminants, lead has the potential to migrate in surface water pathways. Site-specific conditions (i.e., geochemical properties) are useful in quantitatively assessing lead migration, and this information is largely available from existing soil chemistry databases and can be supplemented where necessary via sampling and chemical analysis. Many studies have indicated that metallic lead (such as recently fired, unweathered bullets and shot) generally has low chemical reactivity, low solubility in water, and is relatively inactive in the environment under most ambient or common conditions. However, lead deposited on a range may become mobile in certain conditions (e.g., acidic soils, shallow groundwater, soils with low cation exchange capacity, high erosion rates, and proximity to surface waters) (Clausen et al., 2007, Cao et al., 2003).

If the REVA identifies migration of an aforementioned indicator MC at levels presenting a potential risk to human health or the environment, the REVA Management Team may decide to expand the list of MC under consideration. The team may analyze for additional MC appropriate to the munitions expended at the MC loading area.

#### *3.2.1.2 Development of Preliminary Conceptual Site Model*

Based on a review of the existing data, the REVA Technical Support Team formulates a preliminary CSM that identifies sources of MC loading, type(s) and relative quantity of MC at the site, pathways for MC transport (i.e., surface water, sediment, and groundwater), exposure pathways, and specific receptors (see Section 3.2.3 for detailed descriptions). The REVA Technical Support Team identifies any data gaps that lead to an inconclusive result for pathway analysis. The REVA Technical Support Team generates a list of data gaps that guide the site visit to meet range-specific data needs.

#### *3.2.1.3 Operational Range Summary Tables and Figures*

Based on a review of existing data, the REVA Technical Support Team develops an operational range summary in the form of a table and associated figures. This material is provided to the installation for review prior to conducting a site visit to facilitate coordination and discussion with Range Manager personnel. The site visits ensures that the REVA Technical Support Team has correctly documented range names, usage rates, and munitions used at each range so that the subsequent evaluations are accurate. Information should include training area and/or range name, range type, usage dates, status (active, historical use, inactive), acreage, and authorized military munitions.

#### *3.2.1.4 Read-Ahead Package*

The REVA Technical Support Team will—in collaboration with HQMC/MCICOM and TECOM—prepare a read-ahead package to inform the installation POCs of the planned REVA data collection activities, and to provide information, in advance, to support a review of data generated since the most recent REVA documents and facilitate any necessary site visits. The installation environmental office will receive a Department of the Navy (DON) Tracker task from HQMC LF/MCICOM GF-5 requesting the review of, and response to, the read-ahead package. The installation environmental office will coordinate with appropriate installation offices and provide the read-ahead package for review. The read-ahead package will include:

- a brief summary of the REVA process, installation-specific results to date, and upcoming data collection activities;
- identification of HQMC/MCICOM, TECOM, and REVA Technical Support Team POCs;
- request for an installation POC list of personnel able to respond to questions from the REVA Technical Support Team;
- request for specific GIS data and any security authorization forms needed to release the data; and
- identification of whether a site visit is required and list of specific dates requested for the site visit (For a range site visit, the DON Tracker tasking will request security access requirements for the installation and range complex.)

The REVA Technical Support Team will contact installation POCs to collect pertinent installation documentation to support a review of data generated since the most recent REVA report. During data collection, GIS data layers will be collected and rectified to reflect the new data. Most range and environmental GIS offices hold different types of data that are pertinent to the evaluation. Often, an authorization form is required for the release of GIS data to the REVA Technical Support Team, this form will be included in the read-ahead package. GIS data associated with the REVA must be compliant with the latest GEOFidelis Data Model (GDM) version (currently GDM 3.0.0.2), to include population of attributes according to GDM and applicable Data Layer Specification guidance. The GIS information will also be compatible with Marine Corps Range and Training Area Management System (MCRTAMS).

### 3.2.2 Site Visit

HQMC LF/MCICOM GF-5 may determine that a site visit is necessary for installations where significant changes to ranges, range operations, migration pathways, or receptors have occurred since the last review. The review of data generated since the most recent REVA report and any necessary site visits should be used to verify the accuracy of the information used to create the preliminary CSM, fill any data gaps identified, and refine potential sampling locations (should sampling be required). Site visits typically are conducted over a 2- to 3-day period and focus on the REVA Technical Support Team identifying or verifying:

- new ranges or changes to range design, locations, sizes, or orientations;
- changes in the physical environment on the range or along migration pathways (e.g., removal of soil, erosion, alterations of vegetation or watercourse);
- changes in training operations or range management practices;

- changes in receptors (human and ecological) or changes in protected species classification near the operational range;
- new land uses (e.g., residential, industrial, agricultural, and recreational) near the range boundary;
- changes in water usage (e.g., drinking water) of groundwater and surface water on the installation or near the range boundary; and
- any planned changes to the above.

Upon site visit completion, the REVA Technical Support Team will update the CSM to reflect newly identified information and include it in an interim technical memorandum to HQMC LF/MCICOM GF-5 that details recommended next steps and provide supporting information. Information for drafting the interim technical memorandum after the updated CSM is generated can be found in Section 0.

### 3.2.3 Conceptual Site Model (CSM)

The REVA Technical Support Team will develop/validate/update an installation-specific CSM—graphical and/or tabular styles shown on Figure 4 and Figure 5—that documents the relationship between MC sources, migration and exposure pathways, and receptors. The CSM will depict the source-pathway-receptor relationships at the site, which helps to identify data gaps and focus subsequent data collection. The CSM will be maintained and updated as new information is collected. The following sections describe how MC sources, migration and exposure pathways, and receptors are identified and the criteria for how pathways are deemed complete, inconclusive, or incomplete.

#### *3.2.3.1 Identifying Sources (MC Loading Areas)*

MC loading occurs on the range surface where MC is deposited during training. Loading areas may encompass the entire range or they could be a smaller area within the range boundary (e.g., impact berm). Multiple operational ranges may be consolidated into a single MC loading area if they physically overlap. Conversely, operational ranges may be subdivided into multiple MC loading areas if compelling data are available to separate them into discrete deposition areas, such as specific target arrays. Separate CSMs may be defined for distinct loading areas within a single range complex or for loading areas that drain into separate watersheds each with unique pathway-receptor relationships.

Some operational ranges may have multiple MC loading areas stemming from historical changes in range use and direction of fire. In such cases, it may be more appropriate to define a larger collective MC loading area for use in the CSM. Given the uncertainty associated with defining the historical range usage the MC loading area may conservatively defined by using a broad definition that encompasses the surface danger zones (SDZs) of multiple ranges as a single MC loading area.

Sources of information that assist in defining MC loading areas include GIS data, aerial photography (current and historical), installation maps and documents, and range use data from Installation Range Manager personnel. MC loading areas are influenced by range use and topography. For instance, a bombing target that has consistently been approached in one direction will likely have an elongated MC loading area, accounting for early and late target engagements. Likewise, a range with a distinct ridgeline within the MC loading area may best be defined with two CSMs, one for migration pathways into drainages on either side of the ridge.

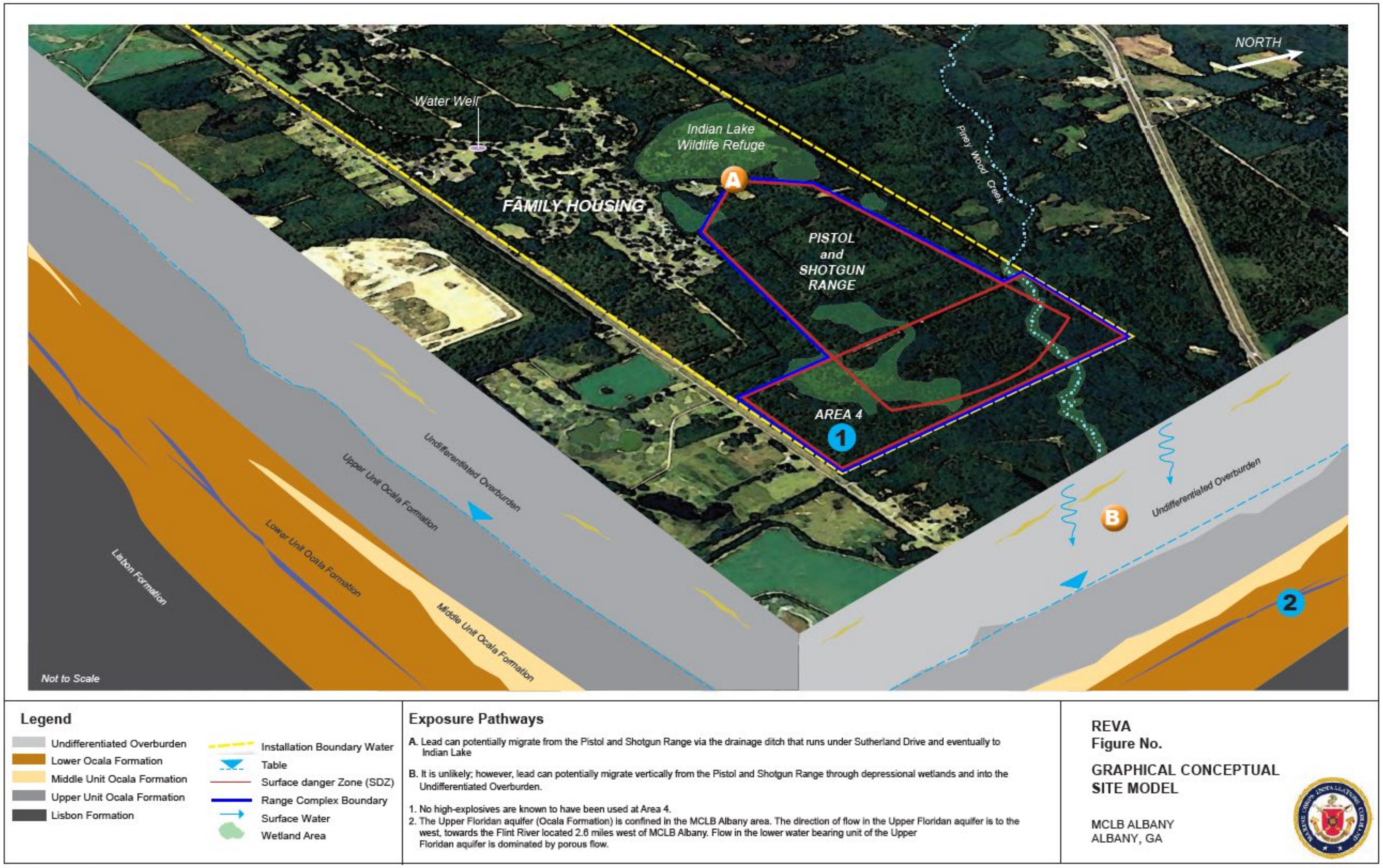


**Figure 4. Example of a Graphical Conceptual Site Mode**

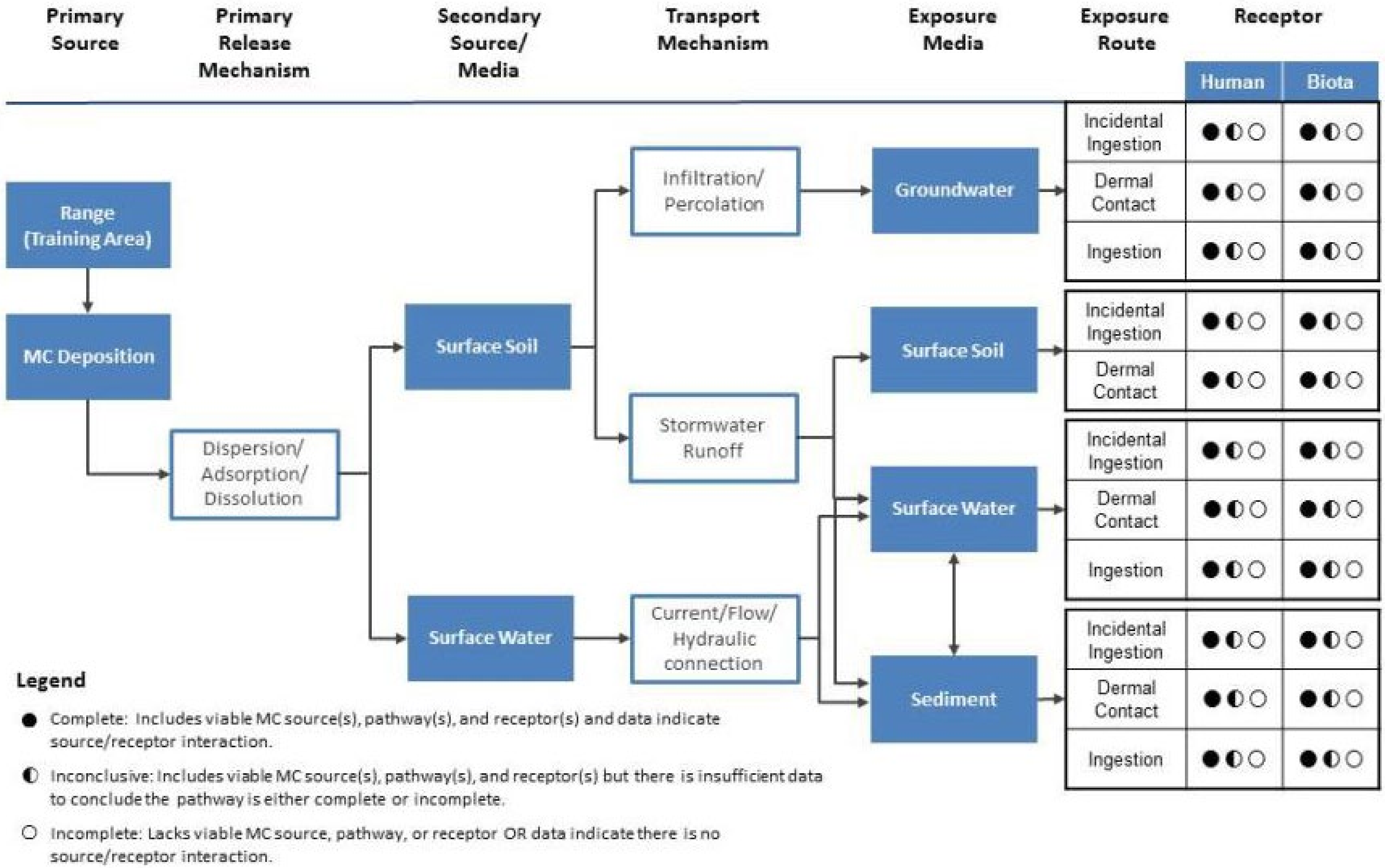


**Figure 5. Example of a Tabular Conceptual Site Model**

#### *3.2.3.2 Military Munitions Expenditures*

Range-specific data on types and quantities of military munitions expended are necessary to evaluate MC loading and migration. RFMSS is used by the Marine Corps to track annual munitions expenditures by range. RFMSS data include total munitions expenditures by associated Department of Defense Identification Codes (DoDICs). The DoDIC for each munition item can be used to identify the MC associated with the item (e.g., high explosives, metals, perchlorate), and the relative likelihood of a low order detonation for that item, which correlates to a higher potential MC loading. The type and quantity of energetic fillers and constituents found in military munitions is primarily gathered through the Defense Ammunition Center's Munitions Items Disposition Action System (MIDAS)[1] web site (https://midas.dac.army.mil/). In addition to MIDAS, other sources used for MC data include the ORDDATA II software (DON 2000) and various ordnance technical manuals. RFMSS data will be compiled and reviewed for completeness and consistency with known operational range and training area characteristics. Some common issues encountered, and the associated adjustments that may be required for RFMSS data for calculating expenditures, are listed below.

