REPORT DOCUMENTATION PAGE

Form Approved
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1. REPORT DATE *(DD-MM-YYYY)*	2. REPORT TYPE	3. DATES COVERED *(From - To)*
30-04-2015	Final	November 2011 to September 2013

4. TITLE AND SUBTITLE

Remedial Investigation Report for RVAAP-032-R-01 40mm Firing Range MRS, Version 1.0

5a. CONTRACT NUMBER
W912DR-09-D-0005

5b. GRANT NUMBER
N/A

5c. PROGRAM ELEMENT NUMBER
N/A

6. AUTHOR(S)

Rachel Daly, David Crispo, P.E.

5d. PROJECT NUMBER
136147

5e. TASK NUMBER
1300130

5f. WORK UNIT NUMBER
N/A

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

CB&I Federal Services LLC
150 Royall Street
Canton, Massachusetts 02021

8. PERFORMING ORGANIZATION REPORT NUMBER
N/A

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

U.S. Army Corps of Engineers
North Atlantic Baltimore District
10 S. Howard Street, Room 7000
Baltimore, Maryland 21201

10. SPONSOR/MONITOR'S ACRONYM(S)
NAB

11. SPONSOR/MONITOR'S REPORT NUMBER(S)
N/A

12. DISTRIBUTION/AVAILABILITY STATEMENT
Reference distribution page.

13. SUPPLEMENTARY NOTES
The views, opinions and/or findings contained in this report are those of the author(s) and should not be construed as an official Department of the Army position, policy, or decision, unless designated by other documentation.

14. ABSTRACT

This Remedial Investigation (RI) Report presents the findings and conclusions of the RI field activities conducted at the RVAAP-032-R-01 40mm Firing Range Munitions Response Site (MRS) between November 2011 and February 2012 at the former Ravenna Army Ammunition Plant. The purpose of the RI Report was to determine whether the 40mm Firing Range MRS warranted further response action pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 and the National Oil and Hazardous Substances Pollution Contingency Plan. More specifically, this RI Report is intended to determine the nature and extent of munitions and explosives of concern (MEC) and munitions constituents (MC) and subsequently determine the likely hazards and risks posed to human and environmental receptors by MEC and MC. Also, this RI Report presents additional data to support the identification and evaluation of alternatives in the Feasibility Study (FS), if required. This RI Report was prepared in accordance with the Army's Final Military Munitions Response Program Munitions Response RI/FS Guidance dated November 2009.

15. SUBJECT TERMS
40mm Firing Range, Remedial Investigation, Military Munitions Response Program

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			David Crispo, Project Manager
Unclassified	Unclassified	Unclassified	UU	444	19b. TELEPHONE NUMBER *(Include area code)* 781.821.3513

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CB&I Federal Services LLC has completed the *Final Remedial Investigation Report for RVAAP-032-R-01 40mm Firing Range MRS* at the former Ravenna Army Ammunition Plant in Portage and Trumbull Counties, Ohio. Notice is hereby given that an independent technical review has been conducted that is appropriate to the level of risk and complexity inherent in the project. During the independent technical review, compliance with established policy, principles and procedures, utilizing justified and valid assumptions, was verified. This included review of data quality objectives; technical assumptions; methods, procedures and materials to be used; the appropriateness of data used and level of data obtained; and reasonableness of the results, including whether the product meets customer's needs consistent with law and existing U.S. Army Corps of Engineers policy.

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Final Remedial Investigation Report for RVAAP-032-R-01 40mm Firing Range MRS Version 1.0

Former Ravenna Army Ammunition Plant
Portage and Trumbull Counties, Ohio

Contract No. W912DR-09-D-0005
Delivery Order 0002

Prepared for:

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April 30, 2015

DOCUMENT DISTRIBUTION

Name/Organization	Number of Printed Copies	Number of Electronic Copies
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ARNG—Army National Guard
CB&I—CB&I Federal Services LLC
Ohio EPA—Ohio Environmental Protection Agency
RVAAP—former Ravenna Army Ammunition Plant
USACE—U.S. Army Corps of Engineers

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Acronyms and Abbreviations

<	less than
°F	degrees Fahrenheit
AEDB-R	Army Environmental Database-Restoration
AMEC	AMEC Earth and Environmental
amsl	above mean sea level
AOC	area of concern
ARAR	applicable or relevant and appropriate requirement
ARNG	Army National Guard
ASR	*Final Archives Search Report*
ASTM	American Society of Testing and Materials
bgs	below ground surface
BSV	background screening value
Camp Ravenna	Camp Ravenna Joint Military Training Center
CAS	Chemical Abstracts Service
CB&I	CB&I Federal Services LLC
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
cm/s	centimeters per second
COPC	chemical of potential concern
CSM	conceptual site model
CT Laboratories	CT Laboratories, Inc.
DERP	Defense Environmental Restoration Program
DGM	digital geophysical mapping
DID	data item description
DOD	U.S. Department of Defense
DQO	data quality objective
e^2M	engineering-environmental Management, Inc.
ELAP	Environmental Laboratory Accreditation Program
EPA	U.S. Environmental Protection Agency
ERA	ecological risk assessment
FS	Feasibility Study
FWCUG	*Final Facility-Wide Human Health Cleanup Goals for the Ravenna Army Ammunition Plant*
FWSAP	*Facility-Wide Sampling and Analysis Plan for Environmental Investigations at the RVAAP*
gpm	gallons per minute
HA	hazard assessment
HE	high explosive
HHRA	human health risk assessment
HRR	*Final Military Munitions Response Program Historical Records Review*
ID	identification
IDW	investigation-derived waste

Acronyms and Abbreviations (continued)

IRP	Installation Restoration Program
ISM	incremental sampling methodology
IVS	instrument verification strip
J	estimated value
lb	pound
LCS	laboratory control sample
LOD	limit of detection
MB	method blank
MC	munitions constituents
MD	munitions debris
MDAS	material documented as safe
MDL	method detection limit
MEC	munitions and explosives of concern
mg/kg	milligrams per kilogram
mm	millimeter
MMRP	Military Munitions Response Program
MPPEH	material potentially presenting an explosive hazard
MRL	method reporting limit
MRS	munitions response site
MRSPP	Munitions Response Site Prioritization Protocol
MS	matrix spike
MSD	matrix spike duplicate
mV	millivolt
NA	not available/not applicable
NCP	*National Oil and Hazardous Substances Pollution Contingency Plan*
NS	not sampled
OHARNG	Ohio Army National Guard
Ohio EPA	Ohio Environmental Protection Agency
QA	quality assurance
QC	quality control
QSM	*Quality Systems Manual for Environmental Laboratories, Version 4.2*
RDX	research department explosive
RI	Remedial Investigation
RPD	relative percent difference
RTS	robotic total station
RVAAP	former Ravenna Army Ammunition Plant
SAIC	Science Applications International Corporation
SAP Addendum	*Final Sampling and Analysis Plan and Quality Assurance Project Plan Addendum*
Shaw	Shaw Environmental & Infrastructure, Inc.
SI	Site Inspection

Acronyms and Abbreviations (continued)

SOP	standard operating procedure
SRC	site-related chemical
SU	standard unit
TBC	to be considered
TNT	2,4,6-trinitrotoluene
TOC	total organic carbon
U	not detected or reported less than the level of detection
U.S.	United States
UJ	not detected
USACE	U.S. Army Corps of Engineers
USATHMA	U.S. Army Toxic and Hazardous Materials Agency
USDA	U.S. Department of Agriculture
USP&FO	U.S. Property and Fiscal Officer
UXO	unexploded ordnance
UXOQCS	UXO QC Supervisor
VQ	validation qualifier
VSP®	*Visual Sample Plan*®
Work Plan Addendum	*Final Work Plan Addendum for Military Munitions Response Program Remedial Environmental Services, Version 1.0*

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EXECUTIVE SUMMARY

This *Remedial Investigation (RI) Report* documents the findings and conclusions of the RI field activities for the 40 millimeter (mm) Firing Range (RVAAP-032-R-01) Munitions Response Site (MRS) located at the former Ravenna Army Ammunition Plant (RVAAP) in Portage and Trumbull Counties, Ohio. This RI Report was prepared by CB&I Federal Services LLC under Delivery Order 0002 for Military Munitions Response Program (MMRP) environmental services at the RVAAP under the *Multiple Award Military Munitions Services Performance-Based Acquisition* Contract No. W912DR-09-D-0005. The Delivery Order was issued by the United States (U.S.) Army Corps of Engineers (USACE), Baltimore District on May 27, 2009.

The purpose of the RI was to determine whether the 40mm Firing Range MRS warrants further response action pursuant to the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) and the *National Oil and Hazardous Substances Pollution Contingency Plan*. More specifically, the RI was intended to determine the nature and extent of munitions and explosives of concern (MEC) and munitions constituents (MC) and subsequently determine the potential hazards and risks posed to likely human and ecological receptors by MEC and MC.

ES.1 MRS Description

Whenever possible, existing information and data were incorporated into this RI Report. Background information related to the MRS was taken from the *Final Archives Search Report* (USACE, 2004), the *Final Military Munitions Response Program Historical Records Review* (engineering-environmental Management, Inc. [e^2M], 2007), and the *Final Site Inspection Report* (Site Inspection [SI] Report) (e^2M, 2008).

The 40mm Firing Range MRS is a 1.27-acre area and is a portion of a former test range that operated between 1969 and 1971. The former test range was used to perform acceptance tests that included muzzle velocity measurements and impact function tests. Munitions reportedly fired at the former test range included the M407A1 series 40mm practice grenade and the M406 series high explosive 40mm grenade. The M407A1 and M406 series cartridges were designed to be fired from 40mm grenade launchers, M79 and M203 series, attached to the M16/M16Al series rifle. The 40mm practice grenades contained yellow marker dye, M9 series propellant, and research department explosive (RDX) booster pellets body (U.S. Army, 1977). The M9 series propellant consisted of nitrocellulose, nitroglycerin, potassium nitrate, ethyl centralite, and graphite. The M406 series high explosive rounds contained Composition B explosive, which is a mixture of RDX and 2,4,6-trinitrotoluene

(e^2M, 2007). Each of the approximately 2,500 rounds fired on this range were reportedly accounted for (U.S. Army Toxic and Hazardous Materials Agency, 1978).

Prior to the 2007 SI, unexploded ordnance (UXO) was reported by facility personnel to be present beyond the impact area at the former firing range, on the slope that leads down to the Fuze and Booster Quarry MRS (e^2M, 2007). The type of UXO encountered by the facility personnel was not documented. Munitions debris (MD) consisting of aluminum nose caps and casings from 40mm grenades were found during the SI field work to be scattered from the target point to a point approximately 100 feet beyond the former impact area. It was concluded in the SI Report that there was a potential for surface and subsurface MEC as well as MC at the former impact area and 100 feet beyond. The SI Report recommended that this 1.27-acre area become the revised 40mm Firing Range MRS for "Further Characterization" of MEC and MC (e^2M, 2008).

During development of the *Final Work Plan Addendum for Military Munitions Response Program Remedial Environmental Services, Version 1.0* (Work Plan Addendum) Shaw Environmental & Infrastructure, Inc. [Shaw], 2011), the current MRS boundaries were reevaluated. Although only MD was found at the impact area of the former test range during the SI field activities, it was determined that the area between the firing point and the furthest possible target distance (350 meters from the firing point) required further investigation during the RI for potential MEC. The revised investigation area for the 40mm Firing Range, hereafter referred to as the "Investigation Area" for the RI, is 8.55 acres and is inclusive of the 1.27-acre MRS. Characterization for MC at the firing point was also recommended during development of the Work Plan Addendum (Shaw, 2011), since this was an area at the former test range where most activities occurred.

Current activities at the Investigation Area include maintenance and natural resource management activities. The future use of the Investigation Area will be military training (Ohio Army National Guard, 2008).

ES.2 Summary of Remedial Investigation Activities

The preliminary MEC and MC conceptual site models (CSMs) were developed during the SI (e^2M, 2008) phase of the CERCLA process and were used identify the data needs and data quality objectives (DQOs) as outlined in the Work Plan Addendum (Shaw, 2011). The data needs and DQOs were determined at the planning stage and included characterization of MEC and MC associated with historical activities at the former test range. The DQOs were developed to ensure the reliability of field sampling, chemical analyses, and physical analyses; the collection of sufficient data; the acceptable quality of data generated for its intended use; and the inference of valid assumptions from the data. The DQOs in the Work

Plan Addendum identified the following decision rules that were implemented in evaluating the Investigation Area:

- Perform a geophysical investigation to identify if buried MEC was present.
- Perform an intrusive investigation of anomalies identified during the geophysical investigation to evaluate if MEC was present.
- Collect surface soil samples using the incremental sampling methodology (ISM) at three predetermined sampling units at the Investigation Area.
- Process the information to evaluate whether there were unacceptable risks to human and ecological receptors associated with MEC and/or MC and make a determination if further investigation was required under the CERCLA process.

Geophysical Investigation

Between November and December of 2011, a digital geophysical mapping (DGM) survey was conducted at the 40mm Firing Range Investigation Area to evaluate for potential buried MEC. The DGM data were collected in all accessible areas within the MRS, and the spatial coverage was 0.86 acres, or approximately 10 percent, of the 8.55-acre Investigation Area. Two munitions-related items considered as material potentially presenting an explosive hazard (MPPEH) were identified on the ground surface during the DGM survey. The MPPEH was inspected by the UXO-qualified personnel in the field, determined to be material documented as safe (MDAS), and were considered MD. The MD consisted of aluminum ballistic windscreens from the M382 series 40mm practice grenade, a munitions item not previously reported to have been used at the former firing range.

Anomaly Selection

Evaluation of the data collected during the DGM survey identified 102 anomalies that had signal strength greater than or equal to 8 millivolts (Channel 2). In general, the geophysical data indicate that the anomaly density at the Investigation Area is relatively low and dispersed. The majority of the anomalies were encountered in the impact and overshot areas that are the defined boundaries of the actual MRS. All of the 102 anomalies that were identified throughout the Investigation Area were selected for intrusive investigation.

Intrusive Investigations

Following the completion of the DGM survey in December 2011, an intrusive investigation was conducted for the locations identified as potentially containing buried MEC based on an analysis of the DGM survey data. All 102 of the identified anomalies were successfully investigated. A total of 53 MPPEH items were encountered at 23 of the 102 target anomaly locations. All of the MPPEH was MDAS and considered as MD following inspection by the

UXO-qualified personnel in the field. The MD consisted primarily of remnants associated with M382 series 40mm practice grenades. The maximum depth of MD found was 8 inches below ground surface (bgs) in what appeared to be a small burial pit. The total weight of the MD items found during the RI field activities was 11.8 pounds.

MC Sampling

Environmental samples for MC were collected at the 40mm Firing Range Investigation Area following completion of the DGM survey. Two ISM surface soil samples, each comprising 0.63 acres, were collected at the impact area and 100 feet beyond that constitutes the current 1.27-acre MRS (e^2M, 2008). A third ISM sample was collected at the 0.05-acre firing point at the east end of the former firing range. This sampling unit is located outside of the current MRS boundary. All three ISM samples were collected at depths between 0 and 0.5 feet. The combined ISM surface soil sampling units are considered as the decision unit for the Investigation Area. The surface soil decision unit for the Investigation Area is based on locations where MD was identified, where site-related chemicals (SRCs) associated with historical activities are expected, are locations that have the same receptor exposure scenarios, and is the area in which a decision regarding MC in surface soil at the Investigation Area will be made (U.S. Army, 2009).

ES.3 Nature and Extent of SRCs

Based on the results of the RVAAP data evaluation process, no MC SRCs were identified in the surface soil samples collected at the 40mm Firing Range Investigation Area during the RI field activities. In the absence of any identified SRCs, evaluation for risks associated with human and ecological receptors, including the Resident Receptor (Adult and Child) that is evaluated for Unrestricted (Residential) Land Use, was not required for the RI.

ES.4 MEC Hazard Assessment

The *Interim Munitions and Explosives of Concern Hazard Assessment (MEC HA) Methodology* (U.S. Environmental Protection Agency, 2008) addresses human health and safety concerns associated with potential exposure to MEC at a MRS under a variety of site conditions, including various cleanup scenarios and land use assumptions. If an explosive hazard is identified for this RI, the MEC HA evaluation will include the information available for the MRS up to and including the RI field activities and provide a scoring summary for the current and future use. If no explosive hazard is found at the MRS, then there is no need to calculate a MEC HA score because there are no human health safety concerns. No MEC was identified at the MRS during the RI field activities. These results indicate that no MEC source or explosive hazard is present at the MRS. Therefore,

calculation of a MEC HA score was not warranted for the 40mm Firing Range Investigation Area.

ES.5 Conceptual Site Model

The information collected during the RI field activities was used to update the MEC CSM for the 40mm Firing Range MRS as presented in the SI Report (e^2M, 2008) and to develop the MC CSM. The purpose of the CSMs for MEC and MC is to identify all complete, potentially complete, or incomplete source-receptor interactions for reasonably anticipated future land-use activities at the MRS. An exposure pathway is the course a MEC item or MC takes from a source to a receptor. Each pathway includes a source, activity, access, and receptor.

The National Guard Trainee is identified as the Representative Receptor for both the current and future activities and has the greatest opportunity for exposure to MEC and MC that may be present at the MRS. The defined MC exposure depths for surface soil and subsurface soil at the facility for the National Guard Trainee are 0 to 4 feet and 4 to 7 feet, respectively (Science Applications International Corporation, 2010). Since this RI was initiated before the finalization of the U.S. Army's *Final Technical Memorandum: Land Uses and Revised Risk Assessment Process for the Ravenna Army Ammunition Plant Installation Restoration Program* (Army National Guard, 2014), the Commercial Industrial Land Use using the Industrial Receptor was not included.

The facility has chosen general ecological receptors that provide a range of potential exposures, including high exposures under a variety of conditions. These terrestrial receptors include terrestrial invertebrates (earthworms), voles, shrews, robins, foxes, and hawks (USACE, 2003b). The MC exposure scenario for the environmental receptors is evaluated for the 0- to 1-foot bgs interval.

MEC Exposure Analysis

No MEC was identified within the 40mm Firing Range Investigation Area during the RI field activities; however, MD associated with the 40mm practice grenades discharged at the former firing range were encountered on the ground surface and subsurface soils. The MD was found on the ground surface at two locations and at nearly 25 percent of the target anomaly locations at a maximum depth of 8 inches bgs.

Based on the results of the RI field investigations, the use or introduction of munitions at the MRS is confirmed. Because no direct evidence of an explosive hazard exists, the pathways for MEC were considered incomplete for all receptors; however, the amount of various MD found during the RI field work suggests a low potential for MEC to be present at the MRS.

MC Exposure Analysis

Sampling for MC was performed at the 40mm Firing Range Investigation Area at likely areas of release to further characterize the nature and extent of contamination associated with previous activities at the former firing range. No SRCs were identified following the data evaluation process, and there are no current risks associated with potential MC at the Investigation Area. Although MD was verified during the RI field activities, given the extent of environmental media coverage achieved for the sampling activities for the RI and the results for the MC characterization, it is unlikely that SRCs will leach from the MD. The CSM for MC has been updated to reflect incomplete pathways for all receptors in the terrestrial environments.

There are no surface water features at the Investigation Area. Therefore, the MC exposure pathways for all receptors at the Investigation Area to the aquatic environments, including surface water and sediment, and the plant/game/fish/prey exposure media are considered incomplete.

Groundwater beneath the RVAAP is evaluated on a facility-wide basis, and MRS-specific sampling was not intended for an MRS being investigated under the MMRP unless there is a likely impact from a MEC source. The soil conditions at the Investigation Area are considered to have low permeability, and the depth to groundwater may be as deep as 50 feet bgs. No SRCs were detected in the surface soil samples collected during the RI field activities, and it is not expected that the likely human and ecological receptors will come into contact with groundwater beneath the Investigation Area. Therefore, the MC exposure pathway for groundwater is considered to be incomplete for all receptors.

ES.6 Conclusions

This RI Report was prepared in accordance with the project DQOs and included evaluations for explosives hazards and potential sources of MC that may pose threats to likely receptors. The following statements can be made for the 40mm Firing Range Investigation Area based on the results of the RI field activities:

- A total of 0.86 acres were investigated at the 8.55-acre Investigation Area during the RI, which exceeds the proposed spatial coverage of 0.7 acres.
- No MEC was encountered during the RI field work at the Investigation Area; however, MD was found on the ground surface and at nearly 25 percent of the target locations at a maximum depth of 8 inches.
- No SRCs were identified in surface soil and there are no hazards associated with MC to the human or ecological receptors at the Investigation Area, including the

Resident Receptor (Adult and Child) that is evaluated at the facility for Unrestricted (Residential) Land Use.

The RI included risk assessments for explosive hazards and MC that may pose threats to likely receptors. The field work results suggest it is statistically possible that MEC may be present at the Investigation Area, although confirmed discoveries of MEC have not been made to date. It is recommended that the 1.27-acre MRS be increased to include the 8.55-acre Investigation Area that includes the former firing point location and the impact and overshot areas that made up the former firing range. A Feasibility Study is recommended as the next course of action for the revised MRS to assess possible response action alternatives because some statistical uncertainty remains for MEC.

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1.0 INTRODUCTION

This *Remedial Investigation (RI) Report* documents the findings and conclusions of the RI field activities for the 40 millimeter (mm) Firing Range (RVAAP-032-R-01) Munitions Response Site (MRS) located at the former Ravenna Army Ammunition Plant (RVAAP) in Portage and Trumbull Counties, Ohio. This RI Report was prepared by CB&I Federal Services LLC (CB&I) under Delivery Order 0002 for Military Munitions Response Program (MMRP) environmental services at the RVAAP under the *Multiple Award Military Munitions Services Performance-Based Acquisition* Contract No. W912DR-09-D-0005. The Delivery Order was issued by the United States (U.S.) Army Corps of Engineers (USACE), Baltimore District on May 27, 2009.

This RI Report presents the results of the RI field activities that were conducted at the 40mm Firing Range Investigation Area between November 2011 and February 2012. This RI Report was developed in accordance with the *Final Work Plan Addendum for Military Munitions Response Program Remedial Environmental Services, Version 1.0* (Work Plan Addendum) (Shaw Environmental & Infrastructure, Inc. [Shaw], 2011) and the *Military Munitions Response Program, Munitions Response Remedial Investigation/Feasibility Study Guidance* (U.S. Army, 2009).

1.1 Purpose

Environmental cleanup decision-making under the MMRP follows the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) prescribed sequence of RI, Feasibility Study, Proposed Plan, and Record of Decision. The RI serves as the mechanism for collecting data to characterize MRS conditions, determining the nature and extent of the contamination, and assessing potential risks to human and ecological receptors from this contamination. While not all munitions and explosives of concern (MEC) or munitions constituents (MC) under the MMRP constitute CERCLA hazardous substances, pollutants, or contaminants, the Defense Environmental Restoration Program (DERP) statute provides the U.S. Department of Defense (DOD) the authority to respond to releases of MEC/MC, and DOD policy states that such responses shall be conducted in accordance with CERCLA and the *National Oil and Hazardous Substances Pollution Contingency Plan* (NCP).

The purpose of the RI was to determine whether the 40mm Firing Range MRS warrants further response action pursuant to CERCLA and the NCP. More specifically, the RI was intended to determine the nature and extent of MEC and MC and subsequently determine the hazards and potential risks posed to likely human and ecological receptors by MEC and MC.

Additional data are also presented in this RI Report to support the identification and evaluation of alternatives in the Feasibility Study, if required.

1.2 Problem Identification

The 40mm Firing Range was used from 1969 to 1971 to test the M407A1 series 40mm practice grenade and the M406 series high explosive (HE) 40mm grenade. The firing range was approximately 5.17 acres in size when it was in operation (engineering-environmental Management, Inc. [e^2M], 2007). The 40mm practice grenades contained yellow marker dye, M9 series propellant, and research department explosive (RDX) booster pellets body. The M406 series HE rounds contained Composition B explosive, which is a mixture of RDX and 2,4,6-trinitrotoluene (TNT). According to the *Final Installation Assessment of RVAAP Report No. 132* (U.S. Army Toxic and Hazardous Materials Agency [USATHMA], 1978), each of the approximately 2,500 rounds fired on this range were accounted for.

Prior to the 2007 Site Inspection (SI), unexploded ordnance (UXO) was reported by facility personnel to be present beyond the impact area at the former firing range, on the slope that leads down to the Fuze and Booster Quarry MRS (e^2M, 2007). A meandering path magnetometer and metal detector assisted UXO survey was conducted at the firing point, range floor, impact area, and down range of the impact area as part of the SI field activities and no MEC was discovered. The magnetometer and metal detector instruments used consisted of a Schonstedt hand-held magnetic gradiometer GA-52Cx model and a White Matrix M6, respectively. Material potentially presenting an explosive hazard (MPPEH) were identified during the survey, were determined to be material documented as safe (MDAS) by UXO-qualified personnel, and were considered munitions debris (MD). The MD consisted primarily of remnants of 40mm rounds (casing and nose fragments) that were found to be scattered from the target point to a location approximately 100 feet beyond the former impact area.

It was concluded in the *Final Site Inspection Report* (SI Report) (e^2M, 2008) that there was a potential for surface and subsurface MEC as well as MC at the former impact area and 100 feet beyond. The SI Report recommended that this approximately 1.27-acre area become the revised 40mm Firing Range MRS for "Further Characterization" of MEC and MC.

During development of the Work Plan Addendum (Shaw, 2011), the current MRS boundaries were reevaluated. Although, only MD was found at the impact area of the former test range during the SI field activities, it was determined that the area between the firing point and the furthest possible target distance (350 meters from the firing point) required further investigation during the RI for potential MEC. The revised investigation area for the 40mm Firing Range, hereafter referred to as the "Investigation Area" for the RI, is 8.55 acres and is inclusive of the 1.27-acre MRS. Characterization for MC at the firing point was also

recommended during development of the Work Plan Addendum (Shaw, 2011) since this was the location at the former firing range where the discharge of the 40mm grenades occurred.

1.3 Physical Setting

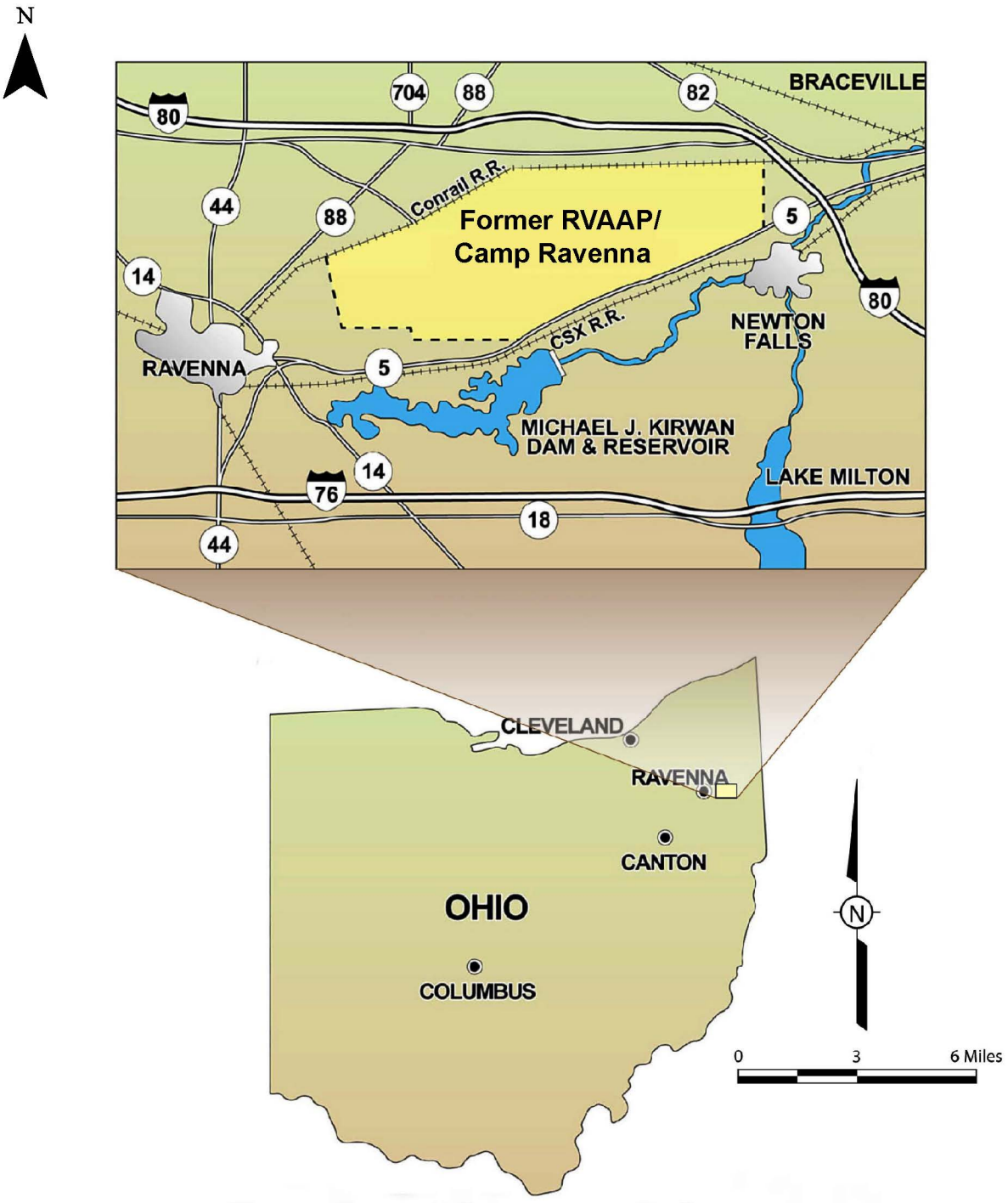
This section presents the physical characteristics of the facility, the 40mm Firing Range Investigation Area, and the surrounding environment that are factors in understanding fate and transport, receptors, conceptual site model (CSM), and exposure scenarios for potential human health and ecological risks. The physiographic setting, hydrology, climate, and ecological characteristics of the facility were compiled from information originally presented in the SI Report (e^2M, 2008) that included the 40mm Firing Range MRS and the *Integrated Natural Resources Management Plan for the Ravenna Training and Logistics Site* (AMEC Earth and Environmental, Inc. [AMEC], 2008) that was prepared for the Ohio Army National Guard (OHARNG).

1.3.1 Location

The RVAAP (Federal Facility ID No. OH213820736), now known as the Camp Ravenna Joint Military Training Center (Camp Ravenna), is located in northeastern Ohio within Portage and Trumbull counties and is approximately 3 miles east–northeast of the city of Ravenna. The facility is approximately 11 miles long and 3.5 miles wide. The facility is bounded by State Route 5, the Michael J. Kirwan Reservoir, and the CSX System Railroad to the south; Garret, McCormick, and Berry Roads to the west; the Norfolk Southern Railroad to the north; and State Route 534 to the east. In addition, the facility is surrounded by the communities of Windham, Garrettsville, Newton Falls, Charlestown, and Wayland (**Figure 1-1**).

Administrative control of the 21,683-acre facility has been transferred to the U.S. Property and Fiscal Officer (USP&FO) for Ohio and subsequently licensed to the OHARNG for use as a training site, Camp Ravenna. The restoration program involves cleanup of former production areas across the facility related to former operations under the RVAAP.

The 40mm Firing Range MRS is an approximate 1.27-acre parcel located in the southern portion of the facility within Portage County (**Figure 1-2**). The MRS is located northeast of the intersection at Fuze and Booster Road and Load Line No. 8 Road at the facility. The Investigation Area for the RI is 8.55 acres and is inclusive of the MRS. The MRS is located on federal property with administrative accountability assigned to the USP&FO for Ohio. The MRS is managed by the Army National Guard (ARNG) and the OHARNG. **Table 1-1** summarizes the administrative description for the areas being investigated for the RI. The table included the facility Army Environmental Database Restoration Module numerical



Note:
The Scale is for the Upper Map Only
Showing the Former RVAAP/Camp Ravenna Location

U.S. ARMY CORPS OF ENGINEERS
BALTIMORE DISTRICT

MILITARY MUNITIONS RESPONSE PROGRAM

FORMER RVAAP/CAMP RAVENNA
PORTAGE AND TRUMBULL COUNTIES, OHIO

CB&I Federal Services LLC
150 Royall Street
Canton, MA 02021

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FIGURE 1-1 INSTALLATION LOCATION MAP

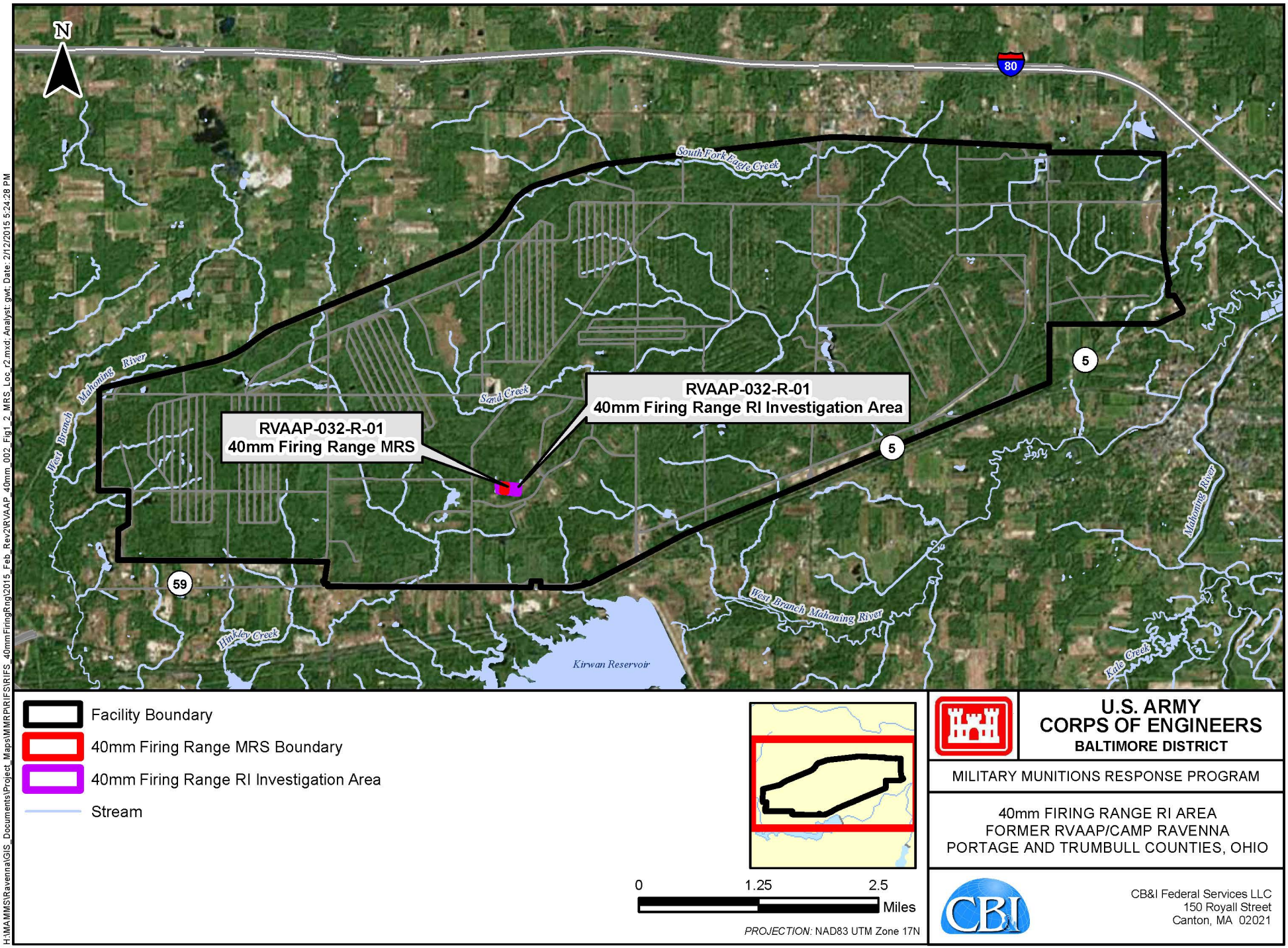


FIGURE 1-2 MRS LOCATION MAP

designation for the MRS, the MRS and Investigation Area acreage, and the agencies responsible for the MRS and Investigation Area.

Table 1-1
Administrative Summary of the 40mm Firing Range MRS and Investigation Area

Investigation Area	AEDB-R MRS Number	Area (Acres)	Property Owner	MRS Management Responsibility
40mm Firing Range MRS	RVAAP-032-R-01	1.27	USP&FO	ARNG/OHARNG
Investigation Area outside the MRS	NA	7.28		
	Total:	8.55	--	--

ARNG denotes Army National Guard.
AEDB-R denotes Army Environmental Database Restoration Module.
MRS denotes Munitions Response Site.
NA denotes not applicable.
OHARNG denotes Ohio Army National Guard.
USP&FO denotes U.S. Property and Fiscal Officer.

1.3.2 Current and Projected Land Use

This section presents the current and future activities for the Investigation Area that is inclusive of the MRS. The future activities are based on the land use exposure scenarios provided in the *RVAAP's Facility-Wide Human Health Risk Assessor Manual* (USACE, 2005) and information provided by the OHARNG during preparation of the Work Plan Addendum (Shaw, 2011).

Current activities at the Investigation Area include maintenance and natural resource management activities. Potential users associated with the current activities include facility personnel, contractors, and occasional trespassers (e^2M, 2008).

The future land use at the Investigation Area is military training, and the Representative Receptor is the National Guard Trainee (USACE, 2005). Since the RI was initiated before the finalization of the U.S. Army's *Final Technical Memorandum: Land Uses and Revised Risk Assessment Process for the Ravenna Army Ammunition Plant Installation Restoration Program* (ARNG, 2014), the Commercial Industrial Land Use using the Industrial Receptor was not included.

1.3.3 Climate

The climate at the facility is classified as humid continental, and the region is characterized by warm, humid summers and cold winters. The National Weather Service identified the

average annual precipitation for Ravenna, Ohio as 40.23 inches, with February as the driest month and July as the wettest month. **Table 1-2** reflects the annual climate and weather normally encountered at nearby Youngstown Municipal Airport.

Table 1-2
Climatic Information, Youngstown Municipal Airport, Ohio

Temperature Type	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Normal Maximum Temperature (°F)	32.4	36.0	46.3	58.2	69.0	77.1	81.0	79.3	72.1	60.7	48.4	37.3
Normal Minimum Temperature (°F)	17.4	19.3	27.1	36.5	46.2	54.6	58.7	57.5	50.9	40.9	33.0	23.4
Mean Precipitation (inches)	2.34	2.03	3.05	3.33	3.45	3.91	4.10	3.43	3.89	2.46	3.07	2.96
Mean Snowfall (inches)	13.1	9.6	10.4	2.2	0	0	0	0	Trace	0.6	4.5	12.3

Source: National Oceanic and Atmospheric Administration Climatography of the United States No. 81 1971–2000.
°F denotes degrees Fahrenheit.

1.3.4 Topography

The facility is located within the Southern New York Section of the Appalachian Plateaus physiographic province. Rolling topography containing incised streams and dendric drainage patterns are prevalent in the province. Rounded ridges, filled major valleys, and areas covered with glacially derived unconsolidated deposits were the product of glaciation in the Southern New York Section. In addition, bogs, kettle lakes, and kames are evidence of past glacial activity in the province. Old stream drainage patterns were disturbed and wetlands were created within the province as a result of past glacial activity (e^2M, 2008).

Topography at the 40mm Firing Range Investigation Area

The topography at the 40mm Firing Range Investigation Area is relatively flat with topography ranging from 1,150 feet above mean sea level (amsl) at the eastern portion of the former range, where the former firing point was located, to 1,170 feet amsl at the central portion of the Investigation Area where the impact area was located. The topography at the western portion of the Investigation Area dips to an elevation low of approximately 1,130 feet amsl. There are no natural streams or ponds located within the Investigation Area and the Investigation Area is not located within a flood plain. The topographical features at the 40mm Firing Range Investigation Area are presented in **Figure 1-3**.

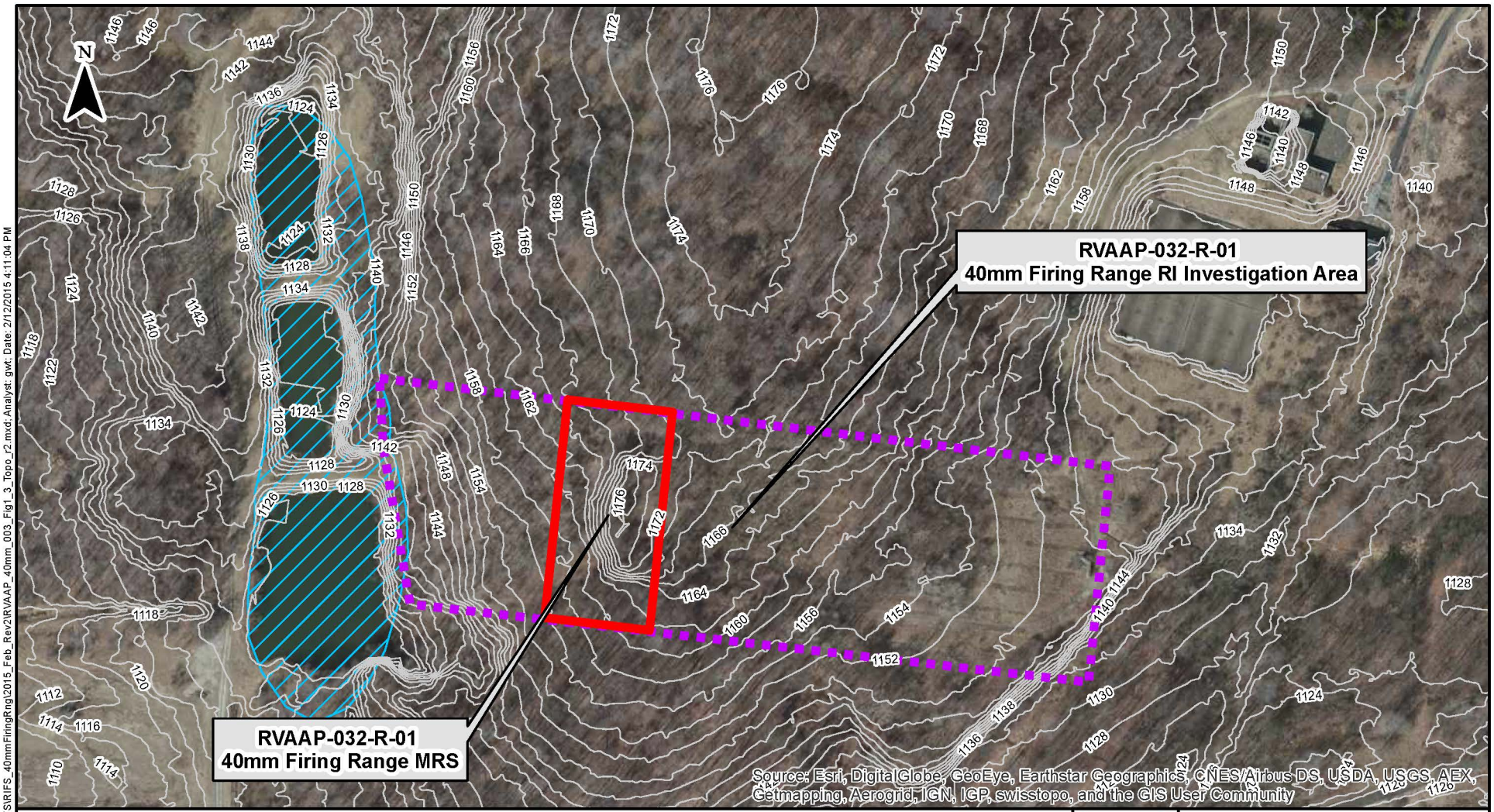


FIGURE 1-3 TOPOGRAPHIC MAP

1.3.5 Geology and Soils

Based on regional geology, the facility consists of Mississippian and Pennsylvanian-age bedrock strata, which dips to the south at approximately 5 to 10 feet per mile. The bedrock is overlain by unconsolidated glacial deposits of varying thickness.

Bedrock is overlain by deposits of Wisconsin-age Lavery Till and Hiram Till in the western and eastern portions of the facility, respectively. The thickness of the glacial deposits varies throughout the facility, ranging from ground surface in parts of the eastern portion of the facility to an estimated 150 feet in the south-central portion of the facility.

Bedrock is present near the ground surface in many locations at the facility. Where glacial deposits are still present, their distribution and character are indicative of ground moraine origin. Laterally discontinuous groupings of yellow-brown, brown, and gray silty clays to clayey silts, with sand and rock fragments are present. Glacial-age standing water body deposits may be present at the facility, in the form of uniform light gray silt deposits over 50 feet thick.

At approximately 200 feet below ground surface (bgs), the Mississippian Cuyahoga Group is present throughout most of the facility. In the northeastern corner of the facility, the Meadville Shale Member of the Cuyahoga Group is present close to the surface. The Meadville Shale Member of the Cuyahoga Group is blue-gray silty shale characterized by alternating thin beds of sandstone and siltstone.

The Sharon Member of the Pennsylvanian Pottsville Formation unconformably overlies the Meadville Shale Member of the Mississippian Cuyahoga Group. A relief of as much as 200 feet exists in Portage County, which can be seen in the Sharon Member thickness variations. The Sharon Member is made up of shale and a conglomerate.

The Sharon Member conglomerate unit is identified as highly porous, permeable, cross-bedded, frequently fractured and weathered quartzite sandstone, which is locally conglomeratic and has an average thickness of 100 feet. A thickness of as much as 250 feet exists in the Sharon Conglomerate where it was deposited in a broad channel cut into Mississippian rocks. In marginal areas of the channel, the conglomerate unit may thin out to approximately 20 feet or may be missing in places, owing to nondeposition on the uplands of the early Pennsylvanian erosional surface. Thin shale lenses occur intermittently within the upper part of the conglomerate unit.

The Sharon Member shale unit is identified as a light to dark gray fissile shale, which overlies the conglomerate in some locations; however, it has been eroded throughout the

majority of the facility. The Sharon Member outcrops in many locations in the eastern half of the facility.

The remaining members of the Pottsville Formation overlie the Sharon Member in the western portion of the facility. Due to erosion and the land surface being above the level of deposition, the Pottsville Formation is not found in the eastern half of the facility.

The Connoquenessing Sandstone Member, which is sporadic, relatively thin channel sandstone comprised of gray to white, coarse-grained quartz with a higher percentage of feldspar and clay than the Sharon Conglomerate, unconformably overlies the Sharon Member. The Mercer Member, which is found above the Connoquenessing Sandstone Member, consists of silty to carbonaceous shale with many thin and discontinuous lenses of sandstone in its upper part. The Homewood Sandstone Member unconformably overlies the Mercer Member and consists of the uppermost unit of the Pottsville Formation. The Homewood Sandstone Member ranges from well-sorted, coarse-grained, white quartz sandstone to tan, poorly sorted, clay-bonded, micaceous, medium- to fine-grained sandstone. The Homewood Sandstone Member occurs as a caprock on bedrock highs in the subsurface.

The soils identified at the facility are generally derived from the Wisconsin-age silty clay glacial till. The major soil types found at the facility are silt or clay loams, ranging in permeability from 6.0×10^{-7} to 1.5×10^{-3} centimeters/second (cm/s) (U.S. Department of Agriculture [USDA] et al, 1978). Much of the native soil at the facility was disturbed during construction activities in former production and operational areas of the facility (Science Applications International Corporation [SAIC], 2011a).