- When expenditure data are missing, expenditure data may be extrapolated to represent a full year based on available data; a monthly average may be calculated and extrapolated to represent annual expenditure averages over the entire review period; or data from specific year(s) with significant gaps may be excluded from the calculations.
- Expenditure data may contain some DoDICs for which data regarding MC content is not available.
  - Where the general descriptions of the munitions associated with the DoDICs are not available, the information is reviewed, along with available information regarding the associated range, its design, and its regulations. MC content is then estimated based on available data for similar munitions.
  - Where munitions descriptions are provided, the associated expenditure counts for the unknown DoDICs may be distributed proportionally from among the other known DoDICs (and within known locations, when available), based on totals for the other DoDICs listed for the same range within that given year.
- Expenditure data may contain DoDICs that are associated with ranges where use of the listed munitions was prohibited.
  - The location where the munitions were likely used may be discerned from nearby ranges or training areas where use of the listed munitions are allowed, and adjustments may be made accordingly.
  - If the use of the listed munitions cannot be linked to a specific range, these munitions may be distributed proportionally among other ranges where the same DoDICs were used in a given year, or disregarded if quantities are insignificant.

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[1] Data are retrieved from MIDAS by performing searches for the munitions, which produces a list of reports on their respective quantities of MC. Often, more than one matching National Stock Number is provided for a given munition; the multiple reports are evaluated to determine the highest and lowest MC quantities, which are then averaged for REVA MC loading calculations.

Any revisions to the RFMSS loading data resulting from the methods described above will be reviewed by the installation Range Management personnel for confirmation that the adjustment is justified.

#### *3.2.3.3 Identifying Migration Pathways*

MC may migrate in sediment, surface water, and groundwater from the source area to an off-range ecological or human receptor. Sediment, surface water, and groundwater that serve as migration pathways from a range are identified using data provided in Table 3. For REVA, soil and air are not considered as transport mechanisms for MC migration to off-range receptors; however, soil may be moved through stormwater or other physical mechanisms and may be considered an exposure pathway. For migration pathways on land ranges to be considered viable, these media must be physically present and continuously connected from the identified source area to an off-range receptor. For water ranges, where the water body is present from the source area to off-range areas, the migration pathway is presumed to be viable and the CSM focuses primarily on evaluating the presence of receptors and the likelihood of exposure to MC above acceptable levels.

**Table 3. Information and Sources to Identify Migration Pathways**

| Media | Information | Source |
|---|---|---|
| Groundwater | Groundwater basins and aquifers | • Information supplied by the installation<br>• Integrated Natural Resources Management Plan (INRMP)<br>• Published articles |
| | Groundwater elevations, hydraulic gradients, groundwater pumping rates | • Information supplied by the installation<br>• Published articles (e.g., Department of Interior, United States Geological Survey [USGS])<br>• State groundwater database |
| | Points of discharge to surface water | • INRMP<br>• Published articles |
| | Potable and non-potable groundwater wells | • GIS data supplied by the installation<br>• State groundwater database<br>• Interviews with installation personnel |
| Surface Water and Sediment | Streams and water bodies | • GIS data supplied by the installation<br>• National Hydrography Dataset (USGS)<br>• Maps<br>• Observations during Site Visit |
| | Sub-watersheds | • GIS data supplied by the installation<br>• Topographic maps |
| | Deposition area in surface water (water ranges) | • Range maps and GIS supplied by the installation |

#### *3.2.3.4 Identifying Receptors*

For purposes of REVA, receptors are those humans, animals, or plants inhabiting or using off-range areas where human or ecological exposure to MC in groundwater, surface water, or sediment downgradient of an MC loading area may occur. Surface water and sediment may serve as habitat for ecological receptors, or provide means of human contact with water or sediment due to recreational use or surface water ingestion. Groundwater exposure for human receptors may occur via drinking water supply wells, or groundwater discharge to surface water. Supply wells down gradient or side gradient from MC loading areas may be considered as receptor locations. Soil may be considered if there is evidence soil is transported and deposited off-range via storm water as dry surface soils (i.e., not sediment).

Table 4 lists information and sources used to determine potential receptor locations.

Within REVA, human populations are evaluated as receptors when they interact with MC from media through direct ingestion, dermal contact, or ingestion of exposed ecological receptors (e.g., shellfish). For ecological receptors, REVA focuses on species that are considered threatened, endangered, or sensitive (e.g. Arroyo Toad), or that provide a higher than typical value due to special status. For a consistent process of identifying such resources, REVA Technical Support Teams can employ the Army Checklist for Important Ecological Places (Department of the Army, 2005). Exposure to sediments is generally the most probable to impact ecological receptors, as sediment dwelling organisms have greater contact times with contaminated media and typically serve as a food source for higher trophic level organisms.

#### *3.2.3.5 Identifying Exposure Scenarios*

For purposes of evaluating exposure, REVA considers only the current and known future use scenarios. The planned future use of resources on an installation will be evaluated only if a physical (e.g., land clearing) or administrative (e.g., planning or rezoning) event indicates a change in future land use.

Exposure pathways considered in REVA include consumption of surface water and groundwater or direct exposure to surface water or sediment by off-range human or ecological receptors. Indirect exposure pathways, such as bioaccumulation and food chain exposure are not typically evaluated in this phase of the process. These exposure mechanisms would be evaluated if data indicate concentrations of MC in environmental media are greater than or equal to regulatory or screening levels and a risk assessment is required (discussed in Section 3.5.2). Table 5 identifies possible direct and incidental exposure scenarios.

**Table 4. Data Needs and Sources to Identify Receptors**

| Media | Information | Source | Receptor |
|---|---|---|---|
| Groundwater | Potable and non-potable, groundwater well(s); supply aquifer(s) | • GIS data supplied by installation<br>• State groundwater database<br>• Information provided by installation | Human |
| | Beneficial uses (e.g., irrigation) | • Information supplied by installation<br>• Department of Interior<br>• On-line research | Human |
| | Discharge points to surface water | • INRMP<br>• Published articles (e.g., Department of Interior, USGS) | Human and/or Ecological |
| Surface Water and Sediment | Range and/or installation boundaries | • GIS data supplied by installation | Human and/or Ecological |
| | Subwatersheds | • GIS data supplied by the installation<br>• Topographic maps<br>• Land use/land cover maps | Human and/or Ecological |
| | Water bodies used as drinking water sources | • Information supplied by installation | Human and/or Ecological |
| | Beneficial uses (e.g., public water supplies, recreation, agriculture) | • Information supplied by installation<br>• On-line research | Human |
| | Ecological habitats | • INRMP<br>• GIS information supplied by the installation | Ecological |
| Soil | Potential for direct human contact (e.g., maintenance activities, recreation) | • GIS data supplied by the installation<br>• Land use maps<br>• Aerial photos | Human |
| | Ecological habitats | • INRMP<br>• GIS information supplied by the installation | Ecological |

**Table 5. Off-Range Exposure Pathway Scenarios**

| Media | Pathways | Direct and Incidental Exposure Scenarios |
|---|---|---|
| Groundwater | Percolation through site soils to water table and migration to a groundwater well | Direct exposure – groundwater well used for drinking water supply.<br>Incidental exposure – groundwater accessed for reasons other than drinking water (e.g., irrigation or fire prevention). |
| Surface water | Direct deposition of munitions or runoff of MC from the operational range to a surface water body | Direct exposure – surface water body used as a drinking water source; ingestion and dermal contact during swimming or wading; and/or is habitat for ecological receptor(s).<br>Incidental exposure – surface water body used for commercial or recreational fishing; ecological uptake, bioaccumulation, and human exposure through ingestion. |
| | Groundwater discharge to surface water body | Direct exposure – surface water body used as a drinking water source; ingestion and dermal contact during swimming or wading; and/or is habitat for ecological receptor(s).<br>Incidental exposure – surface water body used for commercial or recreational fishing; ecological uptake, bioaccumulation, and human exposure through ingestion. |
| Sediment | Direct deposition of munitions or sediment erosion and migration in surface water runoff | Direct exposure – dermal exposure during wading/swimming or contact during dry periods for humans and exposure though osmotic exchange with sediment pore waters for ecological receptor(s).<br>Incidental exposure – incidental ingestion during or subsequent to swimming/wading; ecological uptake, bioaccumulation, and human exposure through ingestion. |
| Soil | Soils moved by storm events | Direct exposure – dermal contact during recreation, maintenance, or land disturbing activities.<br>Incidental exposure – ingestion of soil particles during or subsequent to land disturbing activities. |

### 3.2.4 Interim Technical Memorandum #1 (Post Updated Conceptual Site Model)

Once the CSM is updated, the REVA Technical Support Team will develop and transmit an interim technical memorandum to HQMC LF/MCICOM GF-5 with the recommended next steps. Recommended next steps may include fate and transport modeling, sampling, additional studies, gathering additional data to fill gaps, or finalizing the results of the assessment if no complete CSM pathways are identified. The interim technical memorandum will include an operational range table, updated CSMs, and narrative in support of follow-on actions (see Table 6), as applicable. Decisions about next steps are made by HQMC LF/MCICOM GF-5, in coordination with the relevant installation.

**Table 6. Interim Technical Memo #1 Contents**

| Content | Description | Action Required by Installation and HQMC LF/MCICOM GF-5 |
|---|---|---|
| Operational Range Table | Identification of range name/target area, range type, periods of use, status (active, inactive), authorized munitions type, and other relevant notes. | Provide review and comment. |
| Updated CSM | Document sources, pathways, receptors, and interactions among these three components, in narrative and a graphic and tabular CSM. | Provide review and comment. |
| Written Recommendation of Next Steps | Recommended next steps with support information. | Provide review and decide on next actions. |

## 3.3 Sampling

The determination to sample will be based on site-specific information, including previous analytical data, environmental conditions, range operations, munitions usage, past studies, MC migration potential, potential for source-receptor interaction, and professional judgment. While the decision to sample will be on a case-by-case basis, the following general rationale will be considered.

In general, sampling may be performed when data indicate the pathway is likely complete. Where viable MC sources, transportation pathways, and human or ecological receptors are present; sampling may be conducted to quantify the extent to which MC are present in the transport and exposure media. Sampling may also be performed when previously collected data (e.g., modeling or sampling) indicate that MC is migrating from the source area through a transportation pathway and there is source-receptor interaction. When such complete pathways exist, it may be necessary to sample the migration/exposure pathway to assess the level of risk presented to human or ecological receptors.

Sampling may also be performed if there is insufficient data to conclude that the pathways between MC sources and viable receptors are complete or incomplete (i.e., Inconclusive). Essentially, sampling may be performed when additional data is needed to draw conclusions about the source/receptor interaction in the CSM.

Sampling is not necessary, and will generally not be performed, where there are no viable migration or exposure pathways between MC source areas and receptors. The absence of an MC source, transport mechanism, or receptor indicates the absence of a complete pathway rendering sampling as an unnecessary activity. An example might include situations where there is great depth to groundwater, very little rainfall, and no potential for percolation. In this case, the lack of a groundwater migration pathway would make groundwater sampling unnecessary. Another example might include the presence of an MC source but non-potable groundwater and no other use of the groundwater. In this case, the lack of a groundwater receptor would make groundwater sampling unnecessary. Sampling is also not recommended where the hydrogeological system that is being evaluated is too complex that determining off-range migration of MC through sampling is physically or financially impractical.

### 3.3.1 Sampling Goals

REVA sampling requirements will be determined on an installation-specific basis. The sampling will support the overall purpose of the REVA program:

> *Determining whether there has been a release or substantial threat of release of MC from an operational range or range complex to an off-range area that creates an unacceptable risk to human health and the environment*.

REVA sampling will be designed to achieve the primary goals listed below.

- Determine the presence and quantify concentrations of MC in CSM pathways identified as inconclusive (i.e., there is insufficient data to conclude the pathway is either complete or incomplete). Quantifying MC concentrations in inconclusive CSM pathways allows the REVA Technical Support Team to classify migration/exposure pathways definitively, as either complete or incomplete. (Incomplete pathways are not investigated further and are only re-evaluated if site conditions change [e.g., increased MC loading or identification of new receptors]).
- Determine whether MC concentrations in CSM pathways identified as complete (i.e., data indicate source-receptor interaction) pose an unacceptable risk to human health or the environment. MC concentration data for CSM pathways identified as complete enhance understanding of viability of the pathway and the rate of MC migration.

Although not a specific objective of the REVA program, sampling can be used to identify the specific MC source areas (i.e., ranges) contributing to MC migration off the range complex. Such sampling data provide insight for the implementation of BMPs or other actions useful in managing MC exposure risk.

### 3.3.2 General Sampling Guidelines

The following are general guidelines for sampling environmental media in the REVA program.

- REVA sampling is not intended to characterize the site or the MC source area; it is intended to quantify MC concentrations in the media through which MC may migrate off the operational range and impact receptors.
- Migration and exposure media evaluated within REVA include surface water, groundwater, sediment, and, in particular instances, soil. Sampling will occur in media that constitute viable migration pathways from the MC source area to off-range receptors.
- For instances where there are multiple viable migration pathways of the same media (e.g., multiple streams), the sampling design will be biased toward the pathway where contamination is expected to represent the worst-case scenario. In other words, where it makes sense, pathways may be grouped or only worst-case scenario pathways would be sampled, and additional sampling may occur in other pathways if elevated MC concentrations are detected.
- Sampling will occur at locations close to the installation or range complex boundary so that sample results are indicative of concentrations to which off-range receptors may be exposed.
- Samples will be collected and analyzed using the methods appropriate to the analytes, media, and receptors specified in the CSM pathways. The REVA Technical Support Team will consider specific

sampling and analysis methods required by regulatory agencies when sample results will be compared to media- and receptor-specific regulatory values.

- Samples from reference locations will be collected when analyzing for naturally occurring (e.g., metals, perchlorate) or other, non-range-related sources. The presence of these analytes may be unrelated to the potential MC releases being investigated and a distinction between sources may be necessary. This is particularly important when applicable state or federal screening values are low for the MC and media in question. Reference sample locations should be upgradient of MC deposition and within the same watershed or from a comparable nearby watershed.