Geology and Soils at the 40mm Firing Range Investigation Area

The 40mm Firing Range Investigation Area, inclusive of the MRS, is located predominantly over the Homewood Sandstone Member. The eastern portion of the Investigation Area is located over the Mercer Member. The bedrock elevation across the Investigation Area is relatively flat at 1,150 feet amsl. Depth to bedrock ranges from just below ground surface at the west, south, and east portions of the Investigation Area to approximately 25 feet bgs at the northern portion of the Investigation Area (AMEC, 2008). **Figure 1-4** illustrates the bedrock formations beneath the Investigation Area.

The native soil types at the 40mm Firing Range Investigation Area include the Mitiwanga silt loam with 0 to 2 percent slopes and the Mahoning silt loam with 2 to 6 percent slopes. The western portion of the Investigation Area abuts soils characterized as pits and quarries associated with the former Fuze and Booster Quarry. **Figure 1-5** illustrates the soil types at the 40mm Firing Range Investigation Area (AMEC, 2008).

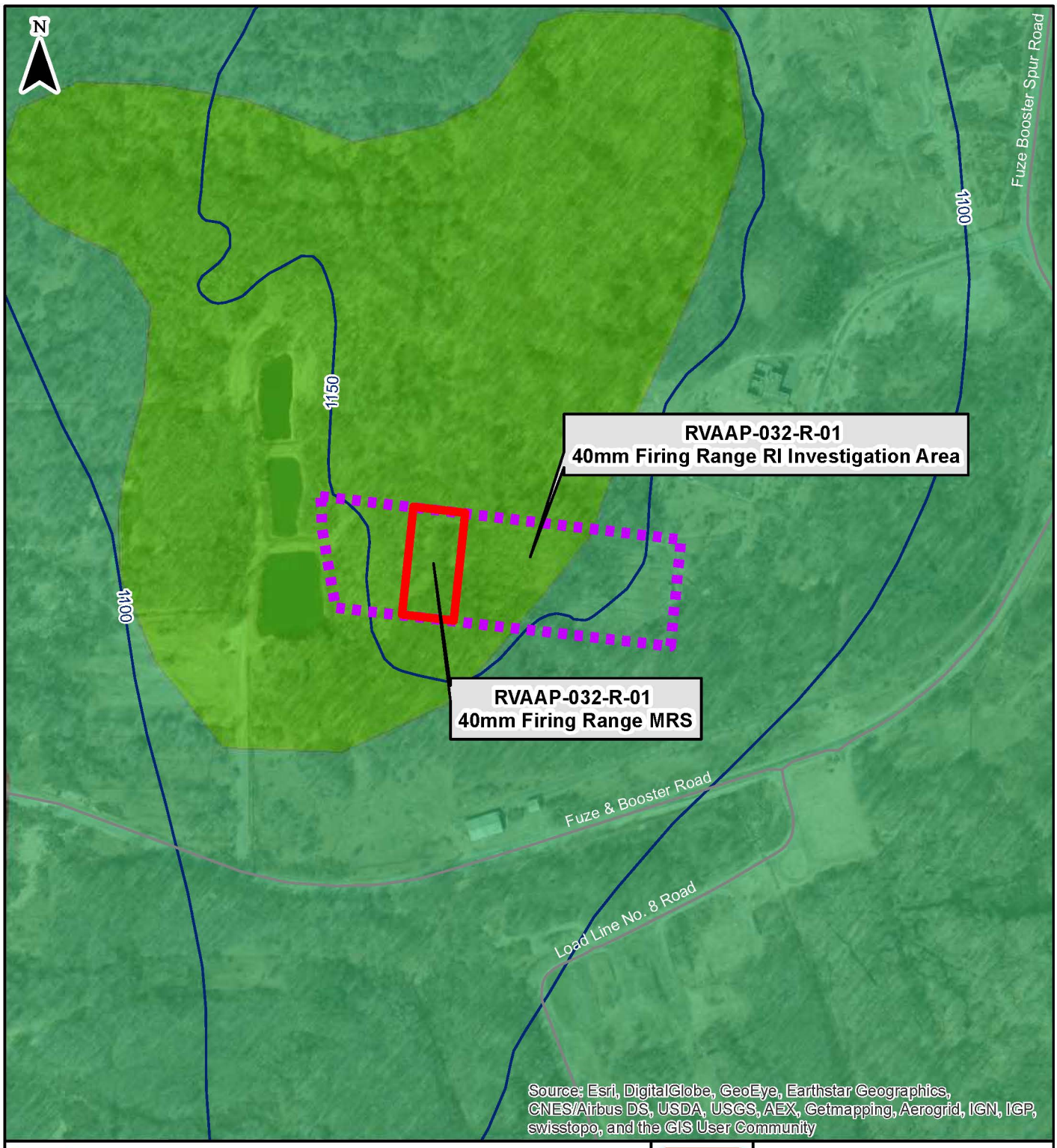
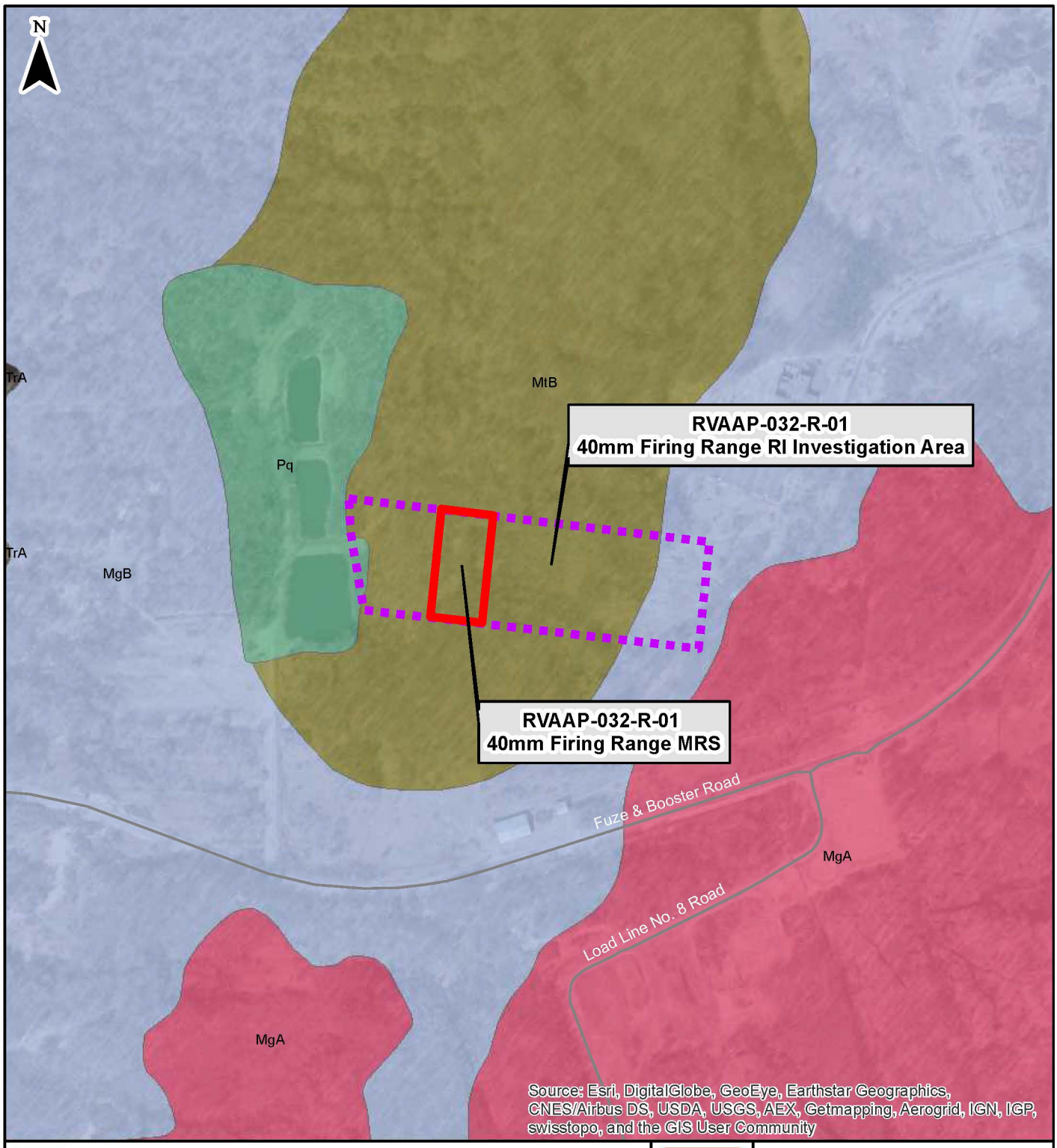


FIGURE 1-4 BEDROCK MAP



40mm Firing Range MRS Boundary

40mm Firing Range RI Investigation Area

Soil Type

- MgA - Mahoning silt loam, 0 to 2 percent slopes
- MgB - Mahoning silt loam, 2 to 6 percent slopes
- MtB - Mitiwanga silt loam, 2 to 6 percent slopes
- Pq - Pits, quarries

0 450 900 Feet

Projection : NAD_1983_UTM_Zone_17N

U.S. ARMY CORPS OF ENGINEERS
BALTIMORE DISTRICT

MILITARY MUNITIONS RESPONSE PROGRAM

40mm FIRING RANGE MRS
FORMER RVAAP/CAMP RAVENNA
PORTAGE AND TRUMBULL COUNTIES, OHIO

CB&I Federal Services LLC
150 Royall Street
Canton, MA 02021

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FIGURE 1-5 SOILS MAP

The majority of the native soil type at the Investigation Area, including the MRS, is the Mitiwanga sit loam. This is a nearly level soil type in wide flat areas such as the Investigation Area. Permeability is very slow in the subsoil and overlying glacial till with an average rate of 1.04×10^{-7} cm/s. Runoff is slow and ponding is common after heavy rains or seasonally wet weather (USDA et al, 1978).

The eastern portion of the Investigation Area borders on the edge of the Mahoning silt loam native soil type. The Mahoning silt loam is characterized with medium to rapid runoff, severe seasonal wetness, and slow permeability. The average permeability of the Mahoning silt loam is 9.1×10^{-5} cm/s (USDA et al, 1978).

1.3.6 Surface Water

The facility is located within the Ohio River Basin. The major surface stream at the facility is the West Branch of the Mahoning River, which flows adjacent to the western end of the facility, generally from north to south, before flowing into the Michael J. Kirwan Reservoir. After leaving the reservoir, the West Branch joins the Mahoning River that is located east of the facility.

Surface water features within the facility include a variety of streams, lakes, ponds, floodplains, and wetlands. Numerous streams drain the facility, including approximately 19 miles of perennial streams. The total combined stream length at the facility is 212 linear miles (AMEC, 2008).

The three primary watercourses that drain the facility include: (1) the South Fork of Eagle Creek, (2) Sand Creek, and (3) Hinkley Creek. Eagle Creek and its tributaries, including Sand Creek, are designated as State Resource Waters. With this designation, the stream and its tributaries fall under the Ohio State Antidegradation Policy. These waters are protected from any action that would degrade the existing water quality.

Approximately 153 acres of ponds are found on the facility. Most of the ponds were created by beaver activity or small man-made dams and embankments. Some were constructed within natural drainage ways to function as settling ponds for effluent or runoff (AMEC, 2008).

A planning level survey (i.e., desktop review of wetlands data and resources [National Wetland Inventory maps, aerials, etc.]) for wetlands was conducted for the entire facility, including the Investigation Area. Wetland delineations have also been completed for select areas of the facility. Wetlands located within the facility include seasonally saturated wetlands, wet fields, and forested wetlands. Sand and gravel aquifers are present within the buried-valley and outwash deposits in Portage County. In general, the aquifer is too thin and localized to provide large quantities of water; however, yields are sufficient for residential

water supplies. Wells located on the facility were primarily located within the sandstone facies of the Sharon Member (MKM Engineers, Inc., 2007).

Surface Water Features at the 40mm Firing Range Investigation Area

Jurisdictional wetlands delineation has not been conducted at the Investigation Area. A planning level survey for wetlands was conducted for the facility, including the Investigation Area. No wetlands, bogs, kettle lakes, or kames have been identified as being present within the Investigation Area and the Investigation Area is not located in a floodplain (AMEC, 2008).

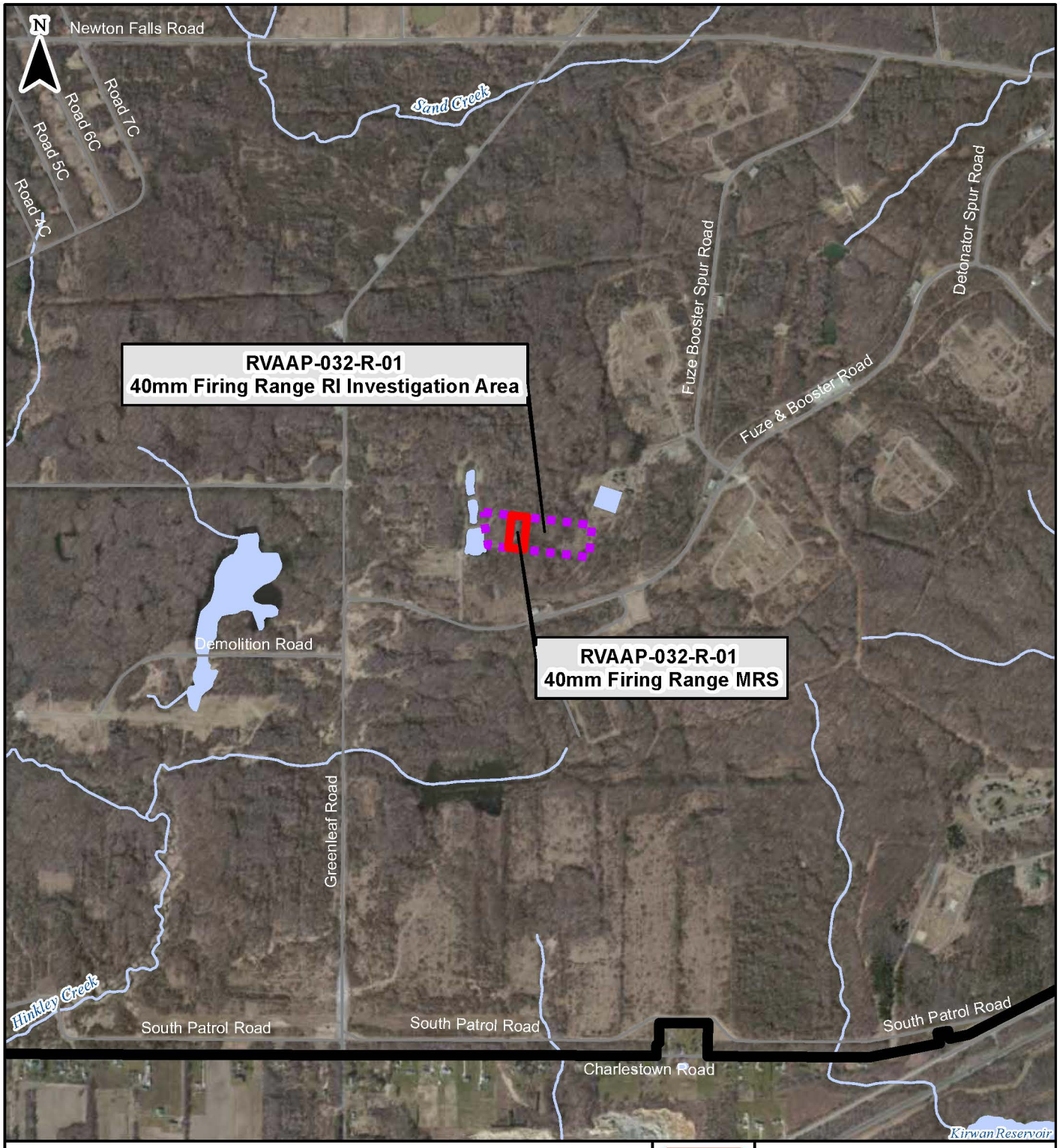
Surface water drainage at the central portion of the Investigation Area generally flows to the east-southeast or to the west following the topography. The nearest surface water drainage features are the ponds associated with the Fuze and Booster Quarry to the west of the Investigation Area.

Perennial surface water features exist outside the Investigation Area to the south that consists of several unnamed headwater streams that eventually drain to the Michael J. Kirwan Reservoir. The local and regional surface water features associated with the MRS are presented in **Figure 1-6**.

1.3.7 Hydrology and Hydrogeology

Sand and gravel aquifers are present in the buried-valley and outwash deposits in Portage County. Generally, these saturated zones are too thin and localized to provide large quantities of water for industrial or public water supplies; however, yields are sufficient for residential water supplies. Lateral continuity of these aquifers is unknown. Recharge of these units comes from surface water infiltration of precipitation and surface streams. Specific groundwater recharge and discharge areas at the facility have not been delineated (USACE, 1998).

The thickness of the unconsolidated interval at the facility ranges from thin to absent in the eastern and northeastern portion of the facility to an estimated 150 feet in the south-central portion of the facility. The groundwater table occurs within the unconsolidated zone in many areas of the facility. Because of the heterogeneous nature of the unconsolidated glacial material, groundwater flow patterns are difficult to determine with a high degree of accuracy. Vertical recharge from precipitation likely occurs via infiltration along root zones and desiccation cracks and partings within the soil column. Laterally, most groundwater flow likely follows topographic contours and stream drainage patterns, with preferential flow along pathways (i.e., sand seams, channel deposits, or other stratigraphic discontinuities) having higher permeability than surrounding clay or silt-rich material (USACE, 1998).



Facility Boundary
40mm Firing Range MRS Boundary
40mm Firing Range RI Investigation Area
Surface Water
Stream

0 1,500 3,000
Feet
Projection : NAD_1983_UTM_Zone_17N

U.S. ARMY
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BALTIMORE DISTRICT

MILITARY MUNITIONS RESPONSE PROGRAM

40mm FIRING RANGE MRS
FORMER RVAAP/CAMP RAVENNA
PORTAGE AND TRUMBULL COUNTIES, OHIO

CB&I Federal Services LLC
150 Royall Street
Canton, MA 02021

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FIGURE 1-6 SURFACE WATER FEATURES

Depending on the existence and depth of overburden, the Sharon Sandstone ranges from an unconfined to a leaky artesian aquifer. Water yields from water supply wells at the facility that were completed in the Sharon Sandstone/Conglomerate were 30 to 400 gallons per minute (gpm) (USATHMA, 1978). Well yields of 5 to 200 gpm were reported for on-site bedrock wells completed in the Sharon Sandstone/Conglomerate (Kammer, 1982). Other local bedrock units capable of producing water include the Homewood Sandstone, which is generally thinner and only capable of well yields less than 10 gpm, and the Connoquenessing Sandstone. Wells completed in the Connoquenessing Sandstone in Portage County have yields of 5 to 100 gpm, but are typically less productive than the Sharon Sandstone/Conglomerate due to lower permeabilities (Winslow et al, 1966).

Hydrology and Hydrogeology at the 40mm Firing Range Investigation Area

Although groundwater recharge and discharge areas have not been delineated at the facility, it is assumed that the extensive uplands areas at the facility, primarily located at the western portion of the facility, are regional recharge zones. Sand Creek, Hinkley Creek, and Eagle Creek are presumed to be major groundwater discharge areas (e^2M, 2008). The 40mm Firing Range Investigation Area is not situated in the upland areas that are considered to be regional recharge zones.

No groundwater monitoring wells have been specifically installed for the 40mm Firing Range MRS or within the Investigation Area, and the depth to the unconsolidated aquifer beneath the Investigation Area is unknown. Based on the facility groundwater data collected for the Facility-Wide Groundwater Monitoring Program, the groundwater elevation at the MRS and the immediate vicinity appears to be at a potentiometric high of approximately 1,100 feet amsl. Therefore the depth to groundwater at the 40mm Firing Range Investigation Area may be as deep as 50 feet. The groundwater appears to flow in all directions from this higher formation (Environmental Quality Management, Inc., 2012).

1.3.8 Vegetation

The facility has a diverse range of vegetation and habitat resources. Habitats present within the facility include large tracts of closed-canopy hardwood forest, scrub/shrub open areas, grasslands, wetlands, open-water ponds and lakes, and semi-improved administration areas. Vegetation at the facility can be grouped into three categories: (1) herb-dominated, (2) shrub-dominated, and (3) tree-dominated. Tree-dominated areas are most abundant, covering approximately 13,000 acres on the facility. Shrub vegetation covers approximately 4,200 acres. A plant species survey identified 18 vegetation communities on the facility. The facility has as total of seven forest formations, four shrub formations, eight herbaceous formations, and one nonvegetated formation (AMEC, 2008).

Vegetation at the 40mm Firing Range Investigation Area

The vegetation community present at the 40mm Firing Range Investigation Area is categorized as the "Dry Midsuccessional Cold-Deciduous Shrubland Alliance." This shrubland alliance is associated with relatively open areas characterized by shrub species covering more than 50 percent of the area, with relatively few large trees. This alliance often is found within previously disturbed areas, and is dominated by gray dogwood, northern arrow-wood, blackberry, hawthorn, and multiflora rose (AMEC, 2008). The vegetation community at the 40mm Firing Range Investigation Area is presented in **Figure 1-7**.

1.3.9 Threatened, Endangered, and Other Rare Species

Federal status as a threatened or endangered species is derived from the *Endangered Species Act* (16 U.S. Code § 1538, et seq.) and is administered by the U.S. Fish and Wildlife Service. While there are species under federal review for listing, there are currently no federally cited species or critical habitats at the facility. State-listed plant and animal species are determined by the Ohio Department of Natural Resources. Although biological inventories have not occurred within the Investigation Area boundary and no confirmed sightings of state-listed species have been reported, there is the potential for state listed or rare species to be within the Investigation Area. Information regarding endangered and threatened species at the facility was obtained from the Camp Ravenna *Rare Species List* (2010). **Table 1-3** presents State-listed species that have been identified to be on the facility by biological inventories and confirmed sightings.

Table 1-3
Camp Ravenna Rare Species List

Common Name	Scientific Name
State Endangered	
American bittern	*Botaurus lentiginosus*
Northern harrier	*Circus cyaneus*
Yellow-bellied sapsucker	*Sphyrapicus varius*
Golden-winged warbler	*Vermivora chrysoptera*
Osprey	*Pandion haliaetus*
Trumpeter swan	*Cygnus buccinator*
Mountain brook lamprey	*Ichthyomyzon greeleyi*
Graceful underwing moth	*Catocala gracilis*
Tufted moisture-loving moss	*Philonotis fontana* Var. *Caespitosa*

Common Name	Scientific Name
Bobcat	*Felis rufus*
Narrow-necked Pohl's moss	*Pohlia elongata* Var. *Elongata*
Sandhill crane (probable nester)	*Grus canadensis*
Bald eagle (nesting pair)	*Haliaeetus leucocephalus*
State Threatened	
Barn owl	*Tyto alba*
Dark-eyed junco (migrant)	*Junco hyemalis*
Hermit thrush (migrant)	*Catharus guttatus*
Least bittern	*Ixobrychus exilis*
Least flycatcher	*Empidonax minimus*
Caddisfly	*Psilotreta indecisa*
Simple willow-herb	*Epilobium strictum*
Woodland horsetail	*Equisetum sylvaticum*
Lurking leskea	*Plagiothecium latebricola*
Pale sedge	*Carex pallescens*
State Potentially Threatened Plants	
Gray birch	*Betula populifolia*
Butternut	*Juglans cinerea*
Northern rose azalea	*Rhododendron nudiflorum* Var. *Roseum*
Hobblebush	*Viburnum alnifolium*
Long beech fern	*Phegopteris connectilis*
Straw sedge	*Carex straminea*
Large St. Johnswort	*Hypericum majus*
Water avens	*Geum rivale*
Shining lady's tresses	*Spiranthes lucida*
Swamp oats	*Sphenopholis pensylvanica*
Arborvitae	*Thuja occidentalis*
American chestnut	*Castanea dentata*

Common Name	Scientific Name
Tufted moisture-loving moss	*Philonotis fontana var. Caespitosa*
State Species of Concern	
Pygmy shrew	*Sorex hoyi*
Woodland jumping mouse	*Napaeozapus insignis*
Star-nosed mole	*Condylura cristata*
Sharp-shinned hawk	*Accipiter striatus*
Marsh wren	*Cistothorus palustris*
Henslow's sparrow	*Ammodramus henslowii*
Cerulean warbler	*Dendroica cerulea*
Prothonotary warbler	*Protonotaria citrea*
Bobolink	*Dolichonyx oryzivorus*
Northern bobwhite	*Colinus virginianus*
Common moorhen	*Gallinula chloropus*
Great egret (migrant)	*Ardea alba*
Sora	*Porzana carolina*
Virginia rail	*Rallus limicola*
Creek heelsplitter	*Lasmigona compressa*
Eastern box turtle	*Terrapene carolina*
Four-toed salamander	*Hemidactylium scutatum*
Mayfly	*Stenonema ithaca*
Coastal plain apamea	*Apamea mixta*
Willow peasant	*Brachylomia algens*
Sedge wren	*Cistothorus platensis*
State Special Interest	
Canada warbler	*Wilsonia canadensis*
Little blue heron	*Egretta caerulea*
Magnolia warbler	*Dendroica magnolia*
Northern waterthrush	*Seiurus noveboracensis*

Common Name	Scientific Name
Winter wren	*Troglodytes troglodytes*
Black-throated blue warbler	*Dendroica caerulescens*
Brown creeper	*Certhia americana*
Mourning warbler	*Oporornis philadelphia*
Pine siskin	*Carduelis pinus*
Purple finch	*Carpodacus purpureus*
Red-breasted nuthatch	*Sitta canadensis*
Golden-crowned kinglet	*Regulus satrapa*
Blackburnian warbler	*Dendroica fusca*
Blue grosbeak	*Guiraca caerulea*
Common snipe	*Gallinago gallinago*
American wigeon	*Anas americana*
Gadwall	*Anas strepera*
Green-winged teal	*Anas crecca*
Northern shoveler	*Anas clypeata*
Redhead duck	*Aythya americana*
Ruddy duck	*Oxyura jamaicensis*

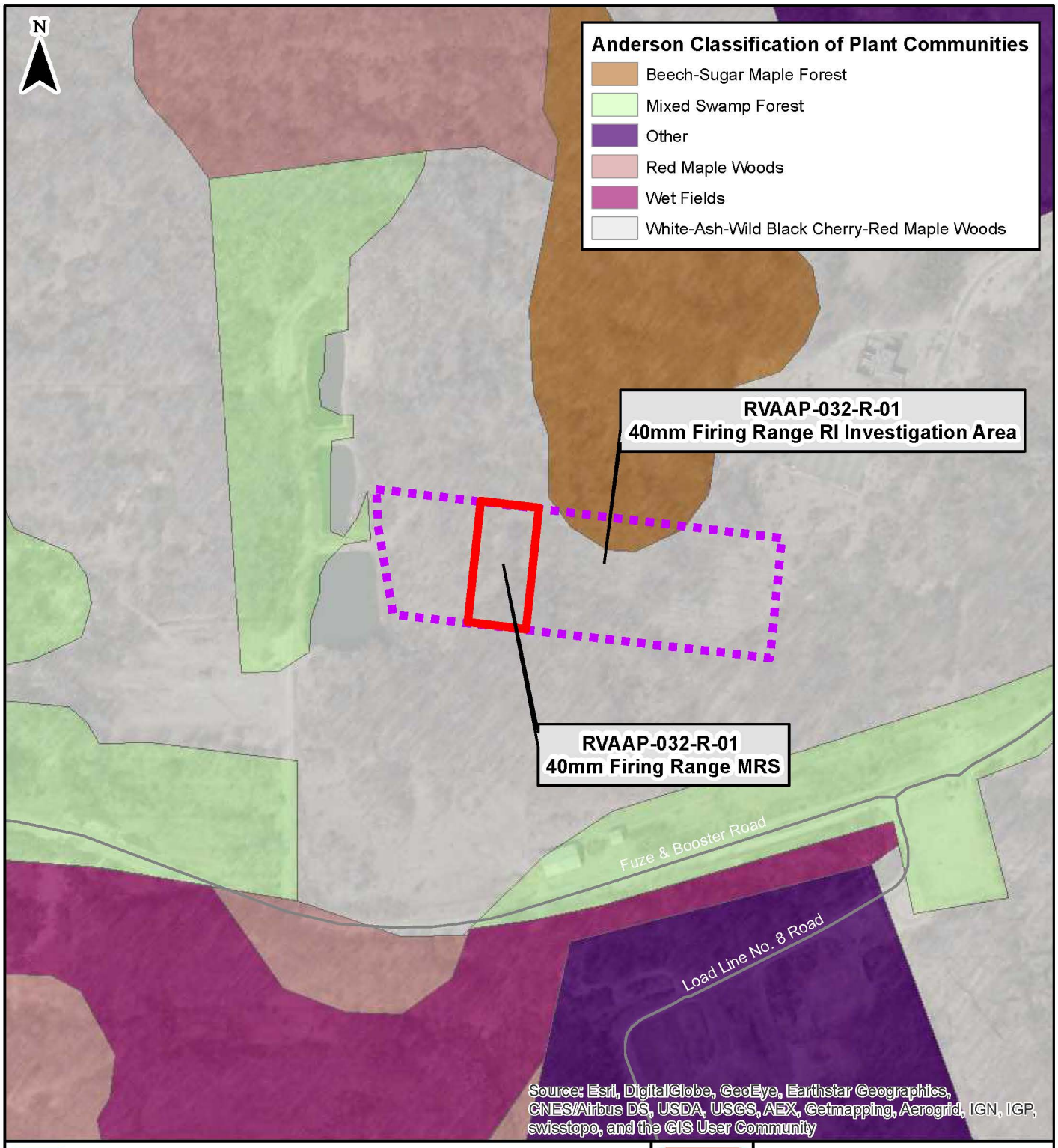
Source: Camp Ravenna Joint Military Training Center Rare Species List, April 27, 2010.

1.3.10 Cultural and Archeological Resources

A number of archeological surveys have been conducted at the facility. Cultural and archeological resources have been identified at the facility during past surveys (AMEC, 2008). The 40mm Firing Range MRS has not been previously surveyed for cultural or archeological resources; however, due to the disturbed nature of the area from former operations, it is unlikely that cultural and/or archeological resources are present at the MRS.

1.4 Facility History and Background

During operations as an ammunition plant, the RVAAP was a government-owned and contractor-operated industrial facility. Industrial operations at the RVAAP consisted of 12 munitions assembly facilities, referred to as “load lines.” Load Lines 1 through 4 were used to melt and load TNT and Composition B into large caliber shells and bombs. The operations on the load lines produced explosive dust, spills, and vapors that collected on the



40mm Firing Range MRS Boundary

40mm Firing Range RI Investigation Area

0 400 800 Feet

Projection : NAD_1983_UTM_Zone_17N

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FIGURE 1-7 VEGETATION

floors and walls of each building. Periodically, the floors and walls were cleaned with water and steam. Following cleaning, the "pink water" waste water, which contained TNT and Composition B, was collected in concrete holding tanks, filtered, and pumped into unlined ditches for transport to earthen settling ponds. Load Lines 5 through 11 were used to manufacture fuzes, primers, and boosters. From 1946 to 1949, Load Line 12 was used to produce ammonium nitrate for explosives and fertilizers prior to use as a weapons demilitarization facility.

In 1950, the RVAAP was placed in standby status and operations were limited to renovation, demilitarization, and normal maintenance of equipment, along with storage of munitions. Production activities were resumed from July 1954 to October 1957 and again from May 1968 to August 1972. In addition to production missions, various demilitarization activities were conducted at facilities constructed at Load Lines 1, 2, 3, and 12. Demilitarization activities included disassembly of munitions and explosives melt-out and recovery operations using hot water and steam processes. Periodic demilitarization of various munitions continued through 1992.

In addition to production and demilitarization activities at the load lines, other facilities at the facility include MRSs that were used for the burning, demolition, and testing of munitions. These burning and demolition grounds consist of large parcels of open space or abandoned quarries. Other areas of concern (AOCs) present at the RVAAP include landfills, an aircraft fuel tank testing facility, and various general industrial support and maintenance facilities (SAIC, 2011b).

40mm Firing Range MRS History and Background

The 40mm Firing Range was originally included in the Installation Restoration Program (IRP) as AOC RVAAP-32; however, the site was placed under the sole jurisdiction of the MMRP in February 2008 and designated as an MRS. The 40mm Firing Range MRS originally encompassed 5.17 acres and was operated between 1969 and 1971. The former test range was used to perform acceptance tests that included muzzle velocity measurements and impact function tests. Munitions reportedly fired at the former test range included the M407A1 series 40mm practice grenade and the M406 series HE 40mm grenade. The M406 and M407A1 series cartridges were designed to be fired from 40mm grenade launchers, M79 and M203 series, attached to the M16/M16Al series rifle. The 40mm practice grenades contained yellow marker dye, M9 series propellant, and RDX booster pellets body (U.S. Army, 1977). The M9 series propellant consisted of nitrocellulose, nitroglycerin, potassium nitrate, ethyl centralite, and graphite. The M406 series HE rounds contained Composition B explosive, which is a mixture of RDX and TNT (e^2M, 2007). According to the *Final Installation Assessment of RVAAP Report No. 132* (USATHMA, 1978), each of the approximately 2,500 rounds fired on this range were accounted for.

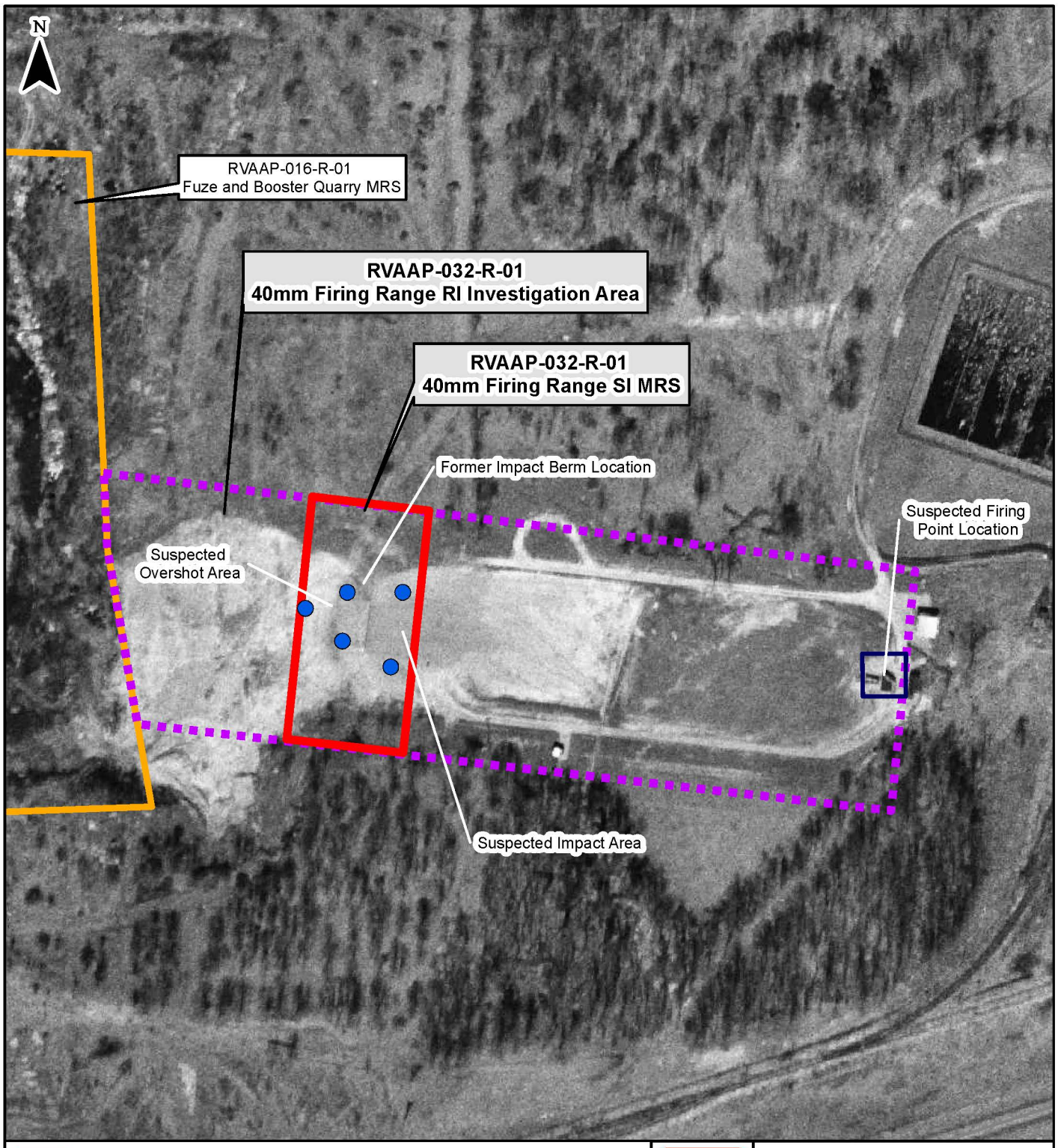
The furthest possible target distance for the 40mm grenades reported to have been fired at the former test range is 350 meters from the firing point (U.S. Army, 2003). The impact area was well defined with a berm that has since been removed. The exact date when the berm was removed and final disposition of the berm material is not known; however, the berm appears to have been removed prior to 1977 based on a review of historical aerial photographs. The firing point was situated at the eastern portion of the former range. Remnants of the firing point location still remain and include a wooden structure believed to be the former storage shed, gun mount foundation, and chronograph foundation (e^2M, 2007). **Figure 1-8** is a historical aerial photograph of the 40mm Firing Range circa 1970 that shows significant features of interest when the range was active.

During the SI field activities, MPPEH was found scattered from the target points in the impact area to approximately 100 feet beyond the former impact area. The MPPEH was inspected by UXO-qualified personnel and determined to be MDAS (i.e., MD). The MD consisted of aluminum nose caps and casings for the 40mm grenades. It was recommended in the SI Report (e^2M, 2008), and subsequently approved by the stakeholders, that the MRS footprint be reduced from 5.17 acres to 1.27 acres to include only the impact berm and 100 feet beyond where the MD was found. Further discussion of the SI findings at the MRS is presented in Section 1.5.3.

During development of the Work Plan Addendum (Shaw, 2011), the MRS boundaries that were recommended in the SI Report (e^2M, 2008) were reevaluated. Although only MD was found at the impact area of the former test range during the SI field activities, it was determined that the area between the firing point and the furthest possible target distance (350 meters from the firing point) required further investigation during the RI for potential MEC. Therefore, the original 3.9 acres removed from the MRS during the RI were reintroduced in addition to the area that extends beyond to the Fuze and Booster Quarry MRS where facility personnel reportedly encountered MEC along the slopes. In all, a total of 8.55 acres were considered for further investigation during the RI. **Figure 1-9** depicts the boundaries and the current conditions at the 40mm Firing Range Investigation Area boundaries.

1.5 Previous Investigations and Actions

This section briefly summarizes the investigations and actions that pertain to the 40mm Firing Range MRS. This information was obtained primarily from the *Final Archives Search Report* (ASR) (USACE, 2004), the *Final Military Munitions Response Program Historical Records Review* (HRR) (e^2M, 2007), and the SI Report (e^2M, 2008).



40mm Firing Range SI MRS Boundary
40mm Firing Range RI Investigation Area
Fuze and Booster Quarry MRS Boundary
Suspected Firing Point Location
Previous MD Find (SI, 2007)

0 200 400 Feet

Projection : NAD_1983_UTM_Zone_17N

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FIGURE 1-8 1970 HISTORICAL AERIAL PHOTOGRAPH

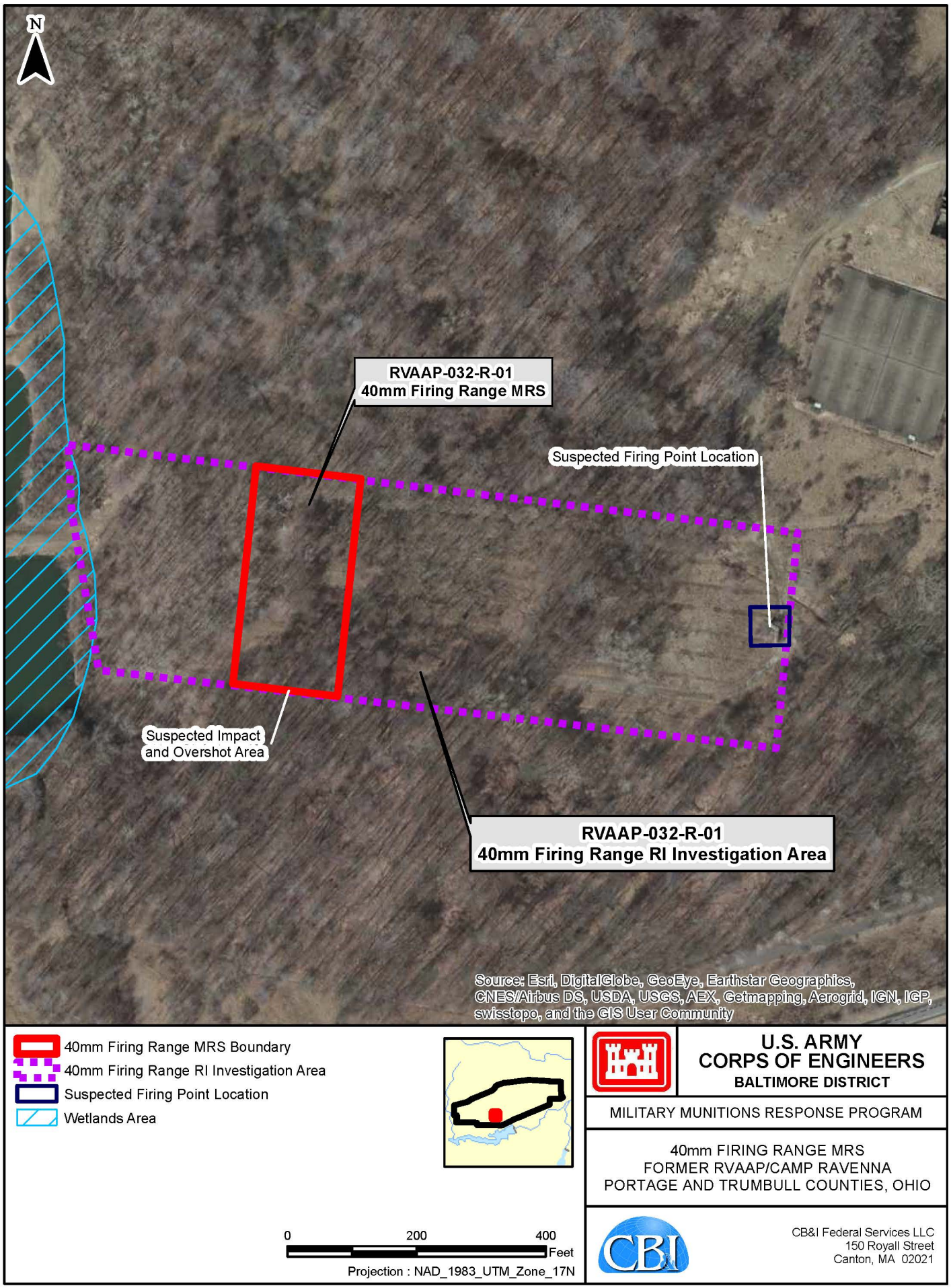


FIGURE 1-9 SITE FEATURES MAP

1.5.1 2004 USACE Archives Search Report

The USACE conducted an archives search in 2004 under the DERP as a historical records search and SI for the presence of MEC at the facility. The ASR was prepared by the USACE in 2004 and identified 12 AOCs as well as four additional locations with the potential for MEC. Based on the ASR, Ramsdell Quarry Landfill, Erie Burning Grounds, Open Demolition Area #1, Load Line 12 and Dilution/Settling Pond, Building 1200 and Dilution/Settling Pond, Quarry Landfill/Former Fuze and Booster Burning Pits, 40mm Firing Range, Building 1037—Laundry Waste Water Sump, Anchor Test Area, Atlas Scrap Yard, Block D Igloo, and Tracer Burning Furnace were identified as potential MRS containing MEC. Confirmed MEC was identified at Open Demolition Area #2, Landfill North of Winklepeck, Load Line #1 and Dilution/Settling Pond, and Load Line 3 and Dilution/Settling Pond (USACE, 2004).

The ASR (USACE, 2004) provided documentation indicating that the M407A1 series 40mm practice grenade and the M406 series HE 40mm grenade were the munitions fired at the 40mm Firing Range. The *Final Installation Assessment of RVAAP Report No. 132* (USATHMA, 1978), referenced in the ASR, reported that approximately 2,500 rounds had been fired at the range and that all rounds were recovered and accounted for.

1.5.2 2007 e^{2}M Historical Records Review

The HRR was performed by e^{2}M in January 2007. The primary objectives of the HRR were to perform a limited scope records search to document historical and other known information on MRS identified at the facility, to supplement the U.S. Army Closed, Transferring, and Transferred Range/Site Inventory, and to support the technical project planning process designed to facilitate decisions on those areas where more information was needed to determine the next step(s) in the CERCLA process.

Of the 19 MMRP-eligible MRS identified during the U.S. Army Closed, Transferring, and Transferred Range/Site Inventory, the HRR identified 18 MRSs that qualified for the MMRP, due to the demolition and/or disposal activities that were conducted on the MRSs that resulted in the possible presence of MEC and/or MC, and where the releases occurred prior to September 2002 (e^{2}M, 2007). These 18 MRS identified during the HRR include the following:

- Ramsdell Quarry Landfill (RVAAP-001-R-01)
- Erie Burning Grounds (RVAAP-002-R-01)
- Open Demolition Area #2 (RVAAP-004-R-01)
- Load Line #1 (RVAAP-008-R-01)

- Load Line #12 (RVAAP-012-R-01)
- Fuze and Booster Quarry (RVAAP-016-R-01)
- Landfill North of Winklepeck (RVAAP-019-R-01)
- 40mm Firing Range (RVAAP-032-R-01)
- Firestone Test Facility (RVAAP-033-R-01)
- Sand Creek Dump (RVAAP-034-R-01)
- Building #F-15 and F-16 (RVAAP-046-R-01)
- Anchor Test Area (RVAAP-048-R-01)
- Atlas Scrap Yard (RVAAP-050-R-01)
- Block D Igloo (RVAAP-060-R-01)
- Block D Igloo TD (RVAAP-061-R-01)
- Water Works #4 Dump (RVAAP-062-R-01)
- Areas between Buildings 846 and 849 (RVAAP-063-R-01) (now identified as "Group 8")
- Field at the Northeast Corner of the Intersection (RVAAP-064-R-01)

Following the HRR, the Field at the Northeast Corner of the Intersection (RVAAP-064-R-01), otherwise known as the Old Hayfield MRS, was classified as an operational range. This MRS was removed from eligibility under the MMRP, reducing the number of active MRSs at the RVAAP to 17.

The HRR described the 40mm Firing Range as an approximate 5.17-acre area surrounded by forest. A wooden structure believed to be the former storage shed, gun mount foundation, and chronograph foundation located at the firing point were the only remnants of range, as the impact area berm had been removed. The HRR reported that facility personnel identified UXO beyond the impact point, on the slope that leads down to the Fuze and Booster Quarry MRS. However, the HRR did not identify the type or disposition of the UXO reported by the facility personnel (e^2M, 2007).