### 3.3.3 Quality Assurance Project Plan

For each REVA where sampling will occur, a Quality Assurance Project Plan (QAPP) will be developed prior to initiation of field sampling activities at the installation. The QAPP will be developed in accordance with the Intergovernmental Data Quality Task Force *Uniform Federal Policy for Quality Assurance Project Plans (UFP-QAPP) Manual* (United States Environmental Protection Agency [USEPA], 2005). The QAPP will document the procedural and analytical requirements for collecting water, sediment, and soil samples. The plan will address data quality objectives (DQOs), sampling rationale, field methods, analytical methods, data validation, and quality assurance procedures.

The REVA Technical Support Team will develop a Programmatic QAPP (PQAPP) to capture the sampling, analysis, and QA procedures that are consistent across the REVA program. The contents of the PQAPP will be augmented by installation-specific QAPPs (ISQAPPs) to address any site-specific content. ISQAPPs will be reviewed and approved by installation range and environmental personnel, HQMC/MCICOM, and TECOM prior to initiation of field sampling. The REVA Technical Support Team will work with range and environmental personnel to schedule sampling that minimizes and avoids interruption to installation activities and ensure safety of the field team.

Protocols and methods for sample collection, documentation, handling, and shipment will be detailed in the REVA PQAPP. QA/QC samples will be collected to evaluate the field collection methods and the laboratory analytical techniques for all media samples in accordance with EPA SW-846, Test Methods for Evaluating Solid Waste: Physical/Chemical Methods (USEPA 2014) and Engineering Regulation 200-1-7, *Chemical Data Quality Management for Environmental Restoration Activities* (United States Army Corps of Engineers [USACE] 2014). The QA/QC samples will consist of duplicate samples, matrix spike/matrix spike duplicate (MS/MSD) samples, and equipment blanks. Duplicate samples will be collected for 10 percent of samples with at least one duplicate per mobilization. Duplicate samples will be collected simultaneously from the same source under identical conditions, submitted to the laboratory as indistinguishable samples, and labeled accordingly. Five percent of samples will be taken in sufficient volume to support MS/MSD analysis. Equipment blanks will be collected at least once per mobilization and at a minimum rate of 10 percent.

### 3.3.4 Site-Specific Safety and Health Plan

Safety considerations associated with all field work, including access to and hazards near sampling locations will be identified in a site-specific safety and health plan (SSSHP). The purpose of the SSSHP is to outline the health and safety procedures and protocol to be followed by the REVA Technical Support

Team during sample collection. This plan will contain site-specific details and be tailored to each installation. The SSSHP will comply with applicable federal, state, and local health and safety requirements, including the Occupational Safety and Health Administration's requirements (29 Code of Federal Regulations [C.F.R.] 1910 and 1926) and EPA's Hazardous Waste Requirements (40 C.F.R. 260-270). The SSSHP will follow the outline presented in Engineering Manual 385-1-1, *Safety and Health Requirements Manual, Appendix A* (USACE 2014).

### 3.3.5 Sample Collection

#### *3.3.5.1 Groundwater Sampling*

State-specific requirements for sampling and analysis of groundwater will be identified and incorporated into the development of project DQOs. Installation-specific groundwater sampling methods will consider the sampling requirements associated with the regulatory standard for the state in which the installation is located.

Groundwater generally is sampled downgradient (hydraulic gradient) of identified MC loading areas. If source areas are hydraulically connected to an aquifer containing potable water supply wells, untreated water samples will be collected directly from an accessible supply well. If potable supply wells are inaccessible, then groundwater samples will be collected from accessible pre-existing monitoring wells screened in the same aquifer serving as a source of drinking water. However, for areas that lack pre-existing potable supply wells or monitoring wells, new monitoring wells will be established downgradient of the source area and in close proximity to the range complex boundary.

Drilling methods will be identified in the ISQAPP, and will be selected based on geologic site conditions and study objectives at the installation. Bedrock wells may be completed as open boreholes. Wells in unconsolidated sediments will be screened using materials appropriate to the aquifer materials.

Newly installed monitoring wells screened in unconsolidated materials will be developed using industry standard practices. The purpose of well development is to remove fine-grained materials from the vicinity of the well screen, which allows the water to flow freely from the geologic formation into the well and reduces the turbidity of the water during sampling. This is executed by stressing the formation around the screen so that mobile, artifact particulates are removed.

A new monitoring well should not be developed for at least 24 hours after complete installation. Well development should be completed at least 14 days before well sampling for new monitoring wells installed by conventional methods.

Prior to sampling established monitoring wells, personnel will purge the well (or packed interval for the temporary bedrock well) of stagnant water. The goal of purging is to remove the volume of stagnant water and the volume of water directly impacted by the installation procedure so that samples collected are representative of aquifer conditions in the area of the sample location. For direct-push or temporary wells, which are small-diameter wells installed into the subsurface by hydraulic or percussive methods, groundwater samples will be collected immediately after installation. No purging will be required in the temporary alluvial well.

In order to determine when a well has been adequately purged, sampling personnel will monitor pH, conductivity, temperature, dissolved oxygen (DO), and turbidity of the groundwater removed from the sampling point during the purging process. Adequate purge volume is achieved when the field monitoring parameters have stabilized and the turbidity has either stabilized or is below five nephelometric turbidity units (NTUs). Five NTUs is the goal for most groundwater sampling objectives; however, this may not be achievable for temporary sampling points and occasionally for established monitoring wells. Measurements will be taken at a frequency that is based on the total purge volume to ensure a sufficient number of readings to evaluate stability. All instruments will be calibrated at least daily and on an as-needed basis. Management and disposal of purge water will be coordinated with installation environmental personnel.

The general stabilization indicators for groundwater sampling that will be achieved prior to sample collection can be found in Table 7. The groundwater parameters will be considered stable when three consecutive measurements over a 15-minute period meet criteria in Table 7 (USEPA, 2010). If field parameters (pH, conductivity, DO, temperature, oxidation/reduction potential, and turbidity) have not stabilized by three equipment volumes (for temporary bedrock wells) or three well volumes (for existing wells), additional equipment or well volumes will be removed. If the parameters have not stabilized within five equipment or well volumes, the sample will be collected at that point, unless the project geologist determines that the purging should continue. The conditions of sampling will be noted in the field book and sample collection forms.

**Table 7. Groundwater Parameter Stabilization Indicators for Field Parameters**

| Parameter | Stabilization Criteria |
|---|---|
| Turbidity | ±10% for values greater than 5 Nephelometric Turbidity Unit (NTU); if three turbidity values are less than 5 NTU, consider the values stabilized. |
| Dissolved Oxygen | ±10% for values greater than 1.5 mg/L, if three dissolved oxygen values are less than 0.5 mg/L, consider the values as stabilized. |
| Specific Conductance | ±3% |
| Temperature | ±3% |
| pH | ± 0.1 unit |
| Oxidation/Reduction Potential | ± 10 millivolts |

*Source: USEPA, 2010*

Low-flow sampling techniques will be used for water collection at monitoring wells; however, water supply wells will be purged and sampled using higher flow rates similar to a water supply scenario. Robust details of groundwater collection, storage, and analysis are contained in the REVA PQAPP.

Turbidity measurements will also be used to determine whether samples collected for metals analysis require field filtering due to high levels of suspended solids. If turbidity is above 10 NTUs following purging, both a filtered and an unfiltered groundwater sample should be submitted for metals analysis (USEPA, 1997). A 0.45-micron, acrylic copolymer-pleated membrane filter housed in a polyethylene capsule should be used to filter water that will be analyzed for dissolved metals. If turbidity is below 10 NTUs following purging, filtering is unnecessary and only an unfiltered groundwater sample should be submitted for metals analysis. An alternative groundwater sampling approach that may be employed in applicable areas is the sampling of seeps, springs, or surface water bodies that receive direct groundwater discharge. SOPs for this approach are addressed in the REVA PQAPP.

#### *3.3.5.2 Surface Water Sampling*

State-specific requirements for sampling and analysis of surface water will be identified and considered in the development of the project DQOs. Installation-specific surface water sampling methods will consider the sampling requirements associated with the regulatory standard for the state in which the installation is located. If deemed appropriate by the REVA Technical Support Team, these methods will be incorporated into the ISQAPP and may include grab samples collected on a single day, an average of grab samples taken from consecutive days, or composite samples.

Where possible, surface water sample locations will be near the installation or range complex boundary. In general, surface water samples will be collected downgradient of the identified MC loading areas within the watershed. Surface water samples will be collected from streams or reservoirs/lakes that serve as viable MC transport or exposure pathways to off-range receptors.

If surface water bodies are perennial, comparison of sampling results to appropriate chronic screening levels (human or ecological) is typically warranted, unless the exposure method is clearly acute. Although the REVA Technical Support Team will select and apply appropriate sampling methods based on project-specific DQOs and site conditions, a generally accepted method to characterize MC concentrations in surface water for chronic exposure is through an average of four separately analyzed grab samples taken on consecutive days, or as a 96-hour composite sample.

If surface waters are seasonal, intermittent, or only present during or immediately following storm events, comparisons to acute screening levels may be more appropriate. Clear rationale will be documented as part of the CSM and the ISQAPP will provide the basis for selecting sampling and analysis methods. A potentially applicable method to collect samples for comparison to acute screening levels involves using an average of two or more samples collected within one hour. Passive samplers may be employed in channels that only contain water during storm events or that are unsafe to access during stormwater flow.

Regardless of the nature of the surface water body (e.g., perennial or intermittent), when surface water samples are collected during or shortly after a storm event the resulting concentrations will be compared to acute screening levels. The collection time, during or after a storm event, will allow for the analysis of stormwater that may have originated from the range/source area.

Other water quality parameters (e.g., pH, DO, temperature, turbidity, conductivity, and oxidation-reduction potential) will be recorded in the field after each sample is collected. Water hardness will be assessed through calculation in the laboratory for surface water samples collected for metals analysis. The calculated hardness will then be used to determine site-specific screening criteria for that location. Robust details of surface water collection, storage, and analysis are contained in the REVA PQAPP.

#### 3.3.5.3 Sediment Sampling

State-specific requirements for sampling and analysis of sediment will be identified and incorporated into the development of the project DQOs. Installation-specific sediment sampling methods will consider the sampling requirements associated with the regulatory standard for the state in which the installation located. These methods will be incorporated into the ISQAPP and may include single grab samples or composite samples.

Sediment sample locations will be near the installation or range complex boundary. In general, sediment samples will be collected downgradient of the identified MC loading areas within the watershed, and as appropriate, sediment will be collected in conjunction with surface water samples. Sediment samples will be collected from streams or reservoirs/lakes that serve as viable MC transport or exposure pathways to off-range receptors. Sediment samples should be collected downgradient of the surface water sampling location, as to not disturb the sediment and increase particulates in the water column—influencing the water chemistry at the site of the surface water sample.

In general, a sediment sample will be a grab or a composite of three grab samples of the organic surface layer (0 to 3 inches) of sediment at each site. Where there is visual evidence of fine organic material accumulation, individual sample locations should be biased to those sections of the stream bed (e.g., current dams or slow moving pools). Sunny weather and lower flow conditions that permit settling of organic fine material are preferred for sediment sampling. The sediment sampling plan should be designed to represent surficial sediments that could be flushed downstream to off-range receptors. In some instances, sediment samples can be taken from dry stream beds; however, careful consideration must be given to the appropriateness of comparing such samples to sediment applicable state or federal screening value levels. Most applicable state or federal screening values are based on potential effects to benthic invertebrates. For such applicable state or federal screening values to be appropriate, the sampled media must be viable benthic habitat.

In addition to metals and explosives constituents, sediment samples may be analyzed for total organic carbon, acid volatile sulfide/simultaneously extracted metals (AVS/SEM), and grain size to assist in evaluating the potential bioavailability of metals to ecological receptors. Detailed sediment sampling procedures can be found in the PQAPP.

#### 3.3.5.4 Soil Sampling

State-specific requirements for sampling and analysis of soil will be identified and incorporated into the development of the project DQOs. Installation-specific soil sampling methods will consider the sampling requirements associated with the regulatory standard for the state in which the installation is located. These methods will be incorporated into the ISQAPP.

Soil sample locations will be immediately off-range or on-range as close to the installation or range complex boundary as possible. Soil is generally not considered an MC transport medium. However, soil containing MC can be carried off-range by storm events or other physical transport mechanisms. This is particularly true when MC source areas (ranges) are near the boundary of the range complex or installation.

Where no state-specific soil sampling methods exist, an incremental sampling methodology (ISM) will be employed. Empirical evidence has shown that collecting a small number of discrete samples does not account for the heterogeneous distribution of MC in soils and leads to an imprecise estimation of the mean concentration present (Interstate Technology & Regulatory Council [ITRC], 2012). ISM is a structured composite sampling method that reduces data variability and provides a reasonably unbiased estimate of mean contaminant concentrations in the volume of soil targeted for sampling (ITRC, 2012).

For REVA, an ISM strategy with a systematic random (random grid) sampling design will be used to obtain a sample of approximately 1 kilograms (kg) mass to characterize the average concentration of MC within a chosen sampling unit. Sampling units will be between 1/10 acre and 1 acre; and sized appropriately to represent the area of interest. A minimum of 30 equally-sized surface soil increments will be collected for each sampling unit, with each increment weighing 20 grams (g) to 60 g. The number of increments to be collected per sample area depends on soil density per Table 8. Soil density can generally be estimated from literature and assumed to be similar across the sample area. Additional details on REVA soil sampling procedures can be found in the PQAPP. Although this sampling procedure is applicable to both surface and subsurface soils, samples will be collected from the first 2 inches of soil unless there is evidence or data indicating the presence of MC in subsurface soils.

**Table 8. Estimated Sample Mass for Set Increment Diameter and Soil Density**

| Core diameter (cm) | Number of increments to obtain desired ISM sample mass | | | | |
|---|---|---|---|---|---|
| | **500 g** | **750 g** | **1000 g** | **1500 g** | **2000 g** |
| Soil density 1.6 g/cm$^3$, increment length 2.5 cm | | | | | |
| 2.0 | 40 | 60 | 80 | 119 | 159 |
| 3.0 | 18* | 27* | 35 | 53 | 71 |
| 4.0 | 10* | 15* | 20* | 30 | 40 |
| Soil density 1.8 g/cm$^3$, increment length 2.5 cm | | | | | |
| 2.0 | 35 | 53 | 71 | 106 | 141 |
| 3.0 | 16* | 24* | 31 | 47 | 63 |
| 4.0 | 9* | 13* | 18* | 28* | 35 |

*Source: ITRC, 2012 (modified)*

cm– centimeters; cm$^3$– centimeters cubed; g – grams

*For purposes of REVA, a minimum of 30 increments will be collected.

### 3.3.6 Analytes of Interest

Samples will be analyzed for the REVA program indicator MC, including TNT, HMX, RDX, and degradation or breakdown products, as well as perchlorate, and lead. In the event these primary indicator MC are found at levels greater than or equal to applicable state or federal screening values, the REVA Management Team may choose to analyze for other MC. Additional MC to be analyzed will be identified based on information compiled during the REVA site visit and the ammunition types used at the operational range.