1.5.3 2008 e^2M Final Site Inspection Report

In 2007, e^2M conducted a SI at each the 17 MRSs under the MMRP. The primary objectives of the SI activities were to collect the appropriate amount of information to support recommendations of "No Further Action, Immediate Response, or Further Characterization" concerning the presence of MEC and/or MC at each MRS. The SI also included a review of

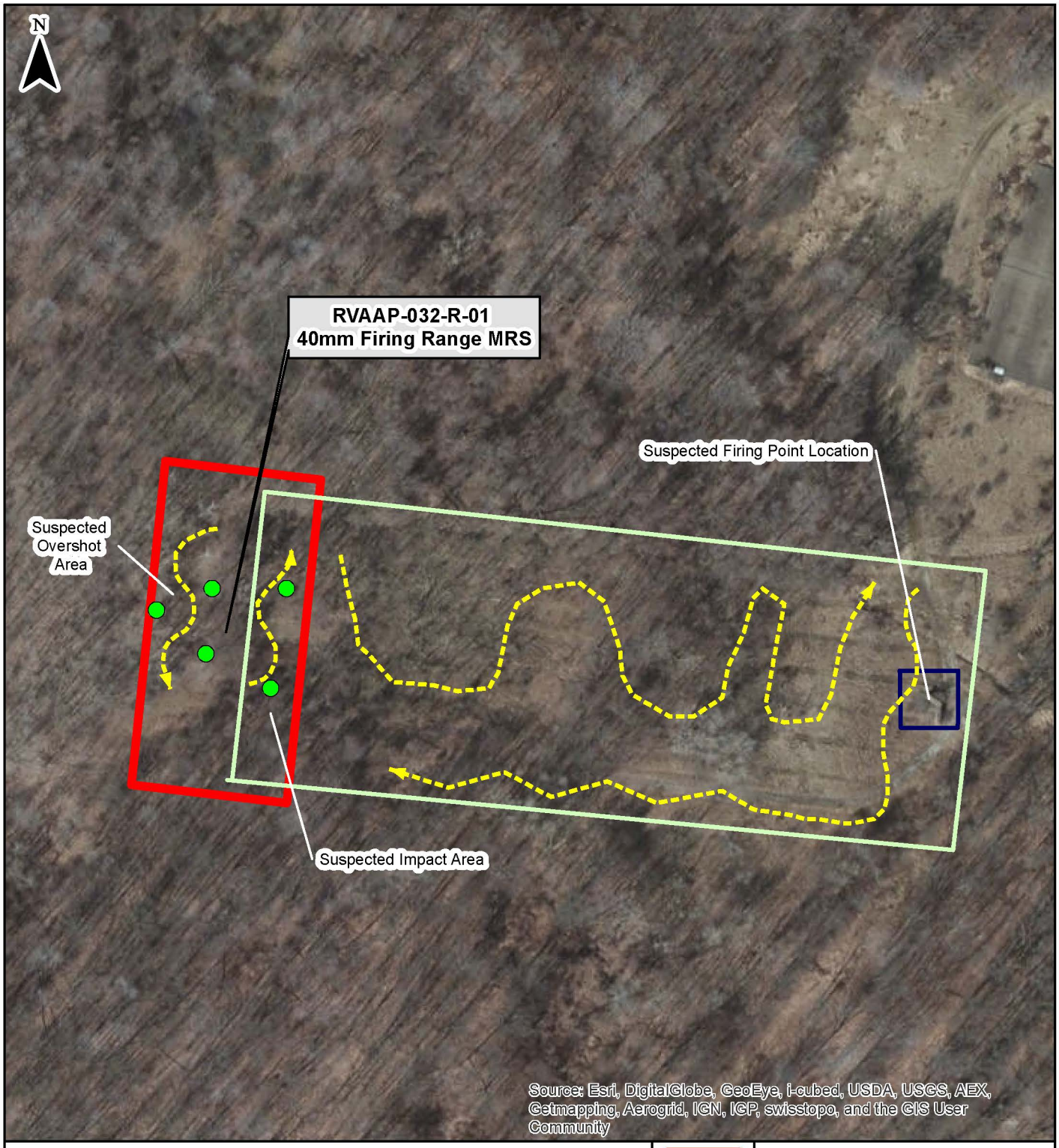
the HRR for each of the applicable MRSs. Out of the 17 MRSs evaluated during the SI, 14 were recommended for "Further Characterization" under the MMRP that included the 40mm Firing Range MRS (RVAAP-032-R-01). A summary of the SI Report (e^2M, 2008) recommendations for the 40mm Firing Range MRS is presented in **Table 1-4** and is discussed below.

Table 1-4
Site Inspection Recommendations

MRS	MRSPP Priority	Recommendation	Basis for Recommendation	
			MEC	MC
40mm Firing Range (RVAAP-032-R-01)	5	Further characterization required to evaluate the potential presence of MEC and MC in the impact area and 100 feet further down range. Decrease MRS footprint to the 1.27-acre impact and downrange area.	No MEC items were found during the SI; however, MD consisting of aluminum caps and casings for 40mm rounds was identified.	The presence of MC has not been determined during previous investigations.

MC denotes munitions constituents.
MD denotes munitions debris.
MEC denotes munitions and explosives of concern.
MRS denotes Munitions Response Site.
MRSPP denotes Munitions Response Site Prioritization Protocol.
SI denotes Site Inspection.

At the time of the SI, the size of the 40mm Firing Range MRS was approximately 5.17 acres that included an open field surrounded by forest. As part of the SI activities, a meandering path magnetometer and metal detector assisted MEC surveys were completed at the down-range target impact area, overshot area, and firing point portions at the MRS. Although the HRR (e^2M, 2007) reported that MEC had been observed by facility personnel beyond the impact area, the presence of MEC was not verified during the SI field activities. Multiple MD items were found on the ground surface during the SI at the target impact area and 100 feet beyond which consisted of aluminum 40mm grenade nose caps and casings. No MEC or MD was observed at the firing point or in the area between the firing point and impact area. No MC samples were planned for the SI field activities since chemical contamination at the MRS was still being addressed under the IRP at the time of the SI work plan development. However, by the time the SI Report was completed, the responsibility for investigation for MC at the MRS was to be addressed under the MMRP going forward (e^2M, 2008). **Figure 1-10** shows the areas investigated during the SI field activities and the locations where MD items were found.



Old CTT/HRR MRS Footprint Boundary
SI Recommended MRS Boundary
Suspected Firing Point Location
Meandering Path Survey Area
Munitions Debris Location

0 150 300 Feet

Projection : NAD_1983_UTM_Zone_17N

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FIGURE 1-10 SI FIELDWORK AND FINDINGS

It was recommended in the SI Report that the MRS be reduced from 5.17 acres to 1.27 acres to include only the impact area and 100 feet beyond where the MD was found during the SI field activities. The new footprint was recommended for "Further Characterization" of MEC and MC concerns (e^2M, 2008).

The SI Report (e^2M, 2008) assigned the 40mm Firing Range MRS a Munitions Response Site Prioritization Protocol (MRSPP) priority of 5. The MRSPP is a funding mechanism typically performed during the Preliminary Assessment/SI stage to prioritize funding for MRSs on a priority scale of 1 to 8 with a Priority 1 being the highest relative priority. Based on the MRSPP priority identified for the MRS in the SI Report (e^2M, 2008), the 40mm Firing Range MRS was selected for inclusion for "Further Characterization" under the MMRP.

1.6 RI Report Organization

The contents and order of presentation of this RI Report are based on the requirements of *Military Munitions Response Program, Munitions Response Remedial Investigation/Feasibility Study Guidance* (U.S. Army, 2009). Specifically, this RI Report includes the following sections:

- **Section 1.0**—Introduction
- **Section 2.0**—Project Objectives
- **Section 3.0—**Characterization of MEC and MC
- **Section 4.0**—Remedial Investigation Results
- **Section 5.0—**Fate and Transport
- **Section 6.0—**MEC Hazard Assessment
- **Section 7.0—**Human Health Risk Assessment
- **Section 8.0—**Ecological Risk Assessment
- **Section 9.0—**Revised Conceptual Site Models
- **Section 10.0—**Summary and Conclusions
- **Section 11.0—**References

Appendices included at the end of this RI Report are as follows:

- **Appendix A—**Digital Geophysical Mapping Report
- **Appendix B—**Field Documentation

- **Appendix C—**Munitions Data Sheets
- **Appendix D—**Data Validation Report
- **Appendix E—**Laboratory Data Reports
- **Appendix F—**IDW Management
- **Appendix G—**Photograph Documentation Log
- **Appendix H—**Intrusive Investigation Results
- **Appendix I—**Munitions Debris Waste Shipment and Disposal Records
- **Appendix J—**Munitions Response Site Prioritization Protocol Worksheets
- **Appendix K—**Ohio EPA Correspondence
- **Appendix L—**Responses to Ohio EPA Comments
- **Appendix M**—Ohio EPA Approval Letter

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2.0 PROJECT OBJECTIVES

This section presents the preliminary CSM for MEC for the 40mm Firing Range MRS based on historical information and identifies data gaps associated with the preliminary CSMs and the data quality objectives (DQOs) necessary to achieve the project objectives. Samples for MC have not been collected at the MRS prior to the RI field activities and a preliminary MC CSM has not been developed.

A CSM for an MRS provides an analysis of potential exposures associated with MEC and/or MC and an evaluation of the potential transport pathways MEC and/or MC take from a source to a receptor. Each pathway includes a source, activity, access and receptor component, with complete, potentially complete, or incomplete exposure pathways identified for each receptor. Each component of the CSM analysis is discussed below.

- **Sources—**Sources are those areas where MEC or MC have entered (or may enter) the physical system. A MEC source is the location where MPPEH or ordnance is situated or are expected to be found. A MC source is a location where MC has entered the environment.
- **Activity—**The hazard from MEC and/or MC arises from direct contact as a result of some human or ecological activity. Interactions associated with activities describe ways that receptors come into contact with a source. For MEC, movement is not typically significant, and interaction will occur only at the source area as described above, limited by access and activity. However, there can be some movement of MEC through natural processes such as frost heave, erosion, and stream conveyance. For MC, this can include physical transportation of the contaminant and transfer from one medium to another through various processes such that media other than the source area can become contaminated. Interactions also include exposure routes (ingestion, inhalation, and dermal contact) for each receptor. Ecological exposure can include coming into contact with MEC or MC lying on the ground surface or through disturbing buried MEC/MC while digging or performing other activities such as burrowing.
- **Access—**Access is the ease with which a receptor can come into contact with a source. The presence of access controls help determine whether an exposure pathway to a receptor is complete, as fences or natural barriers can limit human access to a source area. Furthermore, the depth of MEC items in subsurface soils and associated MC may also limit access by a receptor. Ease of entry for adjacent populations (i.e., lack of fencing) can facilitate trespassing at the MRS, either intentional or accidental.

- **Receptors—**A receptor is an organism (human or ecological) that contacts a chemical or physical agent. The pathway evaluation must consider both current and reasonably anticipated future land use and activities, as receptors are determined on that basis. If present, MEC and/or MC on the ground surface and near the surface can be accessed by facility personnel, contractors, visitors, trespassers, and biota.

A pathway is considered potentially complete when a source has not been confirmed, but is suspected to exist and when receptors have access to the MRS while engaging in some activity which results in contact with the source. Lastly, an incomplete pathway is any case where one of the four components (source, activity, access, or receptors) is missing from the Investigation Area.

In general, the CSM for the Investigation Area is intended to assist in planning, interpreting data, and communicating MRS-specific information. The CSM is used as a planning tool to integrate information from a variety of resources, to evaluate the information with respect to project objectives and data needs, and to evolve through an iterative process of further data collection or action. A discussion of the preliminary CSM identified for the 40mm Firing Range MRS, as presented in the SI Report (e^2M, 2008), is presented in the following section. The data collected during the RI are evaluated in the following chapters and incorporated into this model as discussed in Section 9.0, "Revised Conceptual Site Models."

2.1 Preliminary CSM and Project Approach

The preliminary MEC CSM for the 40mm Firing Range MRS is based on MRS-specific data and general historical information including literature reviews, maps, training manuals, technical manuals, and field observations. The CSM was originally developed during the SI based on guidance from USACE Engineer Manual 1110-1-1200, *Conceptual Site Models for Ordnance and Explosives (OE) and Hazardous, Toxic, and Radioactive Waste (HTRW) Projects* (USACE, 2003a) and is represented by the diagram provided as **Figure 2-1**. A MC CSM was not developed during the SI as no samples were collected and the MRS was not investigated for MC under the IRP.

- **Sources—**Use of the area as a target/test range for 40mm grenade cartridges was considered to be the primary source of potentially explosive MEC at the 40mm Firing Range MRS. Based on review of archival records and available documentation, the principle source area at the 40mm Firing Range is the impact area and downrange of the target area which resulted in the potential for MEC to be present in surface and subsurface soils.

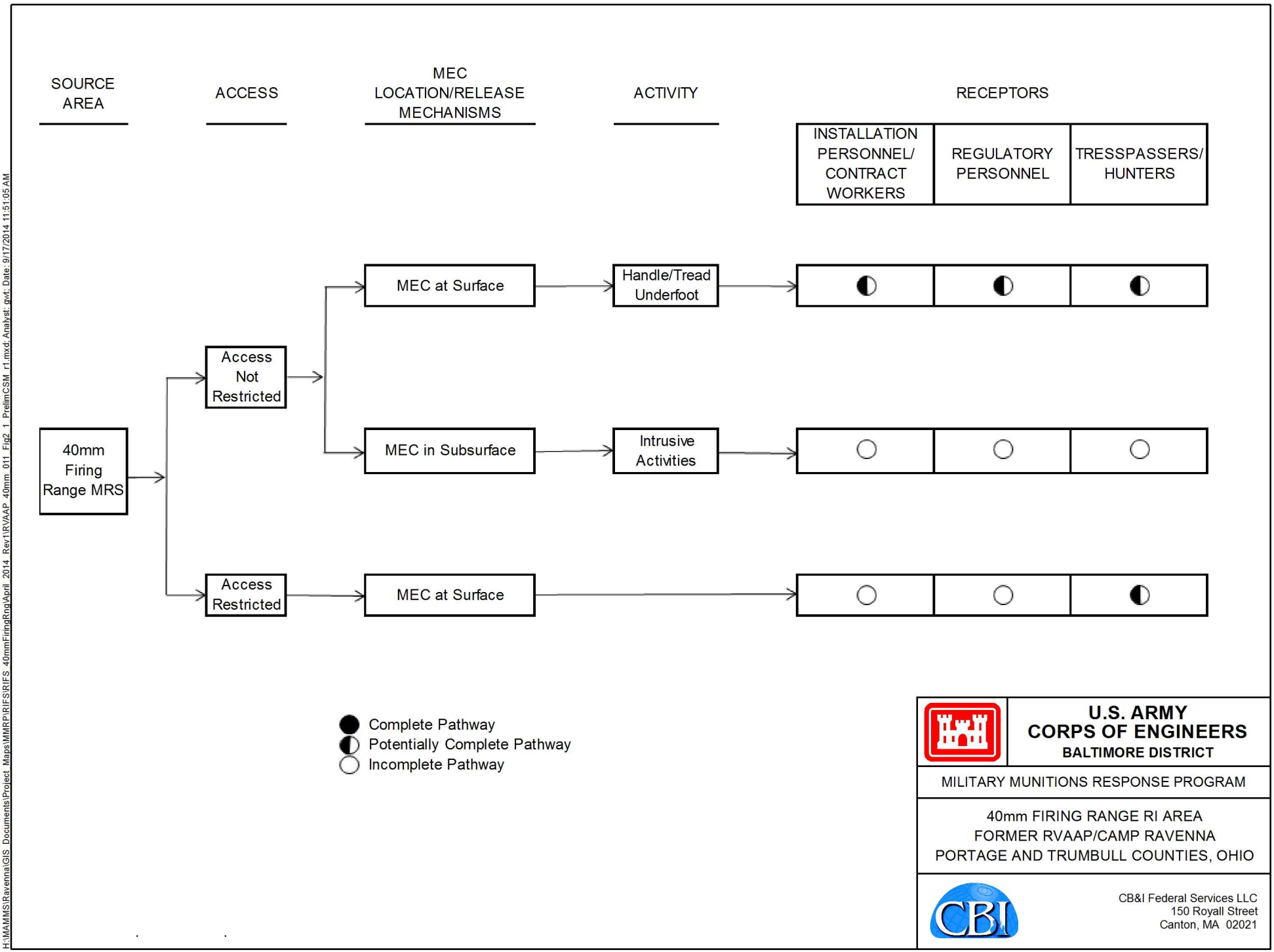

FIGURE 2-1 PRELIMINARY MEC CONCEPTUAL SITE MODEL

- **Activity—**Human activities considered for the preliminary CSM included natural resource management and maintenance activities that were performed at an infrequent basis.
- **Access—**Access to the 40mm Firing Range MRS at the time of the SI was not restricted, and there were no known access controls present.
- **Receptors—**At the time of the SI, current and reasonably anticipated receptors for MEC included facility personnel, contractors (including maintenance personnel), regulatory personnel, and possibly trespassers and hunters. The ecological receptors (biota) identified in the SI Report (e^2M, 2008) were the state-listed species identified as being present at the facility and listed in **Table 1-3**. If present, MEC on the ground surface and subsurface could have been accessed by receptors.

The information collected during the SI was used to prepare the preliminary CSM for MEC (**Figure 2-1**) for the 40mm Firing Range MRS and to identify all complete, potentially complete, or incomplete source-receptor interactions for the MRS. Although, no MEC was found during the SI field activities, MD was found on the ground surface and the possibility that MEC was present at the MRS could not be dismissed. Considering this, the potential exposure pathway for human receptors would be contact on the surface by handling/treading underfoot of munitions (e^2M, 2008).

2.2 Preliminary Identification of Applicable or Relevant and Appropriate Requirements and "To Be Considered" Information

Applicable or relevant and appropriate requirements (ARARs) and "to be considered" (TBC) guidance for future anticipated and reasonable remedial actions at the facility under the MMRP are currently under development. Once ARARs and/or TBC materials have been identified, preliminary remediation goals and remedial action objectives will be developed. The identified ARARs, TBCs, preliminary remediation goals, and remedial action objectives will be included in the Feasibility Study Report as required per the CERCLA process.

2.3 Data needs and Data Quality Objectives

The DQOs and data needs were determined at the planning stage and are outlined in the Work Plan Addendum (Shaw, 2011). The data needs included characterization for MEC and MC associated with former munitions activities at the MRS. The DQOs were developed to ensure the reliability of field sampling, chemical analyses, and physical analyses; the collection of sufficient data; the acceptable quality of data generated for its intended use; and the inference of valid assumptions from the data.

2.3.1 Data Quality Objectives

The DQOs were developed for MEC and MC in accordance with the *Facility-Wide Sampling and Analysis Plan for Environmental Investigations at the RVAAP* (FWSAP) (SAIC, 2011b), and the U.S. Environmental Protection Agency (EPA) *Data Quality Objectives Process for Hazardous Waste Site Investigations*, EPA QA/G-4HW (2000). **Table 2-1** identifies the DQO process developed in the Work Plan Addendum (Shaw, 2011) for the 40mm Firing Range Investigation Area.

Table 2-1
Data Quality Objectives Process at the 40mm Firing Range Investigation Area

Step	Data Quality Objective
1. State the problem.	The 40mm Firing Range was used to test 40mm grenade cartridges from 1969 to 1971. Grenades were fired from a fixed position, located to the east of the current MRS boundary. The impact area and 100 feet beyond are approximately 1.27 acres and constitute the current MRS boundaries. The SI field work identified various MD on the ground surface that suggested the potential for possible MEC on the ground surface and in subsurface soils at the MRS and surrounding area. In addition, there is a potential for environmental impacts from MC at the MRS and the surrounding area. The surrounding area is inclusive of a distance of 350 meters to the west of the former firing point that includes the 1.27-acre MRS. This area totals approximately 8.55 acres, is considered the Investigation Area, and is focus of the RI.
2. Identify the decision.	The goal of the investigation at the 40mm Firing Range Investigation Area is to identify the areas impacted with MEC. In addition, MC sampling will be performed in order to further characterize the type and amount of contamination associated with munitions activities at the 1.27-acre MRS located within the Investigation Area. The information obtained during the RI will be used to assess the potential risks and hazards posed to human health and the environment.
3. Identify inputs to the decision.	• Historical information • DGM survey • Intrusive investigation • Incremental environmental media sampling
4. Define the study boundaries.	The RI will be performed in the MRS boundaries as defined at the conclusion of the SI Report (e^2M, 2008) as well as the proposed range boundaries that includes the firing point and area beyond the MRS.
5. Develop a decision rule.	Although no formal visual survey transects are planned at the Investigation Area, the presence of surface MEC will be investigated during the DGM survey. The DGM survey will be performed at the Investigation Area to assess the presence of MEC on the ground surface and shallow subsurface. The DGM transects will be placed using the VSP® program. The "Transect Sampling for UXO Target Traversal" module of VSP® was used to identify the proposed transect spacing. CB&I will select anomalies based on the geostatistical mapping of anomalies.

Table 2-1 (continued)
Data Quality Objectives Process at the 40mm Firing Range Investigation Area

Step	Data Quality Objective
5. Develop a decision rule (continued)	Following the MEC investigation, MC soil sampling will be performed at the 1.27-acre MRS portion of the Investigation Area for further characterization of MC as recommended in the SI Report. The MRS boundaries include the former target and impact area and 100 feet beyond. Sampling will consist of two ISM soil samples from the MRS (approximately 0.63 acres each) and one ISM soil sample collected from the 0.05-acre former firing point at the eastern end of the range. The ISM soil samples from within the MRS will be analyzed for aluminum and lead, explosives, nitrocellulose, total organic carbon, and pH. The samples will also be analyzed for geochemical metal parameters (calcium, magnesium, manganese, and iron). The ISM soil sample from the firing point will be analyzed for propellants only. The investigation may be expanded if warranted by the identification of MEC outside of the MRS boundary and within the Investigation Area.
6. Specify limits of decision errors.	QC procedures were in place so that all fieldwork was performed in accordance with all applicable standards. Further details on the QC process implemented during the RI are located in Section 4.0 of the Work Plan Addendum (Shaw, 2011).
7. Optimize the design for obtaining data.	The information gathered as part of the field investigation at the 40mm Firing Range Investigation Area will be used to determine what risks or hazards, if any, are present. A MEC HA will be to be developed to identify the potential MEC hazards found during the RI field effort, if any. In addition, an MRS-specific HHRA and ERA will be performed on the analytical results if necessary. If unacceptable risks or hazards to human health and the environment are determined to exist at the conclusion of the investigation, then the 40mm Firing Range Investigation Area will be identified for further evaluation under the CERCLA process.

CERCLA denotes Comprehensive Environmental Response, Compensation, and Liability Act of 1980.
DGM denotes digital geophysical mapping.
ERA denotes ecological risk assessment.
HA denotes hazard assessment.
HHRA denotes human health risk assessment.
ISM denotes incremental sampling methodology.
MC denotes munitions constituents.
MD denotes munitions debris.
MEC denotes munitions and explosives of concern.
MRS denotes Munitions Response Site.
QC denotes quality control.
RI denotes Remedial Investigation.
SI denotes Site Inspection.
UXO denotes unexploded ordnance.
VSP® denotes Visual Site Plan®.

2.3.2 Data Needs

For MEC, data needs include determining the types, locations, condition, and number of MEC items present at the MRS so that the potential hazard to likely receptors can be assessed and remedial decisions can be made. The DQOs were developed in accordance with the FWSAP (SAIC, 2011b), EPA DQO guidance (2000), and past experience with MRSs containing MEC. These data needs for MEC were evaluated using the most applicable methods and technologies that are discussed in the following chapters.