### 3.3.7 Laboratory Analytical Methods

Laboratories in compliance with the DoD Quality Systems Manual (QSM) Version 5.1, and having current DoD Environmental Laboratory Accreditation Program certification will be required for sample analysis (DoD, 2017). Laboratory methods will be selected to achieve the limit of quantitation (LOQ) necessary for comparison to state-specific and federal MC screening values. The laboratory analytical methods selected will have LOQs less than or equal to 50 percent of the MC regulatory standards or screening levels used during data evaluation, where possible. Screening levels for hardness-dependent metals in surface water can vary by orders of magnitude, which affect the potential use of less sensitive analytical methods.

Full details of the analytical methods for the REVA program can be found in the PQAPP and ISQAPPs. Unless otherwise required to achieve LOQs associated with state-specific screening values, USEPA Method 8330B, Method 6020A, and Method 6850 will be used for explosives constituents, metals, and perchlorate, respectively (USEPA, 1998; USEPA, 2006; USEPA, 2007).

### 3.3.8 MC Concentration Comparison Values Hierarchy

States are typically the primary regulating authority for environmental compliance on Marine Corps installations; therefore, the REVA Program focuses primarily on comparison of MC concentration data to state-specific regulatory values. In accordance with the following hierarchy, the Marine Corps REVA program compares sampling and modeling results to:

1. Applicable state-specific regulatory values (regulatory screening values); and
2. Federal regulatory values (regulatory screening values)

Where sampling values are greater than or equal to the applicable state or federal screening values, further assessment of potential human health or ecological risk may be appropriate (see Section 4). MC concentrations less than these conservative screening values will be deemed as not creating an unacceptable risk to human health or the environment and, therefore, would not require further action. Receptors used for the selection of screening values should be defined based on the use of the media. For example, if a surface water body is not used as a drinking water source, but there are ecological receptors of interest present, then the concentrations of MC in the sampled media will only be compared to ecological surface water state or federal screening values.

Applicable state or federal screening values will be reviewed and identified during each assessment and the most current applicable values will be used.

## 3.4 Fate and Transport Modeling

Fate and transport modeling may be used to complement or in place of direct field sampling to estimate the concentrations of MC migrating off-range when:

- sampling locations are inaccessible due to ownership (e.g., when the range and base boundaries are contiguous);
- sampling locations are inaccessible due to physical hazards or other conditions (e.g., groundwater is very deep); or

- receptors are exposed to a medium that cannot be sampled, but which is connected to media that can be modeled (e.g., groundwater cannot be sampled at the receptor location, but soil sources are measurable).

REVA will employ vadose zone and groundwater models with site-specific or literature-derived input values for physical site conditions to quantify the MC concentrations that may migrate to receptors as identified in the CSM. Environmental modeling has inherent uncertainties relative to field measurement; consequently, care will be taken to document modeling results in the context of the tools used and assumptions made as part of any weight of evidence discussion of REVA conclusions.

In some instances, a CSM will indicate that a surface water body off-range may be affected by MC. Where a complete surface water pathway exists, the preferred default approach will be to sample surface water at or near the receptor location. Based on an evaluation of existing surface water modeling, levels of effort, uncertainties, and limitations; the REVA periodic reviews will not employ modeling of MC fate and transport in surface water bodies.

REVA fate and transport modeling will default to industry-standard environmental software to determine MC concentrations off-range. The fate and transport models quantify MC concentrations based on site-specific parameters known to affect the behavior of MC in environmental media. The REVA Technical Support Team will identify a suitable model, input parameters, and data gaps for the input parameters specific to the CSM. Data gaps may require field verification of site characteristics or sampling (e.g., for total organic carbon). Otherwise, reliable input parameters will be gathered through literature searches, RFMSS data, and installation environmental information.

Modeling of MC fate and transport in the vadose zone and groundwater must accommodate physical and chemical factors, such as advection, diffusion, and dispersion in water; sorption or desorption from soil or rock; and alteration by biological, physical, or chemical processes. If it is invoked, the modeling will focus on primary groundwater migration pathways and the most likely exposure scenarios, while assessing uncertainty in the assumptions through sensitivity testing.

The following section details the use of fate and transport models for vadose zone and groundwater transport quantitative models.

### *3.4.1 SEVIEW*

REVA will rely on SEVIEW, a suite of commercially available, peer-evaluated vadose zone and groundwater transport modeling software modules, used to estimate fate and transport in soil and groundwater. SEVIEW combines two USEPA-developed and approved fate and transport models—one for the vadose zone, and another for groundwater. SEVIEW is a peer-evaluated software interface developed by Environmental Software Consultants Incorporated (ESCI). SEVIEW includes the public-domain vadose zone transport model Seasonal Soil [SESOIL]. SESOIL was originally developed for the USEPA and subsequently augmented by ESCI (Bonazountas and Wagner, 1984). SESOIL is a one-dimensional vertical transport model simulating contaminant migration in the unsaturated zone based on diffusion, adsorption, volatilization, cation exchange, and hydrolysis. The SESOIL model contains three sub-models that simultaneously calculate contaminant transport, soil water movement, and soil erosion, simulating seasonal climatic variations and soil properties. SEVIEW also provides the groundwater contaminant transport model AT123D (Analytical Transient 1-, 2-, and 3-Dimensional Simulation of Waste Transport in the Aquifer System), originally developed at Oak Ridge National Laboratory. AT123D was developed to estimate transport of dissolved chemicals in groundwater flowing through continuously porous media. It is not designed to model flow in fractured rock, but can still be used as an estimator of flow in such systems. The transport mechanisms simulated by AT123D include advection, dispersion, sorption, decay/biodegradation, and heat loss to the atmosphere. Model results are used to estimate the migration of a contaminant plume and can be compared to groundwater standards to evaluate risks at specific locations, present and future.

Enhancements to the SESOIL and AT123D models within the SEVIEW interface include the links to referenced chemical, geological, and climate databases (ESCI, 2013). SEVIEW has the advantage that it is used by several state agencies to develop generic and site-specific clean-up levels, and that it can be calibrated with ESCI-provided information.

SEVIEW estimates the concentration of MC at the point of exposure by projecting the source area concentration migrating through the vadose zone to groundwater and then in groundwater to the exposure point. Studies of MC in the environment indicate that metal MC (such as lead) may not leach to the depth of the water table at an operational range, which SESOIL can model effectively for decision-making. If SESOIL shows that MC at a site with the right conditions can migrate to the water table, then AT123D can be used to model the fate and transport in groundwater. Each module requires MC concentration input derived from site information. For SESOIL, the concentration of MC in the source area of concern (i.e., where MC has deposited on the ground surface, such as an impact area) can be estimated from RFMSS use data, or it can be estimated based on data from existing range use studies. When necessary, the REVA Technical Support Team will employ a set of MC loading calculations, as describe in the *REVA Reference Manual for Baseline Assessments*, to estimate the average concentration deposited annually in defining loading area (HQMC, 2009). A description of these methods can be found in Appendix A. For AT123D, the initial MC concentration at the water table can be derived from SESOIL, or it can be determined from on-installation well data.

In addition to MC concentration, each module has required inputs relating to the physical and climatological conditions at the installation. The data inputs and outputs for SEVIEW modules are provided in Table 9. As part of the project planning, the data inputs for the relevant modules must be reviewed, and collected, either in the field or from literature. SEVIEW provides climatological data for most areas of the US; however, it may not contain data for installations outside the US.

### *3.4.2 SEVIEW Validation and Sensitivity Analysis*

SEVIEW is an industry-accepted model, so independent validation for REVA is not warranted. Within the software, a sample case may be set and then run with each iteration of the model. ESCI provides a sample case when the software is purchased, and this sample case is recommended for inclusion as a validation on each model run that the software is functioning as intended and obtaining an identical outcome for the sample case.

A sensitivity analysis will be performed for each model as a means of understanding the uncertainty in the model results. Sensitivity analysis is useful for the following purposes:

- identifying the model input data that is most influential on model outcomes, so that attention is focused on obtaining the best site-specific estimates for those parameters;
- simplifying the model activities by identifying and removing parts of the model that do not influence the model outputs to the extent that decision-making is affected; and
- improving communication of model output and resulting decisions among stakeholders by focusing on meaningful assumptions.

Modeling uses the initial “base case” model that contains parameter values that are most representative of site-specific conditions, via collected or measured data. The sensitivity analysis is relatively simple: a minimum, maximum, and base case estimate for each input parameter will be selected for a series of model runs. Subsequent model runs calculate results after varying a single model input parameter (e.g., bulk density, intrinsic permeability, effective porosity), while other parameters are held constant with the base condition values. A final overly conservative “worst case” model run is recommended for the REVA.

### *3.4.3 SEVIEW Output*

The output of the MC fate and transport modeling will be presented as the expected maximum concentration of modeled contaminants at the range complex boundary and/or receptor location(s). These data will allow prediction of the approximate locations of future maximum concentrations resulting from the integration of the contributions from multiple sources and different pathways. In general, the overall modeling process should be documented to the extent of outlining the general modeling methods, characteristics, and assumptions that are applicable to the installation. A detailed breakdown of the components of the modeling output can be found in Table 10.

**Table 9. SEVIEW Fate and Transport Models for Use in the REVA Process**

| Sub Models | Description | Model Input | Model Output |
|---|---|---|---|
| SESOIL | 1. A one-dimensional vertical transport model based on diffusion, adsorption, volatilization, cation exchange, and hydrolysis.<br>2. Estimates MC concentrations in the soil profile through direct application such as deposition from range use.<br>3. Can simulate biodegradation.<br>4. Consist of three soil submodules (Hydrologic Cycle, Pollutant Fate Cycle, and Sediment Washload Cycle) that simultaneously calculate contaminant transport, soil water movement, and soil erosion simulating seasonal climatic variations and soil properties.<br>5. Uses sub-layers for contaminant mass balance. Predicted concentrations are a function of sub-layer thickness which provides a better representation of contaminant distribution through the soil column.<br>6. Allows up to 4 soil layers and 10 sub-layers per layer (max of 40). | 1. *Soil parameters:* intrinsic permeability; organic carbon content; bulk density; effective porosity; soil pore disconnectedness (used to calculate unsaturated hydrologic conductivity); pH; cation exchange capacity; and, Freundlich exponent (used to set sorption curves).<br>2. *Chemical parameters:* water solubility; Henry's Law constant; air and water diffusion coefficients; molecular weight; metal complexation; and organic carbon adsorption coefficient.<br>3. *Source:* load area, initial concentration of MC in soil, depth to groundwater, and precipitation.<br>4. *Site latitude:* in decimal degrees (used to establish monthly soil temperature).<br>5. *Contaminant:* initial concentration or mass loading rate. Mass loading rates can be instantaneous, continuous, or transient. Layer Thickness: thickness of soil layers in centimeters and number (up to 4).<br>6. *Sublayers:* thickness and number (up to 10).<br>7. *Climate data:* seasonal metrological values. | 1. Estimates MC concentration at various depths.<br>2. Estimates MC loss from surface runoff, percolation, volatilization, and degradation.<br>3. MC mass distribution.<br>4. *Documentation should* include:<br>a. climate (monthly climatic data, tables/graphs, user inputs);<br>b. profile and load (soil properties, chemical properties, MC load, load graphs, user inputs); and,<br>c. hydrologic cycle (monthly water balance, evapotranspiration, recharge, model results). |
| AT123D | 1. A three-dimensional groundwater model based on advection, dispersion, diffusion, adsorption, and biological decay which simulate MC transport in groundwater.<br>2. Can simulate with and without biological decay and degradation.<br>3. Can model time-dependent MC releases from the soil model (SESOIL). | 1. *Soil parameters:* intrinsic permeability; organic carbon content; bulk density; effective porosity; soil pore disconnectedness; pH; cation exchange capacity; and, Freundlich exponent.<br>2. *Chemical parameters:* water solubility; Henry's Law constant; air and water diffusion coefficients; molecular weight; metal complexation; and, organic carbon adsorption coefficient.<br>3. *Source:* load area, initial concentration of MC in soil, | 1. Computes the spatial-temporal concentration distribution of MC in the aquifer system and predicts the transient spread of a contaminant plume through a groundwater aquifer.<br>2. Estimates the dissolved concentration of MC in three dimensions in the groundwater resulting from a mass release over |

**Table 9. SEVIEW Fate and Transport Models for Use in the REVA Process**

| Sub Models | Description | Model Input | Model Output |
|---|---|---|---|
| | | depth to groundwater, and precipitation.<br>4. *Site latitude:* in decimal degrees (used to establish monthly soil temperature).<br>5. *Contaminant:* initial concentration and/or mass loading rate (Mass loading rates can be instantaneous, continuous, or transient).<br>6. *Layer Thickness:* thickness of soil layers in centimeters and number (up to 4).<br>7. *Sublayers:* thickness and number (up to 10).<br>8. *Groundwater properties:* depth to groundwater; hydraulic conductivity; and groundwater gradient.<br>9. *Climate data:* seasonal meteorological values. | a source area (point, line, area, or volume source).<br>3. *Animated Area Concentration:* trends in groundwater concentrations and display of MC plume concentrations for entire area modeled.<br>4. *Centerline:* displays animated contaminated concentrations through the center of the plume.<br>5. *Point of Compliance:* displays trends in groundwater MC concentrations at a single point, such as a groundwater monitoring well or property boundary. |

*Source: SEVIEW Guidance Manual*

**Table 10. Components of the Modeling Output for REVA**

| Section | Purpose |
|---|---|
| Purpose | The purpose and specific goals or objectives of the modeling should be clearly stated. It should be documented that the objectives of the simulation correspond to the decision-making needs. |
| Hydrogeologic Setting | A narrative, with appropriate cross-sections and maps of the hydrogeologic system, should be provided. The data used (e.g., borings, well logs) should be provided or referenced to where the data can be obtained. |
| Data Collection | Methods and techniques for collecting, analyzing and interpreting data should be explained. Levels of confidence for system parameters. Any data gaps and simplifying assumptions should be discussed. Data set strengths and deficiencies should be noted. |
| Detailed Conceptual Model | Per Section 3.2 of this REVA Guidance Manual. |
| Model Description | The rationale for the choice of a particular model should be documented. Simplifying assumptions and limitations of the model should be discussed and related to the problem to be simulated, along with the impact these assumptions may have on the results. A description of where assumptions and actual field conditions do not coincide should be presented. It should be shown that the model chosen is appropriate for the system. Any modifications to the code should also be discussed. |
| Assignment of Model Parameters | It should be shown that there are sufficient data to characterize the site and satisfy the data needs of the model. All input data, including initial conditions, boundary conditions, and hydraulic and transport parameters, should be defined. The reasons for selecting initial and boundary conditions should be justified. Assigned values throughout the modeled area should be presented. Data can be presented on cross-sections and maps showing flow boundaries, topography and surface water features, water-table/potentiometric surfaces, bedrock configuration, saturated thickness, transmissivity/hydraulic conductivity, specific storage, cross sections, etc. All sources of data used, whether derived from published sources, measured, or calculated from field data or laboratory testing, should be documented. |
| Model Calibration | Specific goals and procedures of calibration, results of the final calibrated model, departure from the calibration targets, and the effects of the departure on the model results. |
| Sensitivity Analysis | All sensitivity analyses should be presented and interpreted. Input parameters that have the greatest impact on results should be described. |
| Field Verification | Goals and procedures of any field verification should be presented and discussed. Additional sensitivity analyses on these new comparisons should be documented. |
| Data Pre- and Post-Processing | All pre- and post-processing of model input and output data should be described and any computer codes utilized should be documented. Description of any data manipulation process and why it was conducted. |
| Model Prediction | All output from predictive simulations should be presented and interpreted in detail. The modeler(s) should cover model water balance, highlighting salient features such as pumpage, recharge, leakage, etc. All predictions should be presented in the context of the fundamental assumptions of the model. Limitations of and confidence in predictions should also be stated. |

**Table 10. Components of the Modeling Output for REVA**

| Section | Purpose |
|---|---|
| Sources of Error | Known problems and errors may need to be evaluated and discussed by utilizing ranges and expressing levels of confidence for predictions. |
| Summary and Conclusion | Summarize the modeling effort and draw conclusions related to the study objectives. The limitations of the modeling and all assumptions should be discussed. Also, discuss uncertainties inherent to the model and their effects on conclusions. |
| Model Records | The entity should keep on file, and be able to provide upon request, input and output data sets for model runs (in digital form or hard copy), including final calibration, additional history matching, and all predictions. The original model documentation and a copy of the source code used should also be available upon request. |
| Post Audit | If a model will be used to make decisions that extend beyond its predictive limit, the REVA Technical Team should develop a plan for future evaluations to check the model in time and space to be certain that past decisions are still appropriate. |

## 3.5 Data Evaluation

This section details the method for evaluating and validating sampling results and the process of comparing them to respective, media-specific state or federal screening values. It also outlines the determination factors for proceeding to a risk evaluation step, when necessary.

### 3.5.1 Data Verification and Validation

The REVA program's data verification and validation methods involve a three-step process comprising (1) field, (2) laboratory, and (3) REVA Technical Support Team evaluations. The following sections describe the steps of data verification and validation that will be employed. All planning documents, field records, and analytical data packages will be verified for completeness, correctness, and conformance against the requirement and procedures contained within the ISQAPP. A breakdown of each item undergoing verification will be included in ISQAPP Worksheet #34. All analytical data packages, chain-of-custody forms, field audits (if applicable), deviations/field corrective actions will undergo data validation. Again, ISQAPP Worksheet #34 has outlined which data will be validated of the records generated for the project. The data validation will be generated to review the conformance to the specifications outlined in the QAPP.

#### *3.5.1.1 Step 1: Field and Technical Data Verification*

The verification of field and technical data will begin at the time of sample collection. Standards, procedures, QC measures, and quality checks will be performed at the time of sample collection and reviewed for completeness. The site Field Team Leader will check recordkeeping codes (e.g., sample IDs) and measurement units for accuracy. QC data should be reduced into tables where a review for anomalous values is conducted. The Project Chemist will check the QC data tables for accuracy and completeness. The Field Team Leader will perform random checks of field sampling methods.

#### 3.5.1.2 *Step 2: Laboratory Data Verification*

The analytical laboratory will perform a laboratory review of the sampling data. This process entails a thorough examination of the following QC data for precision, accuracy, and completeness:

- Method Blanks: A measure of laboratory contamination and accuracy.
- Laboratory Duplicates: A measure of laboratory precision.
- Field Duplicates: A measure of field sampling and laboratory precision.
- Matrix Spikes: A measure of laboratory accuracy and any sample matrix effects.
- Surrogate Spike Recoveries: A measure of laboratory accuracy.
- Laboratory Control Samples: A measure of laboratory accuracy.

The analytical laboratory will be required to evaluate and document its ability to meet the DQOs specified in the ISQAPP. The laboratory should flag any anomalies or outliers in the data in accordance with the laboratory's SOPs and take corrective actions to rectify any problems. In addition, the laboratory case narratives should describe any deviations from the method criteria.

#### 3.5.1.3 *Step 3: REVA Technical Support Team Data Validation*

Laboratory data will be generated in accordance with the PQAPP and ISQAPP. The REVA Technical Support Team will perform data validation to determine the quality of the analytical data set. This review of data will be completed based on (1) the analytical method referenced, (2) provisions of the PQAPP and ISQAPP, and (3) qualifications according to the *Superfund Contract Laboratory Program National Functional Guidelines for Data Review* (USEPA, 2017). The review will be conducted to assess precision, accuracy, representativeness, sensitivity, completeness, and comparability, per Table 11. A data validation summary will be produced to document the results of the validation process, and any deficiencies will be identified by data qualifiers.

**Table 11. Measures of Validation used for Sampling Results in the REVA Program**

| Validation Measure | Description |
|---|---|
| Precision | Precision measures the random error component of the data collection and analysis process. Precision is determined by measuring the agreement among individual measurements of the same property, under similar conditions, and is calculated as an absolute value. The degree of agreement is expressed as the relative percent difference (RPD). Analytical precision is assessed by analyzing matrix spike/matrix spike duplicate (MS/MSD) pairs and laboratory duplicate samples. Field precision is assessed by measurement of field duplicate samples. Laboratory and field precision control limits and QC RPD limits are presented in Worksheet #28 of the ISQAPP. $$RPD = \left\{\frac{\lvert X_1 - X_2\rvert}{[X_1 + X_2/2]}\right\} \times 100$$ |

**Table 11. Measures of Validation used for Sampling Results in the REVA Program**

| Validation Measure | Description |
|---|---|
| Accuracy | Accuracy is the degree of agreement of a measurement with an accepted reference or true value. Accuracy measures the bias or systematic error of the entire data collection process. Sources of these errors include the sampling process, field and laboratory contamination, sample preservation and handling, sample matrix interferences, sample preparation methods, and calibration and analytical procedures. In order to determine accuracy, a reference material of known concentration is analyzed, or a sample that has been spiked with a known concentration is reanalyzed. Accuracy is expressed as a percent recovery. $$Accuracy = \frac{Measured\ Value}{Known\ Value} \times 100$$ Analytical accuracy is measured by the analysis of calibration checks, system blanks, QC samples, surrogate spikes, matrix spikes, and other checks required by the selected analytical methods. Sampling accuracy is assessed by evaluating the results of field and trip blanks. Sampling accuracy is also maintained by frequent and thorough review of field procedures. The objective is to meet or exceed the demonstrated accuracy for the analytical methods on similar samples and should be within established control limits for the methods. Accuracy control limits and MS/MSD and surrogate recovery limits are presented in Worksheet #28 of the ISQAPP. |
| Representativeness | Representativeness expresses the degree to which data accurately and precisely represents a characteristic of a population, parameter variations at a sampling point, a process condition, or an environmental condition. Representativeness is achieved through proper development of the field sampling program. The sampling program must be designed so that the samples collected are representative of the area being sampled. There must be sufficient numbers of samples in representative locations to be representative of the area. |
| Sensitivity | Sensitivity is the capability of a method or instrument to discriminate between small differences in analyte concentrations. The laboratory will report all detections greater than the method detection limit. Non-detections will be reported at the limit of detection (LOD). In the circumstance where the LOD for a non-detect result exceeds the applicable screening value, this will be evidence of no contamination. |
| Comparability | Comparability expresses the confidence with which one data set can be compared to another. Comparability cannot be measured in quantitative terms, but must be considered in the sampling design. Therefore, this objective will be met through the use of standard methods for sampling and analyses and by following techniques and methods set forth in the ISQAPP. |

**Table 11. Measures of Validation used for Sampling Results in the REVA Program**

| Validation Measure | Description |
|---|---|
| Completeness | Completeness is a measure of the amount of valid data obtained from a measurement system compared to the amount expected to be obtained under normal conditions. Data is complete and valid if it meets all acceptance criteria including accuracy, precision, and any other criteria specified by the particular analytical method being used.<br>$$Completeness = \frac{Quantity\ of\ Reliable\ Data}{Total\ Quantity\ of\ Data} \times 100$$<br>The objective is to generate a sufficient database for making informed decisions. Every effort must be made to avoid sample loss through accidents or inadvertence. The completeness objective for each project is 90% for solid matrices and 95% for aqueous matrices.<br>The laboratory will provide a full deliverable including raw data for all sample delivery packages. The analytical data will be submitted in electronic format (PDF on CD). Electronic data deliverables will be transmitted with the final data package for each sampling event via e-mail. |

### 3.5.2 MC Concentration Assessment Process

Once validated, the sampling data will be compiled into summary tables and figures. Surface water, groundwater, sediment, and/or soil may be evaluated under REVA and analyzed to determine whether there is off-range migration of MC that presents an unacceptable risk to human health or the environment. The following general steps will be taken based on the data for any given site; however, specific conditions (e.g., elevated detection limits that are higher than applicable screening criteria) may require further examination and professional judgment in determining next steps.

#### *3.5.2.1 Non-Detections of Munitions Constituents*

Non-detections of MC generally indicate no off-range migration is occurring, the migration pathway is incomplete, and no further data collection or analysis is necessary until the next assessment or range conditions have changed significantly. This would be documented in interim technical memo #2 (see Section 3.6) and in the REVA Periodic Review documentation of findings (see Section 5).

#### *3.5.2.2 Munitions Constituents Detections Below Reference (Background) Levels*

As applicable, detected MC concentrations (particularly metals) will be compared to reference concentrations, which would consist of data collected from a background study (if available) or data collected from reference sample locations unaffected by range activity. The comparison of MC concentrations to reference concentrations would be used to assess the contribution of MC concentrations that are naturally occurring or contributed by non-range-related activities. In general, detectable concentrations that are below reference concentrations are indicative that there is not off-range MC migration that presents an unacceptable risk to human health and the environment and the source/receptor pathway is incomplete.

#### *3.5.2.3 Munitions Constituents Detections Above Reference Levels but Below State or Federal Screening Values*

In general, detectable concentrations that are above reference concentrations indicate there is off-range MC migration and the source/receptor pathway will be considered complete. Further comparison of MC concentrations to regulatory or screening values is necessary to evaluate whether the off-range migrations presents an unacceptable risk to human health or the environment. Any detected MC concentrations will be compared to media-specific state or federal screening values for each MC. The comparison values will be defined by the REVA Technical Support Team in the ISQAPP. Generally, state-specific regulatory standards will be used, and, in the absence of state guidance, federal regulatory values are referenced (see Section 3.3.8). Comparison of MC concentrations to these values helps to determine whether the data indicate an off-range migration of MC at levels presenting an unacceptable risk. In general, if concentrations are detected above background levels but below applicable state or federal screening values, then there is no known off-range MC migration that presents an unacceptable risk to human health and the environment. This finding would be documented in interim technical memo #2 (see Section 3.6) and the REVA Periodic Review documentation of findings (see Section 5). The migration pathways associated with these MC concentrations should be considered complete and evaluated as such in subsequent REVA Periodic Reviews.

#### *3.5.2.4 MC Detections Greater than or Equal to State or Federal Screening Values*

Detectable concentrations greater than or equal to applicable state or federal screening value levels will be evaluated further. A confirmatory sample will be taken when analytical results indicate MC greater than or equal to the appropriate comparison value. If a confirmatory sample also indicates MC greater than or equal to the comparison value, the REVA Management Team may implement further evaluation or recommend protective measures/BMPs. The tools used for further evaluation may include assessment of MC bioavailability or screening level risk assessments. Chapter 4 describes further evaluation of such results.

The sampling results and recommended next steps will be documented in interim technical memo #2 (see Section 3.6). The results of further evaluation and an assessment of whether there is an unacceptable risk to human health and the environment will be documented in interim technical memo #3 and in the REVA Periodic Review documentation of findings (see Section 5). The migration pathways associated with these MC concentrations should be considered complete and evaluated as such in subsequent REVA Periodic Reviews.

## 3.6 Interim Technical Memorandum #2 (Post Sampling/Fate and Transport Modeling)

At the completion of sampling, the REVA Technical Support Team will develop and transmit an interim technical memo to HQMC LF/MCICOM GF-5 with the recommended next steps. Recommended next steps may include actions such as completing the REVA Periodic Review or initiating further evaluation or recommending protective measures/BMPs. The interim technical memo should include sampling results, the updated CSM, and a narrative to support follow-on actions (see Table 12). Final decisions about next steps are made by HQMC LF/MCICOM GF-5, in coordination with the relevant installation and shall be incorporated into a final decision memorandum.

**Table 12. Interim Technical Memo #2 Contents**

| Content | Description | Action Required by Installation and HQMC LF/MCICOM GF-5 |
|---|---|---|
| Sampling Results | Detailed descriptions of the sampling results and comparisons to applicable reference and screening levels. | Use to inform decision to support next steps. |
| Updated CSM | An updated version of the CSM provided in interim technical memo #1 that confirms complete and incomplete sources, pathways, receptors, and interactions among these three components in graphic and/or tabular form. | Use to inform decision to support next steps. Provide review or comment. |
| Recommendation of Next Steps | Recommended next steps with supporting information. | Provide review and decide on next actions. |

# 4. FURTHER EVALUATION

If further evaluation is necessary to determine whether off-range migration presents an unacceptable risk to human health or the environment, an assessment of bioavailability, a screening-level human health evaluation, or an ecological risk assessment may be completed.

## 4.1 Assessing Bioavailability of Munitions Constituents

Bioavailability of some metals to ecological receptors can be assessed through AVS/SEM and the freshwater Biotic Ligand Model (BLM). If MC metals are present in sediment greater than or equal to applicable state or federal screening values, AVS/SEM and total organic carbon may be analyzed to determine the bioavailability of metals for uptake by benthic organisms. Bioavailability of some cationic metals (e.g., lead) in most anoxic sediments (i.e., sediments that lack oxygen) can be predicted by measuring the 1:1 relationship between AVS and SEM (total SEM = sum of cadmium, copper, lead, nickel, silver, and zinc). The resulting ratio of $\sum \frac{SEM}{AVS}$ is useful for predicting metals bioavailability and toxicity, or lack thereof, to benthic organisms in sediments (ITRC, 2011). Ratios less than 1 indicate low potential for metals bioavailability, while ratios greater than 1 indicate higher potential for metals bioavailability. Organic carbon in sediment can also bind free metals and reduce their availability to aquatic organisms, so $\sum \frac{SEM}{AVS}$ can be further assessed after being normalized to the fraction of organic carbon, and a prediction of toxicity can be further defined.