For MC, data needs include sufficient information to determine the nature and extent of MC, determine the fate and transport of MC, and characterize the risk of MC to potential receptors by performing a human health risk assessment (HHRA) and an ecological risk assessment (ERA). More specifically, the data needed are concentrations of MC associated with the Investigation Area in surface soil that pose a potential unacceptable risk to human and ecological receptors. Data quality was assessed through the evaluation of sampling activities and field measurements associated with the chemical data in order to verify the reliability of the chemical analyses and the precision, accuracy, completeness, and sensitivity of information acquired from the laboratory. Representativeness and comparability were also evaluated with regards to the proper design of the sampling program and quality of the data set respectively. The reporting limits (a.k.a., method detection limits [MDLs] or method reporting limits [MRLs]) should be equal to or less than the screening criteria to support the HHRA and ERA in this RI Report whenever possible.

2.4 Data Incorporated into the RI

Whenever possible, existing data is incorporated into the RI. The following is a summary of existing data and how it was used:

- **HRR**—The HRR (e^2M, 2007) provides historical documentation regarding the MRS and identifies the types of activities previously conducted, the types of munitions used, and historical finds and incidents. This data was used to identify the expected baseline conditions and other hazards that may be present.
- **IRP Data**—Data collected under the IRP at various MRSs includes analytes considered to be MC associated with previous activities at the MRS, although it should be noted that not all analytes are considered as MC. For the 40mm Firing Range MRS, no media samples were collected under the IRP.
- **SI Data**—The SI Report (e^2M, 2008) provides reconnaissance data identifying surface MD that will be used in conjunction with historical data to preliminarily delineate areas with munitions-related activity. MC sampling was not performed at the 40mm Firing Range MRS during the SI field activities.

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3.0 CHARACTERIZATION OF MEC AND MC

This section documents the approaches used to investigate MEC and MC at the 40mm Firing Range MRS in accordance with the DQOs presented in Section 2.0, "Project Objectives." The MEC and MC characterization activities were conducted in accordance with Section 3.0, "Field Investigation Plan," of the Work Plan Addendum (Shaw, 2011).

3.1 MEC Characterization

Based on the various MD findings at the MRS during the 2007 SI field activities, it was determined in the Work Plan Addendum (Shaw, 2011) development stage that there was the potential for possible MEC on the ground surface and in subsurface soils at the MRS and surrounding area. The initial step in evaluating for buried MEC consisted of performing a digital geophysical mapping (DGM) investigation throughout the MRS as presented in the Work Plan Addendum (Shaw, 2011). Visual surveys of surface conditions were performed at the MRS in conjunction with the geophysical investigation.

The following sections summarize the visual survey, geophysical survey, and subsequent intrusive investigation that were performed at the 40mm Firing Range Investigation Area. The results of the visual survey, DGM survey, and intrusive investigation activities are discussed in Section 4.0, "Remedial Investigation Results."

3.1.1 Geophysical Survey Activities

Between November and December of 2011, a DGM investigation was conducted at the 40mm Firing Range Investigation Area to evaluate for potential buried MEC. The *Digital Geophysical Mapping Report for the 40mm Firing Range MRS (RVAAP-032-R-01*), hereafter referred to as the DGM Report, is presented in **Appendix A**. The DGM Report provides a comprehensive review of the DGM survey at 40mm Firing Range Investigation Area with regard to data acquisition, processing and analysis, anomaly reacquire, and results of the DGM quality control (QC) program.

The approved sampling coverage presented in the Work Plan Addendum (Shaw, 2011) utilized the "*Transect Sampling for UXO Target Traversal*" module of the *Visual Sample Plan*® (VSP®) to identify the proposed transect spacing. The "Transect Sampling for UXO Target Traversal" module of VSP® suggested a transect spacing based on the anticipated target size for a typical 40mm firing range that ranges from 2 to 10 meters (U.S. Army, 2003). In order to ensure the footprint of the target area was traversed with 100 percent certainty, CB&I proposed a 10-meter transect spacing assuming that not every round hit the intended targets when the range was in operation. A total of 0.86 acres (2.16 miles) of

DGM transects were collected at the 8.55-acre Investigation Area, which exceeded the 0.7 acres (1.88 miles) of transects proposed in the Work Plan Addendum (Shaw, 2011).

The DGM survey was performed using an EM61-MK2 time domain electromagnetic instrument and a Leica 1200 Robotic Total Station (RTS) for positioning. The DGM platform consisted of a standard wheeled configuration with the lower coil 16 inches above the ground surface. The team that performed the DGM survey consisted of a geophysicist and a UXO-qualified assistant.

The DGM system used for the 40mm Firing Range MRS Investigation Area and other MRSs at the facility was initially validated during the startup phase of the project at an instrument verification strip (IVS) located near Load Line 7. The results of the initial IVS effort are documented in the *Instrument Verification Strip Technical Memorandum in support of Digital Geophysical Mapping Activities for Military Munitions Response Program Remedial Investigation Environmental Services* technical memorandum presented in the DGM Report (**Appendix A**). A localized IVS was used to ensure the functionality of the DGM system on a daily basis during DGM activities at the 40mm Firing Range Investigation Area.

A discussion of the preparation activities for the DGM investigation, the data collection process, and a summary of the DGM results are presented in the following sections.

3.1.1.1 Civil Survey

A Registered Ohio Land Surveyor established five survey monuments at the 40mm Firing Range Investigation Area. Each monument was established with third order horizontal accuracy (residual error less than or equal to 1 part in 10,000). In areas where data could be acquired using the RTS, the survey monuments were used to provide positional data streamed directly to the EM61-MK2. Portions of some transects were acquired with the fiducial position method due to the extremely dense vegetation that exists at the MRS. In areas where the tree cover prohibited the use of RTS, the control monuments were used as a source to generate additional control points for the fiducial mode surveys. Additionally, all of the survey data documenting MRS features and obstructions is referenced to the established survey monuments.

For QC purposes, the RTS positioning system was used to reacquire a minimum of one known, fixed location each time the system was setup on one of the five survey monuments. Per the project metrics defined in the Work Plan Addendum (Shaw, 2011), static measurements for the positioning system were required not to exceed 0.5 feet. One hundred percent of location checks satisfied the metric. All mapping was developed in the North American Datum 1983 Universal Transverse Mercator Zone 17 North Coordinate System.

3.1.1.2 Vegetation Clearance

Much of the MRS consists of dense vegetation that includes high grasses and thick brush. Vegetation removal was required along transects at the MRS in order to provide adequate ground clearance for the DGM equipment. Vegetation removal was conducted in the October and November months to ensure that grassland nesting species were not impacted and was minimized to the extent possible to allow for the execution of work.

3.1.1.3 Data Collection and Site Coverage

The total area of transects completed within the 8.55-acre Investigation Area was 0.86 acres, or approximately 10 percent, which exceeded the approved coverage of 0.7 acres presented in the Work Plan Addendum (Shaw, 2011). The DGM data were acquired within the Investigation Area boundaries on nine transects spaced approximately 10 meters apart. The 0.86 acres of actual DGM coverage equates to a total transect distance of 2.16 miles with each transect being 1 meter wide. The general DGM procedures performed for data acquisition at the 40mm Firing Range Investigation Area consisted of the following:

- The DGM survey area was reviewed by performing a walkover of the Investigation Area. Special attention was made to difficult terrain and the presence of obstacles, which created potential safety issues.
- The positioning system was set up at a documented control point of known location or a location was determined by using a minimum of two known control points (i.e., RTS). The location control was checked by at least one "checkshot" to a different control point of known location.
- DGM system instrument functional checks were performed at the start and end of each day and the results were documented.
- DGM data were collected over the area in a systematic fashion with respect to the terrain, vegetation, and obstacles present. The acquisition protocol used navigation techniques proven at the IVS.
- Field logs were used to document the Investigation Area conditions during data collection. The field logs included information and observations regarding the data collection process, weather, field conditions, data acquisition parameters, and quality checks performed. The positioning system was used to document the presence of significant site features related to terrain, vegetation, and cultural features so these features could be accounted for during the interpretation of the data.

At the end of each day, the field geophysicist uploaded the DGM data to the designated field computer, where the data was archived, backed-up, and initially processed and analyzed.

Data were also transferred to the CB&I Processing Center in Concord, California on a daily basis for processing and review by the data processor. Raw and final processed data were transferred to the USACE at intervals specified in data item description (DID) MR-09-004, *Geophysics* (USACE, 2009a).

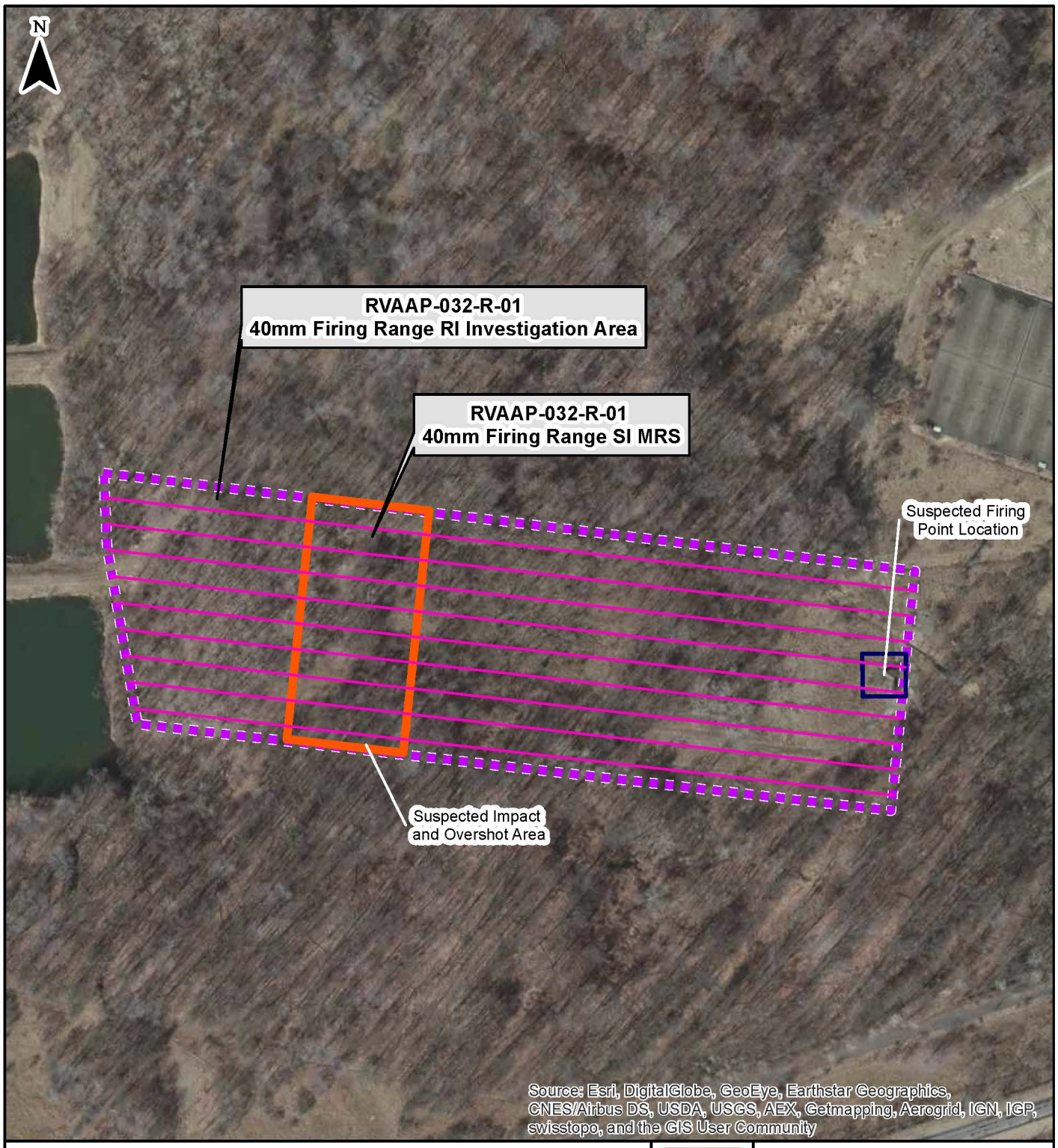
Figure 3-1 provides the area of DGM coverage proposed in the Work Plan Addendum (Shaw, 2011). The actual area covered during the DGM survey is discussed and presented in Section 4.1.2, "Geophysical Survey Results."

3.1.1.4 Data Processing and Interpretation

The geophysical data were processed, analyzed, and interpreted using the methods and approach outlined in the Work Plan Addendum (Shaw, 2011). An 8-millivolt (mV) threshold for Channel 2 of the EM61-MK2 was used to initially select 133 anomalies for potential investigation. From previous experience at the RVAAP, locations that have signal strength (Channel 2) greater than 8 mV are more likely to be munitions-related items than locations with signal strengths less than 8 mV. Additionally, the 8 mV criteria for anomaly selection should be based on the smallest munitions-related item at each MRS that needs to be detected at the greatest depth. With regards to the 40mm Firing Range Investigation Area, the smallest item should be a 40mm grenade to a maximum depth of several inches bgs. Important factors that were considered during the interpretation process include the following:

- Data acquisition methodology (one-dimensional transects as is the case for the 40mm Firing Range Investigation Area)
- Types of MEC most likely present at the Investigation Area based on historical data
- Anomaly shape and signal intensity in relation to the spatial sample density (along track and across track)
- Anomaly time constants
- Local background conditions
- Presence of surrounding anomalies (anomaly density)
- Presence of cultural features and sources of interference
- Anomaly characteristics from the IVS items

After evaluation of the 133 selected anomalies, it was determined that 25 of the anomalies were the result of metal nails intentionally placed for QC checks and 6 anomalies (targets



40mm Firing Range SI MRS Boundary
40mm Firing Range RI Investigation Area
Suspected Firing Point Location
Proposed DGM Transect

0 200 400 Feet

Projection : NAD_1983_UTM_Zone_17N

U.S. ARMY
CORPS OF ENGINEERS
BALTIMORE DISTRICT

MILITARY MUNITIONS RESPONSE PROGRAM

40mm FIRING RANGE MRS
FORMER RVAAP/CAMP RAVENNA
PORTAGE AND TRUMBULL COUNTIES, OHIO

CB&I Federal Services LLC
150 Royall Street
Canton, MA 02021

H:\MAMMS\Ravenna\GIS_Documents\Project_Maps\MMRP\RIFS\RIFS_40mmFiringRng\2015_Feb_Rev2\RVAAP_40mm_008_Fig3_1_PropDGMTransects_r2.mxd: Analyst: gwt: Date: 2/12/2015 1:54:18 PM

FIGURE 3-1 PROPOSED DGM TRANSECTS

105, 117, 127, 131, 132, and 133) were the result of cultural features identified by the field crew that consisted of corrugated metal culverts, a metal sign, a metal bar protruding from the ground, and remains of the firing point building. Therefore, the total number of anomalies selected for potential investigation was reduced from 133 to 102 items. The results of the DGM survey and the locations of anomalies for proposed intrusive investigation activities were submitted to the USACE and the Ohio Environmental Protection Agency (Ohio EPA) for review and approval in the *Final DGM Survey Results and Proposed Dig Locations for the 40mm Firing Range MRS (RVAAP-032-R-01)* technical memorandum that is presented in the DGM Report (**Appendix A**). The anomalies selected following the data interpretation process are discussed further in Section 4.1.2.

3.1.1.5 Geophysical Quality Control Program

The geophysical field QC procedures consisted of tests performed at the start and end of each day to ensure the geophysical sensor and positioning equipment were functioning properly and the data were of sufficient quantity and quality to meet the RI objectives in the Work Plan Addendum (Shaw, 2011). The performance metrics for the DGM system were derived from a combination of DID MMRP-09-004, *Geophysics* (USACE, 2009a) and the USACE Table "Performance Requirements for RI/FS using DGM Methods" (U.S. Army, 2009). Quality objectives and metrics associated with site coverage, signal quality during data acquisition, anomaly reacquire, and the intrusive investigation were also developed from the referenced documents.

The DGM field team and the data processor/analyst reviewed and documented the results of the DGM QC program on a Microsoft© Excel spreadsheet that was updated on a daily basis and delivered to the client for approval. Additional details of the DGM QC program are included in the DGM Report in **Appendix A**.

3.1.1.6 Geostatistical Analysis

Anomalies identified during the DGM survey were entered into the "*Geostatistical Mapping of Anomaly Density*" module of VSP®. This module allows the user to evaluate the DGM results to estimate the anomaly density above background levels in areas that were not traversed. The transect data and anomaly data is imported into VSP® and two tasks are completed in order to provide an anomaly density estimate. The first task is to model the spatial variability of the anomaly densities provided by the data imported into VSP®. The spatial variability identified in the first task is then used to create an unbiased, minimum-variance anomaly density estimate of the unsampled portions of the Investigation Area through a process called "kriging." The model can run in basic or advanced mode. In basic mode, the default values are set based on the data provided. In advanced mode, the user may

adjust parameter values, such as window diameter, data control parameters, and variogram control parameters. For this project, the basic mode was used.

3.1.2 Intrusive Investigation Activities

Following the completion of the DGM survey in December 2011, anomaly selection, reacquisition, and an intrusive investigation was conducted to assess the potential for buried MEC at the 40mm Firing Range Investigation Area. As discussed in Section 3.1.1.4, "Data Processing and Interpretation," the selection process used to determine the 8 mV threshold criteria was in accordance with Work Plan Addendum (Shaw, 2011). The following sections present the anomaly reacquisition and intrusive investigation process performed for the evaluation of potential MEC at the Investigation Area.

3.1.2.1 Target Dig List Development

Since only a portion of the accessible area within the Investigation Area was effectively covered by the DGM survey (approximately 10 percent), all 102 subsurface anomalies were selected for intrusive investigation. The selection of the anomalies for the target dig list is consistent with the guidance provided in Engineer Manual 1110-1-4009, *Military Munitions Response* (USACE, 2007).

3.1.2.2 Anomaly Reacquisition and Investigation Procedures

For the anomaly reacquire task, the site geophysicist used the dig sheet coordinates to guide the relocation of each of the 102 anomaly locations using the RTS. The area around each anomaly was scanned with an EM61-MK2 and the optimum dig location marked with a nonmetallic pin flag. The "x-y" coordinate offset for each individual anomaly was digitally recorded by the anomaly reacquire crew using a handheld personal digital assistance device and the information was uploaded to the project database at the end of each day. Reacquisition of any sampling or dig sheet locations (i.e., interpreted location) was performed to ±0.5 feet of the coordinates specified on the dig sheet.

All anomaly investigation activities were performed by UXO-qualified personnel using a Schonstedt magnetometer to reacquire the 102 anomaly locations. These personnel used hand tools to unearth an item and as the excavation progressed toward the anomaly source, the UXO-qualified personnel continued to use the Schonstedt magnetometer to determine the item location both horizontally and vertically.

Once found, the item was determined if it was MPPEH (i.e., MEC or MD) or other metallic material. If the item was determined not to be MPPEH, then it was temporarily removed from the excavation hole and a Schonstedt magnetometer was used to confirm no additional ferrous items were located beneath the first item. Once confirmed that the source had been identified and no MPPEH was present, the item was replaced and the soil was returned back

into the investigation hole in reverse order from which it was excavated. No MEC or MD was to be returned back to the excavations. The UXO-qualified personnel were also conscious of encountering any cultural artifacts associated with historical cultural or archeological resources.

3.1.2.3 Anomaly Investigation Documentation

All anomalies identified during the reacquisition and intrusive investigation activities were logged and recorded in accordance with DID MMRP-09-004, *Geophysics* (USACE, 2009a). The ShawGeo and/or ShawMEC software was used to record any discrepancies between the dig sheet location and the actual required location and to note any anomalies that could not be investigated. The anomaly reacquisition and investigation results are further discussed in Section 4.1.5, "Intrusive Investigation Results."

3.1.2.4 Anomaly Field Quality Control Procedures

Ground-truth excavation data reported on anomaly-specific dig sheets was the primary basis for field QC. The dig sheets documented the item description; location; and approximate weight, shape, orientation, and depth. Dig sheets were reviewed by the field geophysicist on a daily basis to determine whether the excavation data were representative of the millivolt reading for the selected anomaly. Anomalies that were not representative of the excavation results were revisited by the field geophysicist and the UXO QC Supervisor (UXOQCS).

3.2 MC Characterization

This section summarizes the MC characterization activities and decision making process at the 40mm Firing Range Investigation Area. Sampling for MC was predetermined during the DQO decision-making process to further characterize the nature and extent of contamination associated with previous activities at the MRS. In accordance with the Work Plan Addendum (Shaw, 2011), three soil samples were proposed to be collected using the incremental sampling methodology (ISM) at the Investigation Area. Two ISM samples were proposed to be collected within the impact area and 100 feet beyond that constitutes the current MRS boundaries and one ISM soil sample was proposed at the former firing point at the eastern portion of the former firing range that is outside the MRS. All MC samples were collected in accordance with the *Final Sampling and Analysis Plan and Quality Assurance Project Plan Addendum* included in Appendix A of the Work Plan Addendum (Shaw, 2011) and hereafter referred to as the SAP Addendum. The results of the MC sampling activities are presented in Section 4.3, "Nature and Extent of SRCs."

The DQOs stated that additional sampling for MC may be expanded if warranted by the identification of concentrated areas of MEC/MD outside of the proposed sampling units that constitute the actual MRS boundaries. Although MD was identified outside of the proposed

sampling units, the items were not concentrated and the majority of the MD was found in the former impact and overshot area as expected. Therefore, additional sampling for MC was not warranted.

3.2.1 Surface Soil Sample Collection

The ISM surface soil samples were collected during the RI field activities in February 2012 to further characterize the nature and extent of contamination associated with previous activities at the MRS. Each of the sampling units at the impact area and 100 feet beyond was 0.63 acres in size and covered the entire MRS (1.27 acres). The sampling unit at the former firing point was 0.05 acres in area. The combined ISM surface soil sampling units were considered as the decision unit for the 8.55-acre Investigation Area. The surface soil decision unit for the Investigation Area was based on locations where MPPEH that was inspected and determined to be MD was historically found, where site-related chemicals (SRCs) associated with historical activities are expected, are locations that have the same receptor exposure scenarios, and is the area in which a decision regarding MC in surface soil at the Investigation Area will be made.

The sample depth at all three sampling units was determined to be to 0.5 feet (6 inches) bgs, since any MEC present was expected to be found on or just below the ground surface and 6 inches is the maximum depth that MC associated with the 40mm grenade would be expected to vertically migrate in the soil column. For surface soil sampling at former operational ranges, the *Military Munitions Response Program, Munitions Response Remedial Investigation/Feasibility Study Guidance* (U.S. Army, 2009) indicates that research data have shown that most secondary MC (i.e., explosives) are found in the top 2 inches of soil and that sampling for MC should be performed no deeper than 6 to 12 inches bgs; therefore, the designated 6-inch sample depth is acceptable in accordance with U.S. Army guidance.

Detailed presentation of the procedures used to collect ISM samples are presented in the SAP Addendum (Shaw, 2011) and are based upon the procedures presented in the *Interim Guidance 09-02, Implementation of Incremental Sampling of Soil for the Military Munitions Response Program* (USACE, 2009b). The methods used for the collection of the ISM surface soil samples during the RI are summarized below.

Each ISM surface soil sample consisted of 30 increments collected from locations selected in a systematic random pattern throughout the designated grid area (i.e., sampling unit) in accordance with the USACE guidance (2009b). The key steps for collection of a systematic increment were: (1) subdivide the sampling unit into a uniform grid (i.e., pace out the area and divide into at least 30 grids for a 30-increment sample), (2) randomly select a single increment location in the first grid, and (3) collect increments from the same relative location within each of the other grids.