If MC metals are present in surface water greater than or equal to applicable state or federal screening levels, the REVA Technical Support Team may use the BLM (http://www.windwardenv.com/biotic-ligand-model/#) as a predictive tool to assess variability in metals toxicity using site-specific water chemistry data. The BLM uses measures of temperature, aquatic cations ($Ca^{2+}$, $Mg^{2+}$, $Na^{+}$, and $K^{+}$), aquatic anions ($Cl^{-}$ and $SO_4^{2-}$), sulfide, pH, alkalinity, and dissolved organic carbon to evaluate the availability of free metal ions and the degree to which competitive binding with gill surfaces inhibits metal toxicity. The model results are used to recommend adjustments to the freshwater screening levels for metals at a specific location.

The results of these bioavailability assessments may be sufficient to indicate that the MC concentrations in surface water or sediments do not present an unacceptable risk to the environment. If, however, they indicate MC are bioavailable, the result may be used to inform a screening level risk assessment.

## 4.2 Screening-Level Human Health Evaluation

If maximum detected MC concentrations off-range are greater than or equal to state-specific or federal screening levels, as applicable, the REVA Technical Support Team may perform an additional assessment of human health risk involving one or both of the following steps. *(For risk assessment purposes, risk-based screening levels (RBSLs) are used as comparison values. Some of the applicable state or federal screening values referenced in Section 3.3.8 are not risk-based. The REVA Technical Support Team must identify the most appropriate RBSLs and use them when performing screening level risk assessments within the REVA program.)*

1. Calculate representative MC concentrations of (described in Step 1 below) and compare them to generic RBSLs published in state or federal USEPA guidance.
2. Re-evaluate the assumptions and parameters used to derive generic RBSLs and screen them against site-specific conditions.

Many states, as well as USEPA, have readily available generic RBSLs for soil and groundwater, but not for surface water and sediment. In order to estimate a surface water RBSL, the available groundwater RBSL may be multiplied by a factor of 10 to account for dilution of groundwater discharging to a surface water body. To estimate a sediment RBSL, the available soil RBSL may be multiplied by a factor of 10 to account for lower exposure levels to sediment. However, this will be determined based on site-specific characteristics and state-specific regulations or guidance.

**Step 1**: Determine a representative concentration, which is a reasonable estimate of the MC concentration that is likely to be contacted over time at the exposure site. It is assumed that the receptor is not exposed to the maximum detected MC concentration during the entire duration of exposure. USEPA has developed a statistical software program called ProUCL that calculates mean concentrations and upper confidence limits (UCLs) of the mean concentration for discrete or composite sampling data sets (USEPA, 2016a). The ITRC has developed a calculator tool to derive incremental sampling UCLs (ITRC, 2012). If incremental samples are collected, UCLs are calculated using Student's t-test and Chebyshev statistical methods. USEPA guidance recommends using a mean concentration as the representative concentration when assessing health effects from exposure to lead (USEPA, 2016b). If the representative concentration is above the generic RBSL, then the MC is carried forward to Step 2.

**Step 2**: Generic RBSLs are derived using data from particular receptor species and assumptions (often conservative) about site conditions. Table 13 identifies parameters that may be compared to site-specific conditions to evaluate the appropriateness of the generic RBSL to the site in question. Site-specific RBSLs may also be derived using site-specific information. The parameters in Table 13 may be modified to better estimate a reasonable level of exposure for potential receptors at the site. Site-specific RBSLs may also be used with Steps 1 and 2 outlined above in place of the generic RBSLs.

Once the screening evaluation is completed, the REVA team will meet to discuss the risk screening results along with other lines of evidence to determine whether further action is required. Lines of evidence include a frequency of detection and background evaluation. USEPA recommends looking at the frequency of detection (e.g., less than 5 percent) (USEPA, 1989). This would involve reviewing current sampling data in context of previously collected data during the REVA baseline and 5-year reviews. If background data are available, the REVA Technical Support Team may conduct a statistical hypothesis test where the mean concentrations of the background and site data sets are compared.

**Table 13. Methods for Developing Site-Specific RBSLs**

| Changes | Description | Procedure |
|---|---|---|
| Exposure Frequency | Represents the number of days out of a year that the receptor is exposed to the exposure area or site. | Research the number of days that the receptor may be present at the site; take into consideration annual weather conditions if the receptor is an outdoor receptor. |
| Exposure Duration | Represents the number of years that the receptor spends visiting or living at the exposure area or site. | Research the number of years the receptor may spend at the site (e.g., temporary assignment). |
| Exposure Time | Represents the amount of time that a receptor spends in the exposure area or site. | Research how much time the receptor actually spends at the site (e.g., is it typical 8-hour work day or less). |
| Fraction of Exposure | Represents the amount of contaminated media that the receptor contacts or ingests. | Determine whether a default of 1 is appropriate or account for the fraction of contaminated media that a receptor may come into contact with at the site. |
| RBSL Target Thresholds | Represents the protectiveness of the RBSL in light of the National Contingency Plan risk-based thresholds. Cancer RBSLs use a target cancer risk (TCR), and the non-cancer RBSLs use a non-cancer target hazard quotient (THQ). Default TCR and THQs are 1E-06 and 1, respectively. | If only one or a few MC are identified, the REVA team may decide to use less conservative thresholds to evaluate exposure at the site. |
| Modeled Concentrations | Soil or groundwater concentrations are estimated using conservative models (e.g., conservative degradation factors may have been used to predict soil or groundwater concentrations at the point of exposure). | Revisit default modelling parameters and make the model more site-specific where data are available. |

## 4.3 Screening-Level Ecological Risk Assessment

If sample results indicate a possible risk to ecological receptors, a Screening-Level Ecological Risk Assessment (SLERA) will be used to determine whether there is a general indication of ecological risk. A SLERA can help estimate the likelihood that a particular ecological risk exists, identify the need for site-specific data collection efforts, and focus site-specific ecological risk assessments, if needed. A SLERA is used to assess the need, and if required, the effort necessary, to conduct a detailed or “baseline” ecological risk assessment. A SLERA is a highly conservative estimate of potential ecological risk and is not designed to provide definitive estimates of actual risk or generate cleanup goals.

In general, a SLERA follows the first two steps of the USEPA eight-step ecological risk assessment process (USEPA, 1997). The steps are:

1. Screening-level problem formulation and toxicity evaluation—the majority of this step will have been completed prior to the SLERA. This includes gathering information, conducting a site visit, and

determining applicable screening criteria. This information will be documented in the SLERA as a framework for the evaluation.

2. Screening-level exposure estimate and risk calculation—includes estimating exposures and calculating risk. The purpose of the step is to calculate how much ecological receptors are exposed to MC at the site and compare the exposure levels at the site to levels that are known to cause harm.

Conservative thresholds of adverse ecological effects will be used during risk calculations in Step 2. A literature search of relevant studies that quantify toxicity will be reviewed for each site to determine appropriate screening ecotoxicity values for the selected endpoints identified. To ensure risk is not underestimated, chosen values will represent No Observed Adverse Effect Levels (NOAELs) where available. If only Lowest Observed Adverse Effect Level (LOAEL) values are available, the LOAEL value will be multiplied by 0.1 and the product used per the 1997 USEPA guidance. Similarly, conservative exposure parameters will also be assumed for the screening level assessment. These parameters include: minimum body weight, 100 percent area-use factor, maximum food ingestion rate, and 100 percent bioavailability.

A refined screening level assessment will also be calculated concurrently during Step 2. The refined screening is a less conservative estimate which provides insight regarding the potential results of a Baseline Ecological Risk Assessment. It uses average exposure values and parameters obtained from literature for the endpoints identified. Hazard quotients for both NOAEL and LOAEL values will be presented in the SLERA to provide decision-makers a range of values to consider.

Based on the aforementioned steps, a scientific management decision point will be defined, which will state whether further assessment is needed. Although a SLERA is an abbreviated assessment, it is recognized by USEPA as a complete risk assessment. Therefore, each SLERA includes documentation that supports the risk characterization and uncertainty analysis included in the assessment.

## 4.4 Interim Technical Memorandum #3

At the completion of any further investigation, the REVA Technical Support Team will develop and transmit an interim technical memo to HQMC LF/MCICOM GF-5 with the recommended next steps. Recommended next steps may include actions such as completing the REVA Periodic Review, MC migration, or implementing protective measures/BMPs (See also Section 6). The interim technical memo should include a risk assessment document to support follow-on actions (see Table 14). Final decisions about next steps are made by HQMC LF/MCICOM GF-5, in coordination with the relevant installation and shall be incorporated into a final decision memorandum.

**Table 14. Interim Technical Memo #3 Contents**

| Content | Description | Action Required by Installation and HQMC LF /MCICOM GF-5 |
|---|---|---|
| Summary of Further Investigation | Detailed descriptions of the methods and results of the additional investigative processes. | Use to inform decision to support next steps. |
| Updated CSM | An updated version of the CSM provided in interim technical memo #2 that designates which off-range migrations pose an unacceptable risk to human health and the environment. | Use to inform decision to support next steps. Provide review or comment. |
| Written Recommendation of Next Steps | Recommended next steps with supporting information. Delineates the need for any risk management actions. | Provide review and decide on next actions, if any. |

# 5. DOCUMENTATION OF FINDINGS

At the conclusion of the periodic review for each Marine Corps installation, documentation of findings is produced. The documentation includes methods used during the periodic review, sampling and modeling results (when applicable), and conclusions.

DoDI 4715.14 requires that DoD Components make the documentation of findings from Operational Range Assessments available to the public (DoD, 2005). USMC is implementing this requirement by publishing a REVA Factsheet for each installation, which will be posted on the DoD Environment, Safety, and Occupational Health Network and Information Exchange (DENIX) (http://www.denix.osd.mil/sri/policy/reports/cfm).

## 5.1 Range Environmental Vulnerability Assessment Periodic Review Documentation of Findings

The REVA Technical Support Team will document periodic review findings and conclusions for each installation. The documentation of findings will consist of a REVA Periodic Review Technical Memorandum that captures the process and conclusions and a REVA Periodic Review Factsheet.

The REVA Periodic Review Technical Memorandum and the REVA Periodic Review Factsheet should not contain the following sensitive information.

- well locations – active and inactive;
- names of public water supply wells;
- target locations;
- range boundaries;
- rotary wing landing zones;
- cultural resource locations;
- references to longitudes and latitudes;
- sample locations;
- expenditure data;
- specific munition names; and
- photographs.

### 5.1.1 REVA Periodic Review Technical Memorandum

The REVA Technical Support Team will develop a Technical Memorandum to document the REVA Periodic Review findings at each installation. The Technical Memorandum is intended to be a brief document (i.e., less than 20 pages) that summarizes the methods employed, results, and conclusions of the periodic review. The contents of the REVA Periodic Review Technical Memorandum are outlined in Table 15.

**Table 15. Contents of the REVA Periodic Review Technical Memorandum**

| Section | Contents |
|---|---|
| Introduction | Overall purpose of the REVA program and the Periodic Review.<br>Scope of the REVA program and any excluded facilities or areas at the installation. |
| Installation Background[a] | Installation location, size, history, training mission, and land use.<br>Overview of site characteristics (geography, geology, hydrology, and natural resources).<br>Relevant results and conclusions from previous REVA documents. |
| Conceptual Site Model | Changes in site conditions affecting the CSM since most recent REVA, includes MC sources, migration pathways, receptors, and exposure pathways.<br>Summary of complete, incomplete, or inconclusive pathways for source-receptor interaction. |
| Sampling [b] | Summary of samples collected and analyzed (methods, media, locations, and analytes).<br>Sampling results for groundwater, surface water, sediment, and soil. |
| Fate and Transport Modeling [b] | Modeling methodology (brief description of purpose, model description, and model inputs).<br>Fate and transport modeling output:<br>• Modeled MC concentrations at points of interest<br>• Model sensitivity analysis |
| Further Investigation(s) [b] | Summary of additional investigation to assess whether off-range MC concentrations present an unacceptable risk to human health and the environment, includes screening level risk assessment, bioavailability, and additional exposure assessment.<br>Descriptions of methods and results of additional investigation. |
| Conclusion | Answer the primary REVA study question: *Is there MC migration from the operational range to an off-range area that creates an unacceptable risk to human health or the environment?*<br>Summarize supporting conclusions such as:<br>• CSM conclusions identifying complete or incomplete pathways.<br>• Sampling and modeling conclusions discussing the presence or absence of off-range MC migration.<br>• Conclusions from further investigation(s) (e.g., risk assessments, bioavailability analysis) evaluating presence or absence of an unacceptable risk to human health or the environment. |

[a] Includes a reference to previous REVA documents for details | [b] Section may not be applicable to all installations.

### 5.1.2 REVA Periodic Review Factsheet

The REVA Periodic Review Factsheet is a brief (i.e., 2 page) focused document that answers the primary REVA study question: “Is there MC migration from the operational range to an off-range area that creates an unacceptable risk to human health or the environment?” The Factsheet includes a simplified statement of purpose, brief overview of the installation and operational ranges, summary of the methodology and results, summary of conclusions, and next steps. The Factsheet includes an installation map that provides necessary geospatial context to support understanding of the REVA Periodic Review.

Contents of the REVA Factsheet will be screened to ensure it does not contain sensitive information and will be releasable to the general public following appropriate USMC review procedures (e.g., Public Affairs, Legal). The Final REVA Periodic Review Factsheet is sent to the installation's environmental POC. The installation environmental POC will provide the REVA Periodic Review Factsheet under cover memorandum to the appropriate regulators and stakeholders for their information and awareness. Appropriate stakeholders are determined by the installation Environmental POC and Public Affairs Officer (PAO) and may include, but are not limited to, federal, state, and local government agencies; tribal governments; native Hawaiian organizations; and the general public.

The REVA Factsheets are also posted on DENIX (https://www.denix.osd.mil/sri/Policy/Reports.cfm).

## 5.2 Reporting Program Status

In accordance with DoDI 4715.14, HQMCLF/MCICOM GF-5 is responsible for reporting the REVA program status to the Office of the Secretary of Defense (OSD) each fiscal year (DoD 2005). The REVA Technical Support Team will work with HQMC LF/MCICOM GF-5 to provide required information for reporting, including:

- number of completed and planned operational range assessments;
- list of all operational ranges that have a release or substantial threat of a release of MC from an operational range to an off-range area that creates an unacceptable risk to human health or the environment; and
- dates of upcoming assessments.

OSD may request additional information or a briefing from HQMC LF/MCICOM GF-5 annually regarding operational range assessments and the status of the REVA program. Information requested may include the number of environmental samples analyzed and sampling results, upcoming periodic reviews, and program funding. The REVA Technical Support Team will support the REVA Management Team with requests to OSD.

## 5.3 Notification Requirements

### 5.3.1 No Release Notification

No immediate notification is required of results indicating there is no MC migration from the operational range to an off-range area that creates an unacceptable risk to human health or the environment. Such results are demonstrated through a Conceptual Site Model that indicates no complete exposure pathway and/or sampling results below applicable state or federal regulatory or screening values. Such results will be reported internally to the Marine Corps. Sampling results will be made available to external stakeholders and federal- or state-specific regulatory agencies through the issuance of the REVA Factsheet (see Section 5.1.2).