The sampling units were established by placing nonmetallic pin flags at the corners of each of the sampling units. The ISM samples were collected from the predetermined number of increment sample locations using a $^{7}/_{8}$-inch stainless steel step probe sample collection device. The increments of soil were placed into a plastic lined bucket and combined to make a single sample weighing between 1 to 2 kilograms.

QC samples included two field duplicate samples and one matrix spike (MS)/matrix spike duplicate (MSD) sample. The collection of the QC samples required similar portions of soil as the original sample. Therefore, at the ISM sampling unit where a QC sample was required, an additional ISM sample was collected from within the same sampling unit consisting of at least 30 increments of soil. The increments for the field duplicates were collected at randomly selected locations different from the initial sample increments. The field duplicates were labeled with different sample numbers (40FSS-003m-0001-SO and 40FSS-005m-0001-SO) and were submitted to the laboratory for processing as blind field duplicates. Due to sufficient soil volumes, additional collection of soil was not required for the MS/MSD. A sample was designated as the MS/MSD (40FSS-0001m-001-SO) on the chain-of-custody form prior to shipment.

The sampling field logs, where all data and observations at the sample locations were recorded, and the chain-of-custody forms for the samples submitted to the contracted laboratory are included in **Appendix B**. **Figure 3-2** presents the ISM surface soil sample locations at the MRS. **Table 3-1** summarizes the media samples for the RI and the rationale for the sample strategy.

Table 3-1
Summary and Rationale for Remedial Investigation Sample Collection

Medium	Sample Type	Sample Depth (feet bgs)	Sampling Unit Sizes (Acres)	No. of Samples[1]	Sampling Rationale
Surface Soil	ISM	0–0.5	0.63	2	To characterize MC in surface soil within the former impact area and 100 feet beyond (the MRS).
			0.05	1	To characterize MC in surface soil with the former firing point (outside the MRS)

[1] Number of samples does not include duplicate or other QC samples.
bgs denotes below ground surface.
ISM denotes incremental sample methodology.
MC denotes munitions constituents.
MRS denotes Munitions Response Site.
QC denotes quality control.

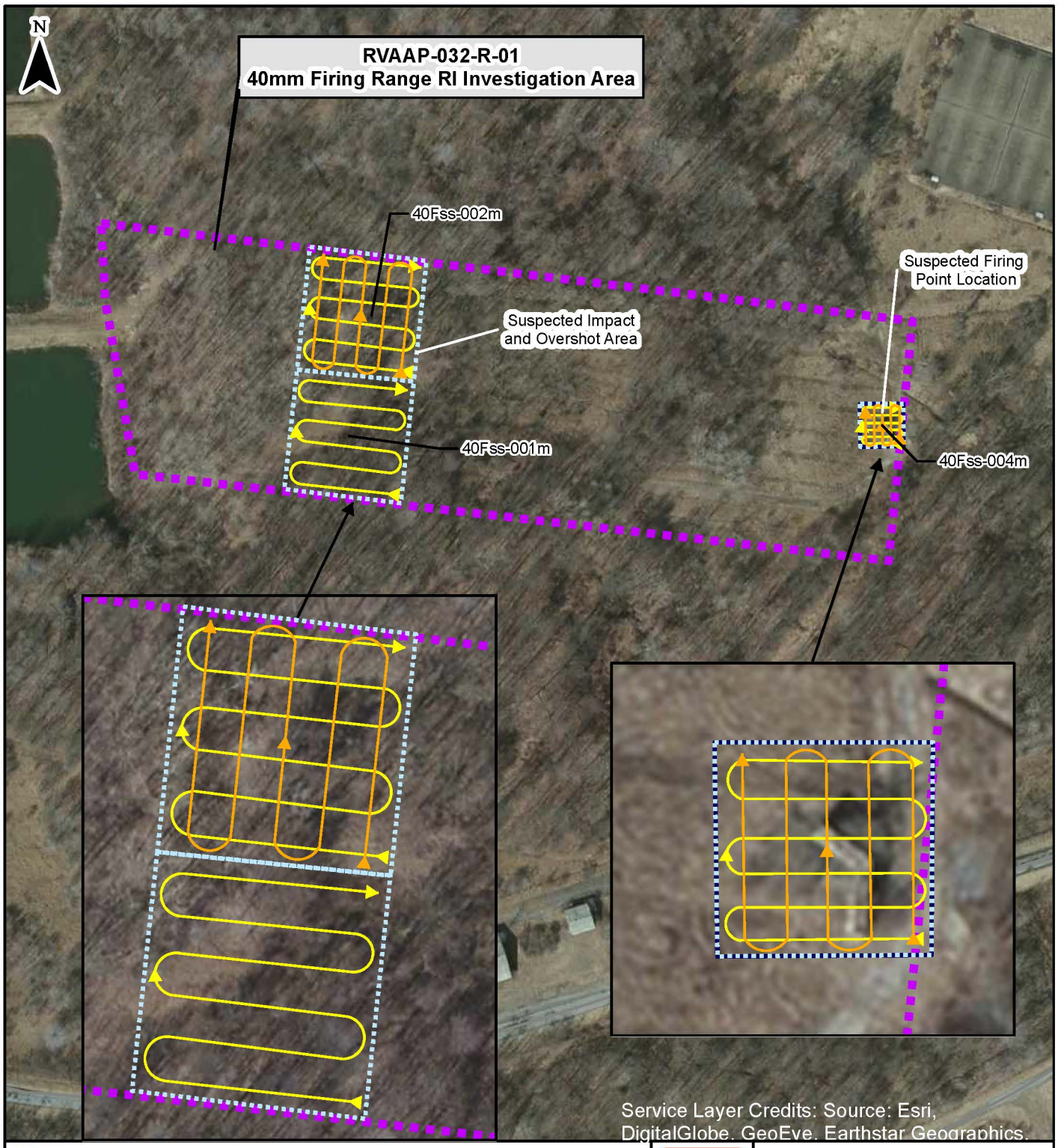


FIGURE 3-2 SURFACE SOIL SAMPLE LOCATIONS

3.2.2 Deviations from the Work Plan

The ISM soil sample identifications were originally designated in the Work Plan Addendum (Shaw, 2011) as 40FSS-001M-0001-SO for the northern portion of the MRS and 40FSS-002M-0001-SO for the southern portion of the MRS. The sample locations were inadvertently switched in the field and represent a slight deviation from the Work Plan Addendum (Shaw, 2011). Additionally, the ISM soil sample at the firing point was originally designated in the Work Plan Addendum as 40FSS-003M-0001-SO; however, this sample designation was used as the sample identification for duplicate sample 40FSS-002M-0001-SO that was collected at the MRS impact area. As a result, the sample identification for the firing point was changed to 40FSS-004M-0001-SO. These deviations from the Work Plan Addendum did not impact the quality of the data.

3.2.3 Sample Analysis

Analytical services for chemical samples were provided by CT Laboratories, Inc. (CT Laboratories) of Baraboo, Wisconsin, a DOD Environmental Laboratory Accreditation Program (ELAP) and National Environmental Laboratory Accreditation Conference accredited laboratory. The selection of chemical analysis for the 40mm Firing Range Investigation Area was based on the types of munitions historically identified for the MRS and the potential MC association with those munitions (i.e., the M407A1 series 40mm practice grenade and the M406 series HE 40mm grenade). The proposed analytical suites and methods were presented in the *MC Sampling Rationale* included in the SAP Addendum (Shaw, 2011). However, during the RI intrusive activities, MD associated with other 40mm grenade types (primarily the M382 series practice rounds) was identified and the selection of chemical analysis was re-evaluated by reviewing the Munitions Data Sheets (**Appendix C**) to ensure that analyses for potential MC were covered. After the re-evaluation, the analytical suites originally identified for the 40mm Firing Range Investigation Area were considered applicable for all of the 40mm grenade types reported and known to have been fired at the former test range and are as follows:

- Metals (aluminum and lead), Method EPA SW846 6010C
- Explosives, Method EPA SW846 8330B
- Nitrocellulose, Method EPA SW846 9056 Modified
- Total organic carbon (TOC), Lloyd Kahn Method
- pH, Method EPA SW846 9045D

The surface soil samples collected at the sampling units at the impact area and 100 feet beyond is the actual MRS portion of the Investigation Area. These samples were analyzed for the full suite of parameters since this was the area of impact where the 40mm rounds

fragmented. In addition to the above analyses, these samples were also analyzed for geochemical parameters via EPA Method SW846-6010C in order to potentially evaluate naturally high metal concentrations and distinguish them from potential contamination. The geochemical parameters analyzed included calcium, iron, magnesium, and manganese.

The surface soil sample collected at the sampling unit at the former firing point portion of the Investigation Area is located outside the actual MRS area. This sample was analyzed for propellants (nitrocellulose, nitroglycerin, and nitroguanidine) only since propellants are MC that would most likely be found at this portion of a firing range.

Each 1- to 2-kilogram sample was submitted to the contracted laboratory for processing and analysis. Processing consisted of drying out the sample and sieving the sample through a #10 sieve. Any material larger than the #10 sieve was discarded. The remaining air-dried, sieved material was then ground using a puck mill to reduce the particle size as sampling splitting and particle size reduction is necessary to reduce fundamental error. The final reduced portions of the ISM field samples 40FSS-001m-0001-SO and 40FSS-002m-0001-SO and field duplicate sample 40FSS-003m-0001-SO were analyzed for aluminum, lead, explosives, and nitrocellulose. These samples were also analyzed for TOC and pH following processing of the sample and prior to grinding. The final reduced portions of the ISM field sample 40FSS-004m-0001-SO and its field duplicate sample, 40FSS-005m-0001-SO, were analyzed for nitroglycerin, nitroguanidine, and nitrocellulose. A summary of the number and types of samples collected are presented in **Table 3-2**.

Table 3-2
Summary of Field Samples Collected and Required Analytical Parameters

Sample Name	Sample Type	Depth (feet bgs)	Analytical Parameters	No. of Samples	Field Duplicate
Surface Soil					
40FSS-001m-0001-SO	ISM	0–0.5	Lead, Aluminum, Explosives, Nitrocellulose, Geochemical Metals[2], TOC, pH	1	
40FSS-002m-0001-SO				1	1
40FSS-004m-0001-SO			Nitroglycerin, Nitroguanidine, Nitrocellulose	1	1

[1] Geochemical metals include analysis for aluminum, calcium, iron, magnesium, and manganese.
bgs denotes below ground surface.
ISM denotes incremental sample methodology.
TOC denotes total organic carbon.

The collected samples were properly packaged for shipment and dispatched to the contracted analytical laboratory, CT Laboratories in accordance with the SAP Addendum (Shaw, 2011). A separate signed custody record with sample numbers and locations listed was enclosed with each shipment. When transferring the possession of samples, the individuals relinquishing and receiving signed, dated, and noted the time on the record. All shipments were in compliance with applicable U.S. Department of Transportation regulations for environmental samples.

3.2.4 Laboratory Analysis

The surface soil samples were collected and analyzed according to the FWSAP (SAIC, 2011b) and the SAP Addendum (Shaw, 2011). The FWSAP and associated addenda were prepared in accordance with USACE and EPA guidance, and outline the organization, objectives, intended data uses, and quality assurance (QA)/QC activities to achieve the desired DQOs and to maintain the defensibility of the data. Project DQOs were established in accordance with EPA DQO guidance (2000). Requirements for sample collection, handling, analysis criteria, target analytes, laboratory criteria, and data validation criteria for the RI are consistent with EPA requirements for National Priorities List sites. The DQOs for this project included analytical precision, accuracy, representativeness, completeness, comparability, and sensitivity for the measurement data.

Strict adherence to the requirements set forth in the FWSAP (SAIC, 2011b) and the SAP Addendum (Shaw, 2011) was required of the analytical laboratory so that conditions adverse to quality would not arise. The laboratory was required to perform all analyses in compliance with the *Quality Systems Manual for Environmental Laboratories, Version 4.2* (QSM) (DOD, 2010), EPA SW-846, *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, Analytical Protocols* (EPA, 2007), or as specified in the FWSAP. The SW-846 chemical analytical procedures were followed for the analyses of metals, explosives, nitrocellulose, and pH. TOC was performed using Lloyd Kahn Method. The contracted laboratory was required to comply with all methods as written recommendations were considered requirements.

The QA/QC samples for this project included field blanks, laboratory method blanks (MBs), laboratory control samples (LCSs), laboratory duplicates, and MS/MSDs. An equipment rinsate blank, consisting of de-ionized water used in the decontamination process, along with field duplicate samples were submitted for analysis to provide a means to assess the quality of the data resulting from the field sampling program. **Table 3-3** presents a summary of the types of QA/QC samples utilized during the RI field activities for the 40mm Firing Range Investigation Area.

Table 3-3
Summary of Quality Assurance/Quality Control Samples

Sample Type	Rationale
Field Duplicate	Analyzed to determine sample heterogeneity and sampling methodology reproducibility
Equipment Rinsate	Analyzed to assess the adequacy of the equipment decontamination processes for soil and groundwater
Laboratory Method Blanks	Analyzed to determine the accuracy and precision of the analytical method as implemented by the laboratory
Laboratory Duplicate Samples	Analyzed to assist in determining the analytical reproducibility and precision of the analysis for the samples of interest and provide information about the effect of the sample matrix on the measurement methodology
Matrix Spike/Matrix Spike Duplicate	

CB&I is the custodian of the project file and will maintain the contents of the files for this investigation, including all relevant records, reports, logs, field notebooks, pictures, subcontractor reports, correspondence, and chain-of-custody forms. These files will remain in a secure area under the custody of CB&I until they are transferred to USACE, Baltimore District and the ARNG. CT Laboratories retain all original raw data in a secure area under the custody of the laboratory project manager.

CT Laboratories performed in-house analytical data reduction under the direction of the laboratory project manager and QA officer. These individuals were responsible for assessing data quality and informing CB&I of any data that are considered "unacceptable" or required caution on the part of the data user in terms of its reliability. Data were reduced, reviewed, and reported as described in the laboratory QA manual and the laboratory standard operation procedures in the SAP Addendum (Shaw, 2011). Data reduction, review, and reporting by the laboratory were conducted as follows:

- Raw data produced by the analyst were turned over to the respective area supervisor.
- The area supervisor reviewed the data for attainment of QC criteria, as outlined in the established methods and for overall reasonableness.
- Upon acceptance of the raw data by the area supervisor, a report was generated and sent to the laboratory project manager.
- The laboratory project manager completed a thorough review of all reports.
- Final reports were generated by the laboratory project manager.

Data were then delivered to CB&I for data validation. CT Laboratories prepared and retained full analytical and QC documentation for the project in electronic storage media (i.e., compact disc), as directed by the analytical methods employed. CT Laboratories provided the following information to CB&I in each analytical data package submitted:

- Cover sheets listing the samples included in the report and narrative comments describing problems encountered in analysis.
- Tabulated results of inorganic and organic compounds identified and quantified.
- Analytical results for QC sample spikes, sample duplicates, and initial and continuing calibration verifications of standards and blanks, MBs, and LCS information.

3.2.5 Data Validation

A systematic process for data validation on all surface soil samples collected at the 40mm Firing Range Investigation Area (including field duplicates and QC samples) was performed by CB&I to ensure that the precision and accuracy of the analytical data were adequate for their intended use. The review constituted comprehensive validation of 100 percent of the primary dataset and a comparison of primary samples and two field duplicate samples.

The data validation process attempted to minimize the potential of using false-positive or false-negative results in the decision-making process (i.e., to ensure accurate identification of detected versus nondetected compounds). This approach was consistent with the DQOs for the project and with the analytical methods, and was appropriate for determining contaminants of concern and calculating risk. Samples were identified through implementation of "definitive" analytical methods. These definitive data were then verified through the review process outlined in the SAP Addendum (Shaw, 2011).

Analytical results were reported by the laboratory in electronic format and were issued to CB&I on compact disc. Data validation was performed to ensure all requested data were received and complete. Data were validated in accordance with specifications outlined in the SAP Addendum (Shaw, 2011), FWSAP (SAIC, 2011b), and the QSM (DOD, 2010). Data use qualifiers were assigned to each result based on laboratory QA review and verification criteria. Results were qualified as follows:

- "U"—Analyte was not detected or reported less than the level of detection.
- "UJ"—Not detected. The detection limits and quantitation limits are approximate.
- "J"—The reported result is an estimated value.

In addition to assigning qualifiers, the validation process also selected the appropriate result to use when re-analyses or dilutions were performed. Where laboratory surrogate recovery data or laboratory QC samples were outside of analytical method specifications, the validation chemist determined whether laboratory re-analysis should be used in place of an original reported result. If the laboratory results reported for both diluted and undiluted samples, diluted sample results were used for those analytes that exceeded the calibration range of the undiluted sample. A complete presentation of the validation process and results for the RI data is contained in the *Data Validation Report* in **Appendix D**.

3.2.6 Data Review and Quality Assessment

This section provides discussion of data review and the results of the data validation process and evaluates usability of data collected for this sampling event in accordance with the project QA program. QA is defined as the overall system for assuring the reliability of data produced. The system integrates the quality planning, assessment, and improvement efforts of various groups in the organization to provide the independent QA program necessary to establish and maintain an effective system for collection and analysis of environmental samples and related activities. The program also encompasses the generation of useable and complete data, as well as its review and documentation.

The QA program was designed to achieve the DQOs for the RI. The program was developed in accordance with the specifications contained and the data were produced, reviewed, and reported by the laboratory in accordance with specifications outlined in the SAP Addendum (Shaw, 2011), FWSAP (SAIC, 2011b), the QSM (DOD, 2010), and the laboratory's QA manual. Laboratory reports included documentation verifying analytical holding time compliance. The DQOs were developed concurrently with the Work Plan Addendum (Shaw, 2011) to ensure the following:

- The reliability of field sampling, chemical analyses, and physical analyses
- The sufficiency of collected data
- The applicability of data for intended use
- The inference of valid of assumptions from the data

Attainment of the DQOs was assessed throughout the evaluation of all data collected using data quality indicators that are discussed in detail in this section. For this RI Report, a full data validation effort was performed to assess laboratory performance, including a review of the following:

- Completeness

- Chain-of-custody records
- Sample holding times
- QC results reported on summary forms as applicable to the analysis performed (i.e., initial and continuing calibrations; method, calibration, equipment, and trip blanks; LCS/MS/MSD; performance and interference check samples and instrument tunes; surrogates; internal standards; and serial dilutions)
- Detection and reporting limits
- Other contractual items

Criteria for QC results were compared to laboratory established criteria in accordance with the analysis methods and the requirements in the Work Plan Addendum (Shaw, 2011). Further details and discussion are provided in the *Data Validation Report* in **Appendix D**.

Data were qualified during the validation process from predetermined criteria for QC nonconformances. The quality of data collected in support of the RI sampling activities as noted in data tables is considered acceptable with qualifications during the validation process. Results were assessed for accuracy and precision of laboratory analyses to identify the limitations and quality of data. A QA review of the data was performed and the following data quality indicators were measured:

- **General Review.** The EPA guidance, *Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual (Part A) Interim Final* (1989), states that the data qualified during the validation process as estimated "J" or "UJ" may be included in quantitative assessments indicating the associated numerical value is an estimated quantity, i.e., the guidance states to "use J-qualified concentrations the same way as positive data that do not have this qualifier." All project samples were analyzed in one batch sample delivery group 89285. In review of analytical information, the sample results qualified as "J" (i.e., estimated or nondetect estimated values) during the validation process are considered usable data points (EPA, 1989), and are included in the data summary tables of this report. The majority of the "J"-qualified samples were the result of the common condition of reported values being below the certainty range of detection (i.e., either less than the MRL and greater than the MDL, or less than 3 times the MDL, whichever is greater) as well as analytical column confirmation or MSD precision recoveries found outside criteria. The confirmation for nitroguanidine for sample 40FSS-004M-0001-SO (detected at trace levels) was outside criteria between the primary and confirmation analysis; therefore, was qualified estimated "J" based upon this

outlier. There were no data rejections (i.e., R-flagged results) as a result from the data validation reviews.

- **Precision.** Laboratory duplicate pairs and/or laboratory spiked duplicate pairs were analyzed as per method requirements for each parameter and/or compound on a batch and matrix specific basis. Field duplicates were collected on the basis of 10 percent frequency per matrix to identify the cumulative precision of the sampling and analytical process and were sent on a blind basis to the laboratory. Field duplicates are evaluated at less than or equal to 50 percent relative percent difference (RPD) for organic parameters and less than or equal to 25 percent RPD for inorganic parameters. Field duplicate pairs, laboratory duplicate pairs, and/or laboratory MSDs were evaluated for the surface soil samples.

  All laboratory duplicate pairs were within RPD criteria limits; therefore, did not warrant further qualification. The serial dilution for sample 40FSS-001M-0001-SO was outside criteria for iron and lead; however, the post digestion spike for this sample had acceptable recoveries for these elements; therefore, no qualifiers were applied based upon these outliers. Blind field duplicate sample pair 40FSS-002m-0001-SO/40FSS-003m-0001-SO was collected for aluminum, lead, explosives, nitrocellulose, geochemical metals, TOC, and pH. Blind field duplicate sample pair 40FSS-004m-0001-SO/40FSS-005m-0001-SO was collected for nitroglycerin, nitroguanidine, and nitrocellulose. All target analytes were within precision criteria for both duplicate pairs. The MSD sample 40FSS-001M-0001-SO had a RPD failure for target compound 1,3,5-trinitrobenzene and the spiked sample was qualified estimated "UJ" based upon this outlier. Although these results have been qualified as estimated due to the outliers noted, the data are still considered useable (EPA, 1989). Further discussion is provided in the *Data Validation Report* in **Appendix D**.

- **Accuracy.** Accuracy was evaluated for each matrix by reviewing the recovery results of the LCS, MS/MSD, and surrogate, as applicable, for each analytical method performed. The LCS, MS/MSD, and surrogate QC samples were analyzed as per method requirements for each parameter and/or compound on a batch and matrix specific basis.

  The MS and MSD for parent sample 40FSS-001m-0001-SO failed recovery limits for aluminum, manganese, iron, and lead. The sample concentrations were greater than 4 times the spike added for these metals; therefore, no qualifiers were applied based upon these outliers. All other MS/MSD recoveries were within criteria for all parameters. All LCS and surrogate recoveries were within limits for all target compounds, as applicable. All accuracy data quality indicators were within criteria

limits. No further actions were required for the field soil samples. Further discussion is presented in the *Data Validation Report* in **Appendix D**.

- **Representativeness.** Representativeness is a measure of the degree to which the measured results accurately reflect the medium being sampled. It is a qualitative parameter that is addressed through the proper design of the sampling program in terms of sample location, number of samples, and actual material collected as a "sample" of the whole. Representativeness applies to both sampling and analytical evaluations and should be 100 percent. Analytical representativeness is inferred from associated documentation (i.e., data validation reports, field records, etc.) for holding times, QC blanks, accuracy, and precision, as well as from the completeness evaluations. Sampling protocols were developed to assure that samples collected are representative of the media. Field handling protocols (i.e., storage, handling in the field, and shipping) were designed to protect the representativeness of the collected samples.

  For this sampling event, the sample collection was performed using CB&I's standard operating procedures (SOPs) and the sampling requirements presented in the FWSAP (SAIC, 2011b). The analytical testing was performed using the EPA methodology with the ELAP-accredited laboratory. Sampling protocols were properly followed to ensure that samples collected are representative of the media including the field handling protocols (i.e., storage, handling in the field, and shipping) of the collected samples. Sample identification and integrity were maintained (i.e., chain of custody) during this sampling event as determined during data validation. In review of the analytical data, data validation reports, and field records, no significant nonconformances were noted for holding times, QC blanks, accuracy, precision, and completeness evaluations. All analytical data were deemed representative in accordance with the EPA guidance (1989), with no sample or data rejections for the compounds of concern.