### 5.3.2 Installation Notification Associated with Sample Results Greater than or Equal to Applicable Regulatory Values

If MCs are detected off-range and are greater than or equal to a federal or state-specific regulatory standards, the installation's environmental POC will be immediately notified so that the installation can make any required notifications and take actions, where appropriate, to ensure public safety (e.g., restrict access or use). The procedure for notifications will be dependent upon, and in accordance with, the specific federal or state regulatory requirements. The REVA Technical Support Team will collect and analyze confirmatory sample(s), as discussed in Section 3.5.2.4.

### 5.3.3 Notification Associated with Off-Range Munitions Constituents Releases that Cause Unacceptable Risk to Human Health or the Environment

Immediate notification is necessary for a result indicating that there is MC migration from the operational range to an off-range area that creates an unacceptable risk to human health or the environment. The REVA Technical Support Team must notify the REVA Management Team immediately upon awareness of the aforementioned assessment designation. An MC release from an operational range that presents a risk to human health or the environment is identified upon receipt of confirmatory sample results or a final risk assessment conclusion, which designates that the release presents an unacceptable risk to a human health or the environment. Upon notification, the Management Team will inform the installation's Environmental POC. With support from the Management Team, HQMC LF /MCICOM GF-5 will prepare a notification letter to the Deputy Assistant Secretary of the Navy (DASN) (Environment) and to OSD, as required by DoDI 4715.14 (DoD, 2005).

External reporting to stakeholders may be required if off-range MC migration is found to present an unacceptable risk to human health or the environment. HQMC LF/MCICOM G-5 will provide the necessary information in the form of a Factsheet containing sampling and analysis results. Installations will notify the appropriate stakeholders as required by applicable laws and regulations. Stakeholders may include federal, state, and local government agencies; tribal governments; Native Hawaiian organizations; and the general public. The installation environmental office and installation PAO are responsible for the timely notification of relevant stakeholders. The REVA Management Team will support the installation, as needed, but all further external communication is led by the installation.

# 6. FOLLOW-ON ACTIONS

The REVA Management Team may choose to implement additional actions once the REVA Periodic Review is completed. These follow-on actions are intended to enhance range sustainability and to ensure protection of human health and the environment during the five-year period between periodic reviews. These actions will be documented separately from the REVA Periodic Review, as appropriate, and may be included in the next periodic review, if implemented at that time.

## 6.1 Identifying Additional Actions

Additional actions may be warranted based on the findings of the REVA installation review. Table 16 presents the follow-on actions for each of the possible REVA conclusions, and potential actions are discussed in the subsequent subsections.

**Table 16. REVA Findings and Possible Follow-On Action**

| REVA Finding | Risk to Human Health or the Environment | Follow-On Action(s) |
|---|---|---|
| No MC migration | No | The operational range is identified for reassessment during the next periodic review. |
| MC migration off-range at concentrations below applicable state or federal screening values | No | The REVA Management Team will determine whether BMP(s) and/or monitoring are recommended, and the operational range is identified for reassessment during the next periodic review. |
| MC migration off-range at concentrations greater than or equal to applicable state or federal screening values | No | The REVA Management Team will determine whether BMP(s) and/or monitoring are recommended, and the operational range is identified for reassessment during the next periodic review. |
| | Yes | The REVA Management Team will determine whether BMP(s) and/or monitoring are recommended, and/or whether the off-range site should be referred to a restoration program. The operational range is identified for reassessment during the next periodic review. |

## 6.2 Periodic Reassessment

REVA installation reviews are scheduled in accordance with DoDI 4715.14, which stipulates that operational ranges are assessed at least every 5-years or sooner if significant changes occur that may affect determinations made in the previous assessment. Operational ranges are identified for reassessment during the subsequent REVA periodic review, or sooner if conditions significantly change. Operational ranges that become inactive or closed between scheduled periodic reviews will undergo one additional REVA periodic review. If the range is re-opened, it will be assessed during the next scheduled periodic review.

Significant changes to ranges or their operations and management that could affect determinations made in the previous assessment, may be observed through the REVA Technical Support Team's annual review of RFMSS data (discussed in Section 6.4.1) or may require notification from the installation. Marine Corps installations will inform HQMC LF/MCICOM GF-5, through their respective chain of command, of changes in MC sources, pathways, or receptors that could adversely affect off-range MC migration and impact REVA findings. Such conditions could be a change in range design, footprint, or operation; major land disturbance; significant variation in groundwater withdrawals; or identification of new off-range human or ecological receptors (e.g., a water body is converted to a drinking water source, drinking water wells are installed, or ecological habitat is identified or created).

The REVA Management Team will review previous REVA conclusions and the changed conditions to determine whether an expedited reassessment of the affected operational range(s) is warranted. Discussions with installation personnel may be necessary to gather additional information for making this determination. HQMC LF/MCICOM GF-5 may decide to accelerate the schedule for the installation's periodic REVA if a majority of the installation is affected by identified changes.

## 6.3 Best Management Practice (BMP) Recommendations

Methods and technologies, referred to as BMPs, are available as management strategies to reduce the potential for MC migration from operational ranges. The implementation and selection of BMPs should be based on REVA findings and site-specific conditions, range design and use, and range maintenance activities. Various resources can help inform the selection of BMPs, in particular, the *Department of Defense Best Management Practices for Munitions Constituents on Operational Ranges* (Jenkins and Vogel, 2014) and the "Environmental Management at Operating Outdoor Small Arms Firing Ranges" (ITRC, 2005). These documents describe management technologies designed to slow or halt the migration of MC in environmental media and the process for selecting appropriate and effective BMPs.

BMPs to manage MC migration from operational ranges include, but are not limited to, operational changes, vegetative solutions, stormwater management, berm design and structural enhancements, geosynthetic materials, and soil amendments. Though operational range clearance and lead recovery are not conducted for environmental sustainment, they can be effective BMPs because they reduce the source of MC from operational ranges.

Some BMPs can be very easy to implement and have a negligible financial investment. These options may be considered even in scenarios where off-range MC migration has not been observed. Appendix B contains a range BMP evaluation form that installations can use to identify which BMPs would be most appropriate for a particular range, given site-specific conditions. Some effective BMPs include:

- mowing with reduced frequency; staggering firing lane use;
- ensuring storm drains are not clogged and function properly;
- minimizing firing into water bodies or wetlands;
- moving target locations; and
- amending soils.

One or more BMPs may be applied in a complementary and cumulative manner to achieve the greatest reduction in MC migration, while accounting for other factors such as operational requirements, available funding, and required maintenance. Determining the appropriate BMP(s) is a multi-step process that must consider the suitability of a BMP for specific types of ranges or impact areas, the predominant transport mechanism, and the site-specific physical characteristics of the area being addressed. After considering these factors, the feasibility of implementing and maintaining the BMP and a cost-benefit analysis should be considered in the final selection.

## 6.4 Monitoring

The REVA Management Team may choose to conduct monitoring at individual ranges or range complexes where MC have been detected within environmental media of a migration pathway, even when such MC concentrations do not create an unacceptable risk to human health or the environment. Monitoring between periodic reviews supports the identification of potential changes in MC loading that could affect REVA findings. This could involve reviewing munitions expenditure data and additional environmental sampling.

### 6.4.1 Review of Expenditure Data

Marine Corps range managers use the RFMSS to schedule range use and track munitions expenditures at operational ranges. This system allows expenditure data to be easily exported, so the REVA Technical Team can review it and identify significant changes in expenditure rates or changes in munitions types, compared to those used during the last periodic review. In cases where expenditures have significantly changed, the REVA Technical Support Team should discuss changes with range managers to ensure an accurate understanding and to learn whether targets, impact areas, or range design have also been affected. The REVA Management Team will use this information to determine whether annual RFMSS review, sampling, or reassessment is warranted for an operational range complex or portion thereof.

### 6.4.2 Sampling

Sampling may be conducted at select locations between periodic reviews, if changed conditions or results from the last periodic review indicate a need for additional data. Sample selection, laboratory analyses, and data evaluation should follow guidelines and procedures outlined in Chapter 3.

## 6.5 Referral to Restoration Program

Off-range MC migration that presents an unacceptable risk to human health or the environment may require additional investigation, characterization, and remediation. REVA is not an environmental restoration program and remedial activities will not be performed within the REVA program. If additional investigation or remediation is warranted, the off-range site will be referred to the appropriate restoration program for that installation (e.g., Environmental Restoration Program) for further action. Areas within operational range boundaries will be addressed as range sustainment.

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# Glossary

| | |
|---|---|
| **Code of Federal Regulations** | The compilation of regulations promulgated by the United States Environmental Protection Agency and other federal agencies to implement federal laws. |
| **Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)**<br>**42 United States Code (U.S.C) 9601 et seq** | Legislation covering hazardous substance releases into the environment and the cleanup of hazardous substance disposal sites. The regulations are located at 40 CFR 305 and 307. |
| **Data Quality Objective (DQO) Process**<br>**USEPA. 2000. Guidance for the Data Quality Objectives Process (EPA QA/G4)** | A process used to develop performance and acceptance criteria (or data quality objectives) that clarify study objectives, define the appropriate type of data, and specify tolerable levels of potential decision errors that will be used as the basis for establishing the quality and quantity of data needed to support decisions. |
| **Detonation**<br>**DoD 6055.9-STD, DoD Ammunition and Explosives Safety Standards, August 1997, (A-3)** | As relating to open detonation, detonation is a violent chemical reaction within a chemical compound or mechanical mixture evolving heating and pressure; a detonation that proceeds through the reacted material toward the unreacted material at a supersonic velocity. The result of the chemical reaction is exertion of extremely high pressure in the surrounding medium forming a propagating shock wave that originally is of supersonic velocity. |
| **Explosive Ordnance Disposal (EOD)**<br>***Office of the Chairman of the Joint Chiefs of Staff, "Joint Explosive Ordnance Disposal," JP 3-42, current edition*** | The detection, identification, on-site evaluation, rendering safe, recovery, and final disposal of unexploded explosive ordnance. The organizations engaged in such activities. |
| **Impact Area**<br>**Marine Corps Order (MCO) 3570.1B** | The ground and associated airspace within the training complex used to contain fired or launched ammunition and explosives and the resulting fragments, debris, and components from various weapon systems. A weapon system impact area is the area within the SDZ used to contain fired or launched ammunition and explosives and the resulting fragments, debris, and components. Indirect fire weapon system impact areas include probable error for range and deflection. Direct fire weapon system impact areas encompass the total SDZ from the firing point or position down range to distance X:<br>*a. Temporary impact area.* An impact area within the training complex used for a limited period of time to contain fired or |

launched ammunition and explosives and the resulting fragments, debris, and components. Temporary impact areas are normally used for non-dud-producing ammunition or explosives and should be able to be cleared and returned to other training support activities following termination of firing.

*b. Dedicated impact area.* An impact area that is permanently designated within the training complex and used indefinitely to contain fired or launched ammunition and explosives and the resulting fragments, debris, and components. Dedicated impact areas are normally used for less sensitive ammunition and explosives than that employed in high hazard impact areas. However, any impact area containing fuzed HE or white phosphorous duds represents a high risk to personnel and access must be limited and strictly controlled.

*c. High hazard impact area.* An impact area that is permanently designated within the training complex and used to contain sensitive HE ammunition and explosives and the resulting fragments, debris, and components. High-hazard impact areas are normally established as part of dedicated impact areas where access is limited and strictly controlled because of the extreme hazard of dud ordnance such as ICM, HEAT, 40mm, and other highly sensitive ammunition and explosives.

**Military Munitions**
**40 CFR §260.10**

All ammunition products and components produced for or used by the armed forces for national defense and security, including ammunition products or components under the control of the Department of Defense, the United States Coast Guard, the Department of Energy, and the National Guard. The term includes confined gaseous, liquid, and solid propellants; explosives; pyrotechnics; chemical and riot control agents, smokes, and incendiaries, including bulk explosives and chemical warfare agents; chemical munitions; rockets; guided missiles; bombs; warheads; mortar rounds; artillery ammunition; small arms ammunition; grenades; mines; torpedoes; depth charges; cluster munitions and dispensers; demolition charges; and devices and components thereof.

**Military Range**
**40 CFR §266.201**

A designated land or water area set aside, managed, and used to conduct research on, develop, test, and evaluate military munitions and explosives, other ordnance, or weapon systems, or to train military personnel in their use and handling. Ranges include firing lines and positions, maneuver areas, test pads, detonation pads, impact areas, and buffer zones with restricted access and exclusionary areas. This definition does not include airspace, water, or land areas underlying airspace used for training, testing, or research and development where military munitions have not been used.

| | |
|---|---|
| **Munitions Constituents**<br>**10 U.S.C. § 2710(e)(4)** | Any materials originating from unexploded ordnance, discarded military munitions, or other military munitions, including explosive and nonexplosive materials, and emission, degradation, or breakdown elements of such ordnance or munitions. |
| **Range**<br>**10 U.S.C. § 101(e)(3)** | The term "range," when used in a geographic sense, means a designated land or water area that is set aside, managed, and used for range activities of the Department of Defense. Such term includes the following:<br>A. Firing lines and positions, maneuver areas, firing lanes, test pads, detonation pads, impact areas, electronic scoring sites, buffer zones with restricted access and exclusionary areas.<br>B. Airspace area designated for military use in accordance with regulations and procedures prescribed by the Administrator of the Federal Aviation Administration. |
| **Off-Range** | Areas outside the boundaries of an operational range complex or areas outside the boundary of a single operational range where there is only one range (no adjacent ranges) in the area. |
| **Operational Range**<br>**10 U.S.C. § 101(e)(3)** | A range that is under the jurisdiction, custody, or control of the Secretary of a military department and (1) that is used for range activities or (2) although not currently being used for range activities, that is still considered by the Secretary to be a range and has not been put to a new use that is incompatible with range activities. |
| **Range**<br>**10 U.S.C. § 101(e)(1)** | When used in a geographic sense, means a designated land or water area that is set aside, managed, and used for range activities of the Department of Defense. Such term includes the following:<br>• Firing lines and positions, maneuver areas, firing lanes, test pads, detonation pads, impact areas, electronic scoring sites, buffer zones with restricted access, and exclusionary areas.<br>• Airspace areas designated for military use in accordance with regulations and procedures prescribed by the Administrator of the Federal Aviation Administration. |
| **Range Activities**<br>**10 U.S.C. § 101(e)(2)** | Research, development, testing, and evaluation of military munitions, other ordnance, and weapons systems.<br>The training of members of the armed forces in the use and handling of military munitions, other ordnance, and weapons systems. |

| | |
|---|---|
| **Surface Danger Zone (SDZ)**<br>**MCO 3570.1C, Range Safety** | The ground and airspace designated within the training complex (to include associated safety areas) for vertical and lateral containment of projectiles, fragments, debris, and components resulting from the firing, launching, or detonation of weapon systems to include ammunition, explosives, and demolition explosives. |

# Appendix A. MC Loading Calculator Details and Development

REVA MC LOADING CALCULATOR DEVELOPMENT

Each MC loading area identified within REVA requires a MC loading rate be calculated in order to perform the modeling; therefore, the MC Loading Calculator was developed. For the purposes of REVA, the MC loading estimates are determined as average concentrations (kg/m2) deposited annually in the MC loading area for the duration that the range activities generating the MC loading were conducted. Each of the assumptions associated with the determination of a loading rate, as well as the calculator parameters used, are documented for the respective installations.

The mass-loading principles discussed in Section 4.2.3 Estimating MC Loading, of the *REVA Reference Manual for Baseline Assessments,* were observed in order to more accurately quantify the MC potentially deposited as a result of low order detonations, high order detonations, and duds (HQMC, 2009). Dud rate and low order rate data are estimated based upon the July 2000 study done by the U.S. Army Technical Center for Explosives Safety Report of Finding for Study of Ammunition Dud and Low Order Detonation Rates. Dud and low order rates are tracked, reported and made available according to DoDIC. For the DoDICs that dud or low order rates are not available, default values of 3.45% (dud rate) and 0.028% (low order rate) are used. In addition, the amount of residual explosives remaining after a low-order detonation, and a high order detonation are estimated to be 50% and 0.1%, respectfully.

The primary source for MC data is U.S. Army Defense Ammunition Center's (DAC) MIDAS website. In addition to MIDAS, other sources used for MC data included the ORDDATA II software and various ordnance technical manuals. These sources provided the types and amounts of energetic fillers associated with the military munitions known or suspected to have been used at the range. In cases where specific munitions use data are unavailable, the military munitions types selected were based upon common military munitions used during the active time periods of the operational range. Perchlorate data are obtained from an analysis of perchlorate containing military munitions, which can be obtained from various technical manuals or other electronic database systems such as MIDAS (https://midas.dac.army.mil/). The Marine Corps authorized allowances, with a few minor exceptions, are similar to the Army.

TRAINING FACTOR

Historically, military training operations have been affected by campaigns and wars over time. This affect usually resulted in an increase in training prior to a conflict and tapering off during it, with training increasing again toward the end of the conflict and then subsequently decreasing again to a non-war level. REVA attempted to account for this training affect by developing a training timeline of significant events beginning in 1914 through today. This timeline accounts for the following events:

- World War I
- World War II

- The Cold War
- The Korean War
- The Vietnam Conflict
- The Persian Gulf
- Afghanistan, and
- Iraq

The results of the training analysis resulted in the development of four periods that increase the loading rate for that period by a Training Factor, as well as a baseline[1] level of training. The periods identified and their associated Training Factors are as follows:

- Period A:  1914-1924 (Baseline + 40%)
- Period B:  1925-1937 (Baseline)
- Period C:  1938-1976 (Baseline + 50%)
- Period D:  1977-1988 (Baseline + 20%)
- Period E:  1989-Present (Baseline + 50%)

The baseline expenditure rate is applied to each year the area of interest or range was in use. The MC Loading Calculator automatically applies the training factor adjustments according to the time period so that loading rates are estimated for each year the range was known or suspected to be in use. All known data and assumptions input into the MC Loading Rate Calculator for each operational range area being assessed are documented.

Using the Calculator

In its simplest application, the Calculator initially requires completion of the MC spreadsheets (see Table B1).  This entails entry of the following data points:

- Description of the military munitions used within a MC loading area (Column F: Documented Munition DoDIC or Nomenclature)
- Quantity of military munitions used (Column L: Total Ordnance Quantity for Baseline)
- Matching the munitions description to an item in the DoDIC picklist (Column G: Picklist DoDIC Match).
- Area of the MC loading area (Column AC: Affected Target Surface Area)
- Years of the respective time periods (Periods A, B, C, D, and/or E) that the MC loading area was operational (Columns AI, AO, AU, BA, and BG: Duration)

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[1] 1 Training model assumes a 20-60-100% increases for years leading up to war (Vietnam training increases stretched over longer periods), with only a 60-40% percent increase during two years after war, maintaining at 40% during war, and a 60-80% increase beginning at end of war followed by a 60-40-20-return to non-war (baseline) level.  This is modeled for each war, with the highest modeled level taking precedence when determining what level of training occurred during overlapping timeframes.  Assume cold war had only a 20% increase over its life.

Once this information has been entered, the Calculator references the munition worksheet to retrieve MC, dud, low order, and high order data and calculates the Total Average Load Rate for each MC loading area, by period. The following figure demonstrates the calculation of the load rate for a MC loading area for RDX during Period C.

Calculations where less information is available can be made using additional columns that attempt to account for the type of weapon system being used, number of weapon systems, number of military munitions per weapon system, and etcetera.

**Table B1. Example of the Loading Calculator**

Munitions Worksheet

| DODIC | Nomenclature | DUD (%) | Low Order Dets (%) | High Order Dets (%) | EXPLOSIVES (lbs) Low RDX | High RDX | Average RDX |
|---|---|---|---|---|---|---|---|
| H929 | [illegible] | 3.45 | 0.02800 | 96.52 | 0.00000 | 0.00000 | 0.00000 |
| H930 | [illegible] | 3.45 | 0.02800 | 96.52 | 5.46000 | 5.46000 | 5.46000 |
| H931 | [illegible] | 3.45 | 0.02800 | 96.52 | 9.04470 | 9.04470 | 9.04470 |
| HA06 | [illegible] | 3.45 | 0.02800 | 96.52 | 0.00000 | 0.00000 | 0.00000 |
| [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |

Munition description gathered from range expenditure source (i.e., range control, ASR, PRA, etc.

MC Worksheet data reference row for DoDIC H930

Data Automatically Pulled from Munitions Worksheet

Data Automatically Pulled from Munitions Worksheet

Data Automatically Pulled from Munitions Worksheet

Picklist item match

Data Automatically Pulled from Munitions Worksheet (Converted to Kg)

Size of MC loading area ($M_s$)

Training Factor

Length of use during Period C

MC Worksheet (RDX)

| F | G | L | O | Q | S | T | V | W | Y | Z | AB | AC | AD | AT | AU | AV | AW | AX |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | | Period C (1938-1976) | | | | |
| Documented Munition DoDIC or Nomen. | Picklist DoDIC Match | Total Ordnance Quantity for Baseline | REVA MC Weight (Kg) | Percent DUD Estimate | DUD Analyte Cont. (Kg) | Percent Low Order Estimate | Low Order Analyte Cont. (Kg) | Percent High Order Estimate | High Order Analyte Cont. (Kg) | Total Potential Surface Analyte Cont. (Kg) | Total Potential Surface Analyte Available at Target (Kg) | Affected Target Surface Area (m²) | Surface Soil Baseline Annual Load Rate (Kg/m²) | Training Factor | Duration | Surface Load Rate (Kg/m²) | Soil Conc. (Kg/m²) | Average Annual Surface Load Rate (Kg/m²) |
| Whd, 5", MK 28 HE | H930 | 27 | 2.48E+00 | 3.450000 | 2.31E-02 | 0.028000 | 9.36E-03 | 96.522 | 6.45E-02 | 9.70E-02 | 9.70E-02 | 2.21E+04 | 4.38E-06 | 1.50 | 27 | 1.77E-04 | 3.88E-04 | 6.57E-06 |
| Whd, 5", MK 32 HEAT | H931 | 19 | 4.10E+00 | 3.450000 | 2.69E-02 | 0.028000 | 1.09E-02 | 96.522 | 7.52E-02 | 1.13E-01 | 1.13E-01 | 2.21E+04 | 5.10E-06 | 1.50 | 27 | 2.07E-04 | 4.53E-04 | 7.66E-06 |
| Whd, 5", MK 34, AP/ASW | H929 | 2 | 0.00E+00 | 3.450000 | 0.00E+00 | 0.028000 | 0.00E+00 | 96.522 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 2.21E+04 | 0.00E+00 | 1.50 | 27 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Whd, 5", MK 36, PWP | H929 | 2 | 0.00E+00 | 3.450000 | 0.00E+00 | 0.028000 | 0.00E+00 | 96.522 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 2.21E+04 | 0.00E+00 | 1.50 | 27 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Rocket Motor, 5" | H311 | 100 | 0.00E+00 | 3.450000 | 0.00E+00 | 0.028000 | 0.00E+00 | 96.522 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 2.21E+04 | 0.00E+00 | 1.50 | 27 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Whd, 2.75", MK 5, HE | H842 | 316 | 6.40E-01 | 3.450000 | 6.98E-02 | 0.028000 | 2.83E-02 | 96.522 | 1.96E-01 | 2.93E-01 | 2.93E-01 | 2.21E+04 | 1.32E-05 | 1.50 | 27 | 5.36E-04 | 1.17E-03 | 1.99E-05 |
| Whd, 2.75", MK 7, HEAT | 2.75" HEAT | 117 | 2.53E-01 | 3.450000 | 1.02E-02 | 0.028000 | 4.14E-03 | 96.522 | 2.85E-02 | 4.28E-02 | 4.28E-02 | 2.21E+04 | 1.93E-06 | 1.50 | 27 | 7.83E-05 | 1.72E-04 | 2.90E-06 |
| Whd, 2.75" (inert warhead) | INERT | 400 | 0.00E+00 | 0.000000 | 0.00E+00 | 0.000000 | 0.00E+00 | 100.000 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 2.21E+04 | 0.00E+00 | 1.50 | 27 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Rocket Motor, 2.75" | HA07 | 833 | 0.00E+00 | 3.450000 | 0.00E+00 | 0.028000 | 0.00E+00 | 96.522 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 2.21E+04 | 0.00E+00 | 1.50 | 27 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Rocket, 2.25", SCAR | 2.75" SCAR | 833 | 0.00E+00 | 3.450000 | 0.00E+00 | 0.028000 | 0.00E+00 | 96.522 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 2.21E+04 | 0.00E+00 | 1.50 | 27 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| | | | | | | | | | | | | | | Total Average Target Load Rate | | | | 3.70E-05 |

Note: Several columns have been hidden from the figures in this graphic due to space limitations.

Total Period C load rate for RDX at this discrete MC loading area

# Appendix B. REVA Best Management Practice Evaluation

## REVA Best Management Practice Evaluation

**Application: This evaluation may be used for all ranges, but criterion may be inappropriate (N/A) or inaccessible for evaluation due to hazards or available time (N/D)**

| Range Information | |
|---|---|
| Range/Area Name(s) | Installation: |
| Type (HE, SAR, Demo, MOUT, Mixed): | Date: |

| 1. Operational BMPs | | | | |
|---|---|---|---|---|
| **A. CASING/SCRAP MANAGEMENT** | | | | |
| • Is there a notable collection of spent casings or scrap present at the range? *(Focus on accessible areas, as opposed to impact areas.)* | ☐Yes | ☐No | ☐N/A | ☐N/D |
| • Are all spent casings collected at regular intervals? | ☐Yes | ☐No | ☐N/A | ☐N/D |
| If yes – describe interval: ___________________________ | | | | |
| For questions in parts B and C, if training needs require specific placement targets or concentration of expenditures, mark the respective question "N/A" and note those training needs here:___________________________ | | | | |
| **B. TARGET LOCATION** | | | | |
| • Are targets predominantly located outside of stormwater channels and surface water features? | ☐Yes | ☐No | ☐N/A | ☐N/D |
| **C. IMPACT DISTRIBUTION** | | | | |
| • Is erosion evenly distributed across targets/impact areas? | ☐Yes | ☐No | ☐N/A | ☐N/D |
| • Does typical range use result in even use of target impact areas? | ☐Yes | ☐No | ☐N/A | ☐N/D |

| 2. Maintenance BMPs | | | | |
|---|---|---|---|---|
| **A. EXISTING TECHNOLOGY** | | | | |
| • Has particulate been removed from the bullet trap within the last 5 years? | ☐Yes | ☐No | ☐N/A | ☐N/D |
| • Has debris been removed from the lead separators within the last 5 years? *(Lead separators may include subsurface vaults which intercept runoff from impact areas.)* | ☐Yes | ☐No | ☐N/A | ☐N/D |
| • Has debris been removed from sedimentation basins within the last 5 years? *(Sedimentation basins may include "dry ponds" which temporarily fill with runoff from impact areas.)* | ☐Yes | ☐No | ☐N/A | ☐N/D |
| • Has debris been removed from diversion channels within the last 5 years? *(Such channels may include natural and improved culverts that redirect on–coming runoff so it does not come into contact with impact areas.)* | ☐Yes | ☐No | ☐N/A | ☐N/D |
| **B. WASH DOWNS** | | | | |
| • In areas where munitions use occurs, is wash water capture and/or containerized? | ☐Yes | ☐No | ☐N/A | ☐N/D |

| 3. Erosion BMPs | | | | |
|---|---|---|---|---|
| For questions in part A, if the fire hazards are a significant concern for the area where the range is located, mark all questions "N/A." | | | | |
| **A. VEGETATION MANAGEMENT** | | | | |
| • Is vegetative growth (e.g., grasses) present on the impact area? | ☐Yes | ☐No | ☐N/A | ☐N/D |
| • Is vegetative growth (e.g., grasses, brush) present in unimproved drainages and areas surrounding the impact area? | ☐Yes | ☐No | ☐N/A | ☐N/D |
| If no to either question – describe any mowing/clearance (interval): ___________________________ | | | | |

**B. VISIBLE EROSION**

- Are the edges/toe of the impact area/berm free of visible and distinct accumulation of eroded material? ☐Yes ☐No ☐N/A ☐N/D

If no–note areas of significant erosion: ______________________________

**C. EROSION BARRIERS**

- Are erosion control fabric(s) utilized to prevent erosion on impact berms or steeply sloped areas? ☐Yes ☐No ☐N/A ☐N/D
- Are there any erosion control barriers (e.g., hay bales, silt fence) in place at the range? ☐Yes ☐No ☐N/A ☐N/D
- Do existing control barriers appear to address all visible locations of erosion? ☐Yes ☐No ☐N/A ☐N/D

If no, note areas of not addressed: ______________________________

## 4. STORMWATER BMPs

For questions in parts A and B, if the area where the range is located is prone to flooding, mark all questions "N/A."
For questions in part B, if none of the channels directing stormwater away from the range are improved (e.g., lined, artificial), mark all questions "N/A."

**A. Range Design**

- Is the impact area/berm elevated above its immediate surroundings? ☐Yes ☐No ☐N/A ☐N/D
- Is the upgradient edge of the impact area/top of berm bordered by a diversion? *(Diversions may include a "bump" or barrier which deflects run-on, or a culvert/channel which re-directs run-on away from the impact area/berm.)* ☐Yes ☐No ☐N/A ☐N/D

**B. Improved Drainages**

- Is rip-rap or silt checks (sand bags, hay bales) present in the gently sloping portions (less thank 2:1 slope) of the channels(s)? ☐Yes ☐No ☐N/A ☐N/D

## NOTES

Use this section to document:

1. Other conditions or activities which potentially capture and/or reduce the transport of munitions constituent from the range.
2. Other opportunities to capture and/or reduce the transport of munitions constituent from the range.