  Although the impact berm in the target area was removed, some pea gravel used to construct the berm remains and is mixed in with the soil. In addition, the gravel road that accesses the former firing range cuts across a small portion of the southeast corner of the former firing point. The presence of the gravel road at the former firing point and the pea gravel mixed with soil at the former impact area resulted in poor recovery at some of the incremental sample locations that made up the ISM soil samples at each of the sampling units. The lack of recoveries occurred at a minimal number of sample increment locations (approximately 3 to 5 increments at each sampling unit). The poor recoveries did not affect the total volume of soils required to process the ISM samples and approximately 1 to 2 kilograms of soil were able to be collected from each of the designated sampling

units. Therefore, the sample volumes collected at each of the sampling units are considered to be representative of the current conditions at the former firing point and the impact area and 100 feet beyond, and there were no impacts to the data quality.

A QC field inspection was conducted for field sampling activities at the facility in accordance with the Work Plan Addendum (Shaw, 2011). The inspection was activity-based and covered ISM surface soil sample collection conducted at the Group 8 MRS in February 2012. Although the inspection was not conducted at the 40mm Firing Range Investigation Area, it is considered applicable to the representativeness of the ISM surface soil samples collected at the MRS. The *Quality Surveillance Summary Report* conducted at the Group 8 MRS is presented along with the field documentation in **Appendix B**.

Several nonconformances were observed during the QA field inspection by the CB&I UXOQCS at the Group 8 MRS, which is also representative of the ISM surface soil field sampling activities conducted at the 40mm Firing Range Investigation Area. The noncomformances included not having the sampling SOPs on site during the beginning of field sampling activities and the potential for cross-contaminating equipment with used sampling gloves. These noncomformances were remedied in the field and the corrective action included retrieving the sampling SOPs from the field office and ensuring that new sampling gloves were donned after handling used equipment. The primary nonconformance that had the potential to affect the data was the handling of decontaminated equipment with used gloves. However, this incidence was observed by the UXOQCS prior to actual sampling activities and during the removal of the sampling equipment and materials from the vehicle. There was no contact with used gloves on the end of the step probe used to collect the ISM samples and the handle and stem of the step probe was recleaned prior to sample collection. Results of the rinsate blank (GR8-RB-01) for the sampling equipment step probes support the evidence that equipment was properly decontaminated during field activities.

An additional nonconformance was identified by the UXOQCS but was more of a recommendation. The recommendation was to ensure the separation of the step probes from other equipment in the vehicle during transport to the sampling locations. The step probes were properly protected at the time of the observance as noted in the audit and did not affect the data.

- **Completeness.** Completeness is a measure of the amount of information that must be collected during the field investigation to allow for: (1) successful achievement of the objectives of the program and (2) valid conclusions. Completeness is

defined as the percentage of measurements which are judged to be usable. The percent completeness criterion is 90 percent. In this data validation review, three categories of completeness quotients are calculated, including the overall sampling completeness, overall analytical completeness, and analytical completeness by parameter group.

The sampling percent completeness is determined by taking the number of planned samples (including QC samples) and dividing that number by the number of samples actually collected during the current round of sampling. Five surface soil samples (including two field duplicate samples) and one rinsate blank were collected and sent to the laboratory for analyses. Five surface soil samples (including two field duplicate samples) and one rinsate blank were proposed in the Work Plan Addendum (Shaw, 2011) for this sampling event. Excluding rinsate blanks, the overall sampling completeness was 100 percent (or five surface soil samples collected divided by five planned surface soil samples).

The overall analytical percent completeness is calculated from the number of usable data inputs divided by the number of analyzed data inputs. The evaluation of completeness for the surface soil samples resulted in 92 useable data points of possible 92 data points, resulting in an overall analytical completeness quotient of 100 percent for all parameter groups. The completeness statistics were computed as follows:

- 92 represents the total number of accepted analytes as usable data points (no analytes were rejected).
- 92 represents the number of analyzed inputs which is equal to the total number of analytes for all field samples.

There were no rejected data points for any of the parameters for explosives, metals, and nitrocellulose for this event; therefore, their analytical completeness quotients were each 100 percent. All of the overall and parameter-specific analytical completeness and soil sampling completeness quotients were above the predefined completeness goal of 90 percent. Further discussion is presented in the *Data Validation Report* in **Appendix D**.

- **Comparability.** Comparability is the confidence with which one data set can be compared to another. Comparability was controlled through the use of SOPs that have been developed to standardize the collection of measurements, samples, and approved analytical techniques with defined QC criteria. The laboratory chemical analyses were performed by CT Laboratories, an ELAP-accredited laboratory, in accordance with the approved SAP Addendum (Shaw, 2011) using cited EPA

methodology. Where applicable, the EPA-approved methods and the QSM (DOD, 2010) provided the QC criteria guidelines for the analytical methods and the ELAP accrediting body provided the QA oversight. The laboratory adapted its processes accordingly into an applicable working SOP specific to their laboratory capabilities (i.e., instrumentation, prep method, sample volumes, etc.) in applying the EPA methods. The SOPs were followed throughout the process by the laboratory, as reviewed by the ELAP accrediting body. Furthermore, laboratory data were validated in accordance with established SOPs, and the validation qualifiers were applied when QC nonconformances were identified (as applicable). The consistent use of the laboratory SOPs provides confidence with which one data set can be compared to another previous data set.

Established field SOPs that were preapproved in the SAP Addendum (Shaw, 2011) for the RI program were applied to on-site work during this surface soil sampling round. The field SOPs were followed, as established in the SAP Addendum (Shaw, 2011) to ensure that protocols meet project DQOs. The recorded field documentation provided verification (i.e., field calibration, etc.) that proper field procedures were followed. The consistent application of field SOPs over the course of the RI program from sampling event to sampling event lends confidence in the comparison of field data sets.

- **Sensitivity.** The sensitivities are dependent on the analytical method, the sample volumes, and percent moistures (solid matrix) used in laboratory determinative analysis. For each analyte, the method sensitivities (i.e., MDLs, MRLs, limits of detection [LODs], etc.) and analyte detections presented in the analytical data were compared to the facility human and ecological screening criteria for the each of the samples collected. Upon comparing the soil sample results to the minimum project screening criteria, the method sensitivity requirements were met. All MDLs, LODs, or MRLs were less than the project screening criteria. The facility screening criteria used to compare against the data results are presented in Attachment F of the Work Plan Addendum (Shaw, 2011).

- **QC Blanks.** MBs, calibration blanks, and rinse blanks were evaluated to identify potential non-site-related contamination from sample collection through laboratory analyses. Analytical results found within the “5 times” and “10 times” rules were qualified “U” and considered nondetect at the LOD or level of contamination, whichever was greater. From EPA guidance (1989), the definitions of the “5 times” and “10 times” rules are as follows:

  > “If the blank contains detectable levels of one or more organic or inorganic chemicals, then consider site sample results as positive only if the

concentration of the chemical in the site sample exceeds five times the maximum amount detected in any blank for compounds that are not considered by EPA to be common laboratory contaminants. Consider ten times the maximum amount for common laboratory contaminants acetone, 2-butanone (methyl ethyl ketone), methylene chloride, toluene, and the phthalate esters. Treat samples containing less than five times (ten times for common laboratory contaminants) the amount in any blank as nondetects and consider the blank-related chemical concentration to be the quantitation limit for the chemical in that sample."

The rinsate blank (40F-RB-01) was analyzed for lead, aluminum, explosives, and nitrocellulose, and was nondetect for all target analytes performed (i.e. less than or equal to the LOD). All calibration blanks (metals) were within criteria (i.e. less than or equal to the LOD); therefore, no data qualification was required. For batch sample data group 89285, aluminum, calcium, iron, lead, magnesium, and manganese were detected above the LOD in the associated soil MB. The results for aluminum, calcium, iron, lead, magnesium, and manganese in the associated soil samples were either not detected or (if detected) were all greater than 5 times the MB results; therefore, no data qualification was required based upon these outliers. For all other analytes, all MB criteria (less than the LOD) were met. Further discussion is provided in the *Data Validation Report* in **Appendix D**.

The 40mm Firing Range Investigation Area data were determined to be of sufficient quality to make informed decisions for the surface soil samples collected. Further discussions of data qualifications are provided in the *Data Validation Report* in **Appendix D**.

3.3 Decontamination Procedures

Decontamination of dedicated sampling equipment was performed in accordance with the procedures presented in the SAP Addendum (Shaw, 2011) with the exception that the hydrochloric acid step was eliminated due to previous observations of surface corrosion on the sampling equipment when applied. The sampling equipment consisted of individual $^{7}/_{8}$-inch diameter stainless steel step probes used to collect each of the ISM and the field duplicate surface soil samples. All sampling decontamination procedures were performed at Building 1036, the facility contractors' building. In summary the decontamination procedures consisted of the following:

- Wet the equipment with American Society of Testing and Materials (ASTM) Type I water and phosphate-free detergent solution (Liquinox) to remove residual particulate matter and surface film from the equipment.

- Rinse the equipment with ASTM Type I water.
- Rinse the equipment with methanol.
- Rinse with ASTM Type I water.
- Allow equipment to air dry.

Once dry, the sampling equipment was wrapped in aluminum foil to prevent cross contamination while in storage or transport to an MRS for sampling. In order to minimize waste, the liquids used in the decontamination process were applied using hand-held spray bottles.

Following the equipment decontamination process, an equipment rinsate sample was collected by running distilled water through the sampling equipment for the identical analytical parameters as the environmental samples. The purpose of the equipment rinsate sample was to assess the adequacy of the equipment decontamination process.

The results of the equipment rinsate blank analysis (40F-RB-01) did not identify any interference or anomalies in the laboratory data and supports the adequacy of the equipment decontamination process. Evaluation of the equipment rinsate sample analytical data to assess the adequacy of the equipment decontamination process is further discussed in Section 3.2.6, "Data Review and Quality Assessment." A summary of the results of the equipment rinsate sample is presented in **Appendix E**.

3.4 Investigation Derived Waste

The investigation-derived waste (IDW) generated during the field activities at the 40mm Firing Range Investigation Area consisted of solid waste that included personal protective equipment and equipment decontamination materials. Due to the minimal number of pieces of sampling equipment used and an effort to minimize waste generation, the decontamination liquids were applied using hand-held spray bottles and the spray and excess liquid was collected on absorbent pads. No free liquid wastes were generated.

The disposal of IDW was performed in accordance with the procedures presented in the Work Plan Addendum (Shaw, 2011). The IDW generated was containerized separately along with similar materials generated from other MRSs and were staged at Building 1036 in accordance with the FWSAP (SAIC, 2011b). IDW Management that describes the waste characterization analyses performed, waste characterization screening, and IDW transport and disposal is presented in **Appendix F**.

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4.0 REMEDIAL INVESTIGATION RESULTS

This section presents a discussion of the results of the RI data that were collected for MEC and MC at the 40mm Firing Range Investigation Area in accordance with the procedures discussed in Section 3.0, "Characterization of MEC and MC." These results will be used to determine the nature and extent of MEC and associated MC and subsequently determine the potential hazards and risks posed to likely human and ecological receptors. Once the risks are determined, they will then be integrated into the preliminary MEC CSM developed during the SI (e^2M, 2008) that was presented in Section 2.0 and a CSM for MC will be developed based on the RI data. Photographs of the RI activities at the 40mm Firing Range Investigation Area are presented in **Appendix G**.

4.1 MEC Investigation Results

The following sections present the results of the RI field efforts that were performed to achieve the DQOs defined in Section 2.3.1, "Data Quality Objectives," and define the nature and extent of MEC at the 40mm Firing Range Investigation Area. These efforts included a combination of visual surveys, DGM surveys, and intrusive investigations at the 40mm Firing Range Investigation Area that were conducted in accordance with the Work Plan Addendum (Shaw, 2011).

4.1.1 Visual Survey Results

While no visual survey transects were proposed for the MRS, the potential presence of MEC on and just below the ground surface were investigated during the DGM survey. A total of 2.16 miles of DGM transects were covered during the geophysical investigation. Two MPPEH consisting of aluminum ballistic windscreens from the M382 series 40mm practice grenade, a munitions item not previously reported to have been used at the former firing range, were identified on the ground surface during the DGM survey. The MPPEH was inspected by the UXO-qualified personnel and were determined to be MDAS (i.e., MD). The total weight of the MD was estimated at 0.225 pounds (lbs). Cultural debris or "Other Debris" were also identified on the ground surface at seven of the anomaly locations and consisted largely of scrap steel and pieces of concrete. No MEC was found on the ground surface during the visual survey.

4.1.2 Geophysical Survey Results

The DGM data was acquired on a line spacing of approximately 10 meters, which resulted in a spatial coverage of 0.86 acres over the 8.55-acre 40mm Firing Range Investigation Area (approximately 10 percent). The actual DGM transect coverage exceeded the planned

coverage of 0.7 acres that was based on the Transect Sampling for UXO Target Transversal module of VSP® as presented in the Work Plan Addendum (Shaw, 2011).

As discussed in Section 3.1.1.4, a total of 133 anomalies were identified during the DGM survey that exhibited signal strengths greater than or equal to 8 mV (Channel 2). The anomaly selection process for intrusive investigation identified 31 of the anomalies to be either items placed for QC checks for the DGM survey or non-munitions-related features identified by the field crew during the survey. This reduced the total number of anomalies selected for intrusive investigation from 133 to 102. In general, the geophysical data indicates that the anomaly density at the 40mm Firing Range Investigation Area is relatively low and dispersed.

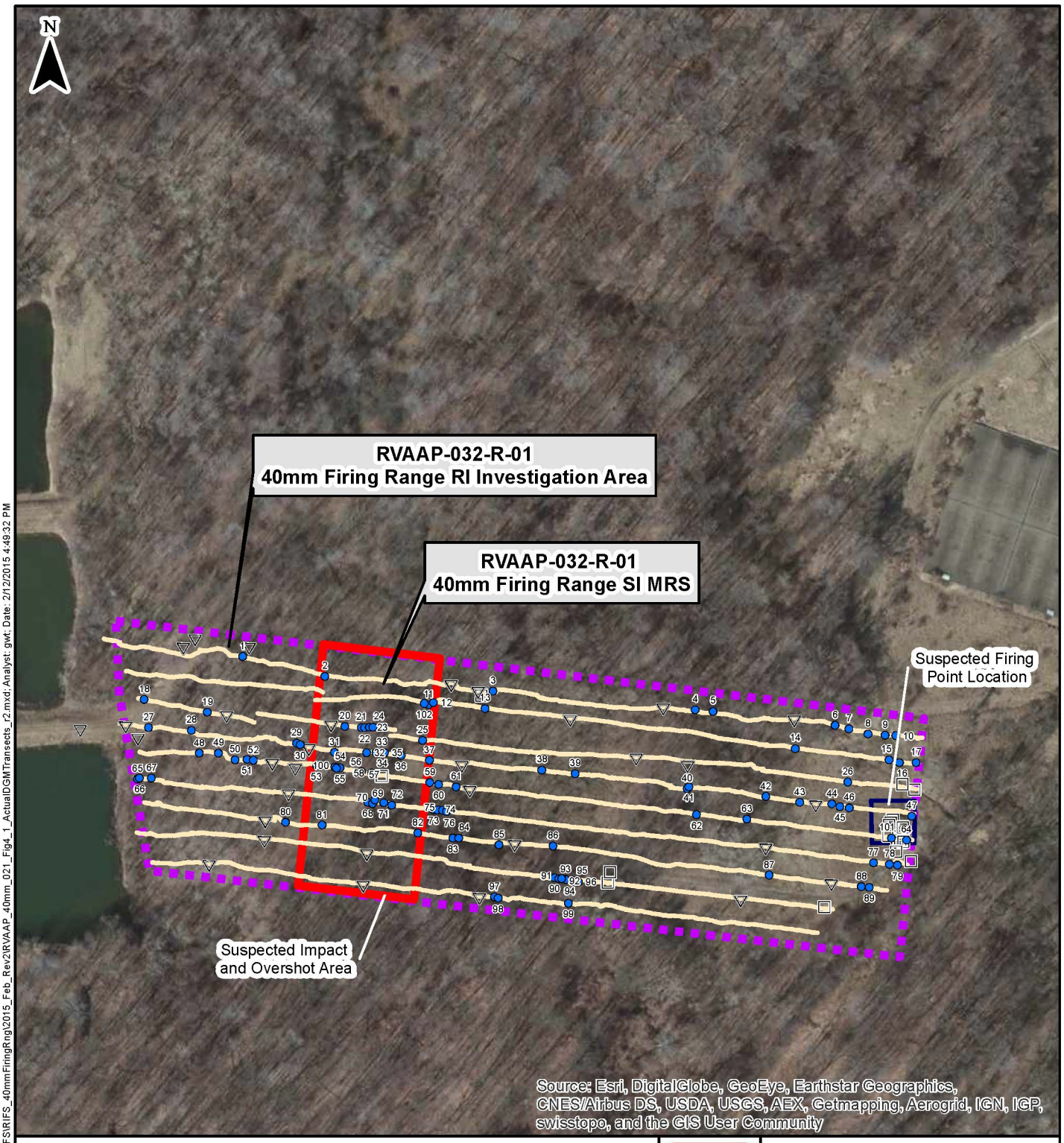
Figure 4-1 illustrates transects where the areas of actual DGM survey coverage were performed during the RI field activities in addition to the anomalies selected for intrusive investigation along those transects. **Figure 4-2** and **Figure 4-3** display the results of the EM61-MK2 survey. **Figure 4-2** provides a sensitive color-scale that highlights all single point anomalies above a signal threshold of 8 mV, while **Figure 4-3** uses a coarse color-scale to delineate the major aggregates of buried metal with increased definition.

4.1.3 Geophysical Quality Control Results

The data were processed and interpreted consistent with the Work Plan Addendum (Shaw, 2011), and the DGM quality objectives and metrics were achieved for all data collected. The geophysical data files generated during the DGM activities consist of field data and QC test files. This data and the results of the DGM quality objectives and metrics are discussed and presented in further detail in the DGM Report in **Appendix A**.

4.1.4 Geostatistical Analysis Results

The DGM survey data for the 40mm Firing Range was entered into the "*Geostatistical Mapping of Anomaly Density*" module of VSP® as discussed in Section 3.1.1.6. The purpose of this module is to create an anomaly density map based on the DGM data collected that identifies areas where anomalies cluster above background levels and to estimate the anomaly density in areas that were not traversed. The geophysical data indicate that the anomaly density is relatively low and dispersed throughout the Investigation Area. In general, the highest density of anomalies was clustered in the area of the actual MRS, along with a somewhat increased density near the firing point location. The anomaly density results are presented in **Figure 4-4**.



H:\MMMS\Ravenna\GIS_Documents\Project_Maps\MMRP\RIFS\RIFS_40mmFiringRng\2015_Feb_Rev2\RVAAP_40mm_021_Fig4_1_ActualDGMTransects_r2.mxd: Analyst: gwt: Date: 2/12/2015 4:49:32 PM

40mm Firing Range SI MRS Boundary
40mm Firing Range RI Investigation Area
Suspected Firing Point Location
DGM Tracks (~2.1 mi)
Anomaly Selected for Investigation
Surface Metal/Cultural Feature
Control Point (QC)

0 200 400 Feet

Projection : NAD_1983_UTM_Zone_17N

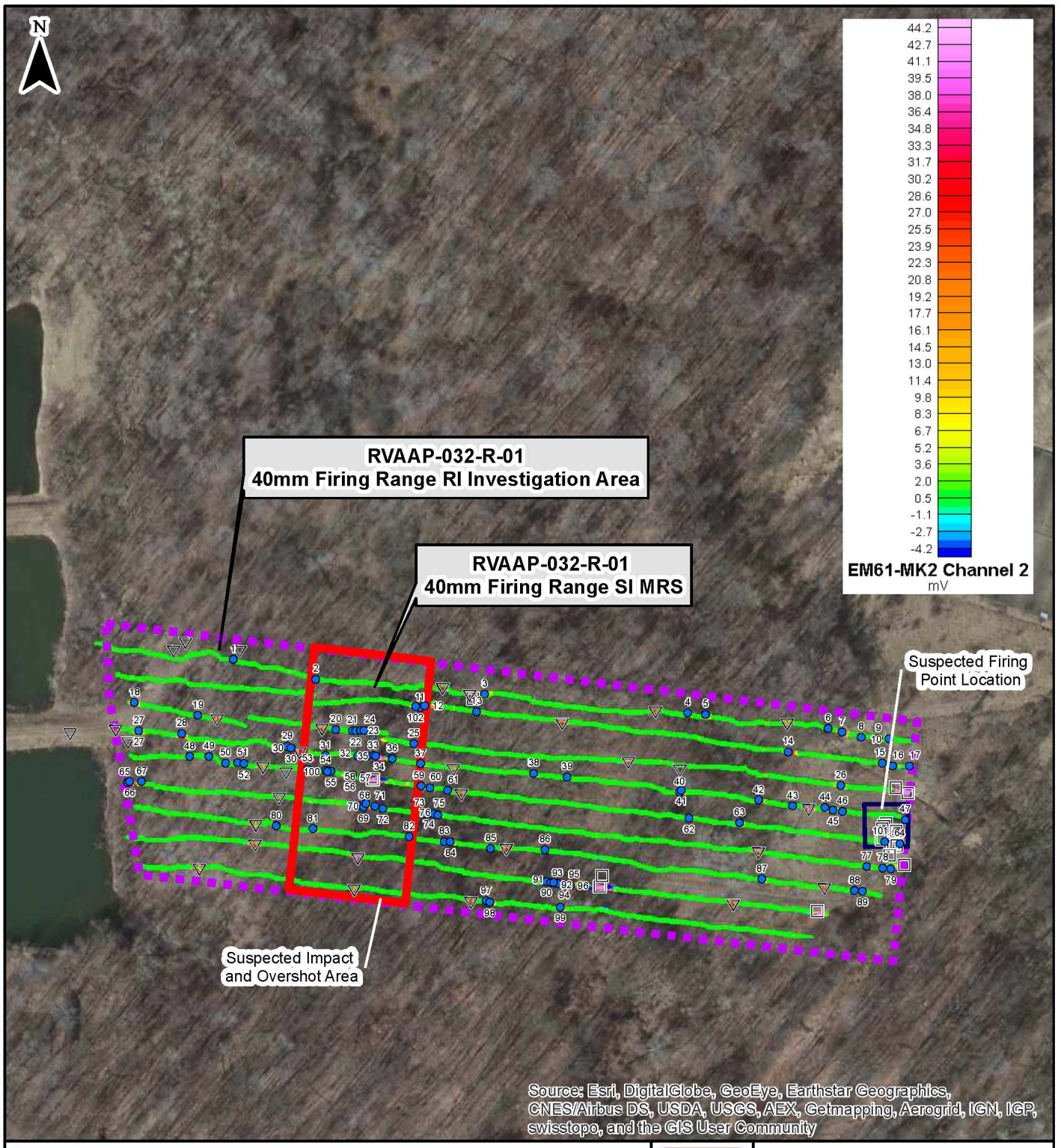
U.S. ARMY
CORPS OF ENGINEERS
BALTIMORE DISTRICT

MILITARY MUNITIONS RESPONSE PROGRAM

40mm FIRING RANGE MRS
FORMER RVAAP/CAMP RAVENNA
PORTAGE AND TRUMBULL COUNTIES, OHIO

CB&I Federal Services LLC
150 Royall Street
Canton, MA 02021

FIGURE 4-1 ACTUAL DGM TRANSECTS



40mm Firing Range SI MRS Boundary
40mm Firing Range RI Investigation Area
Suspected Firing Point Location
Anomaly Selected for Investigation
Surface Metal/Cultural Feature
Control Point (QC)

0 200 400 Feet

Projection : NAD_1983_UTM_Zone_17N

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MILITARY MUNITIONS RESPONSE PROGRAM

40mm FIRING RANGE MRS
FORMER RVAAP/CAMP RAVENNA
PORTAGE AND TRUMBULL COUNTIES, OHIO

CB&I Federal Services LLC
150 Royall Street
Canton, MA 02021

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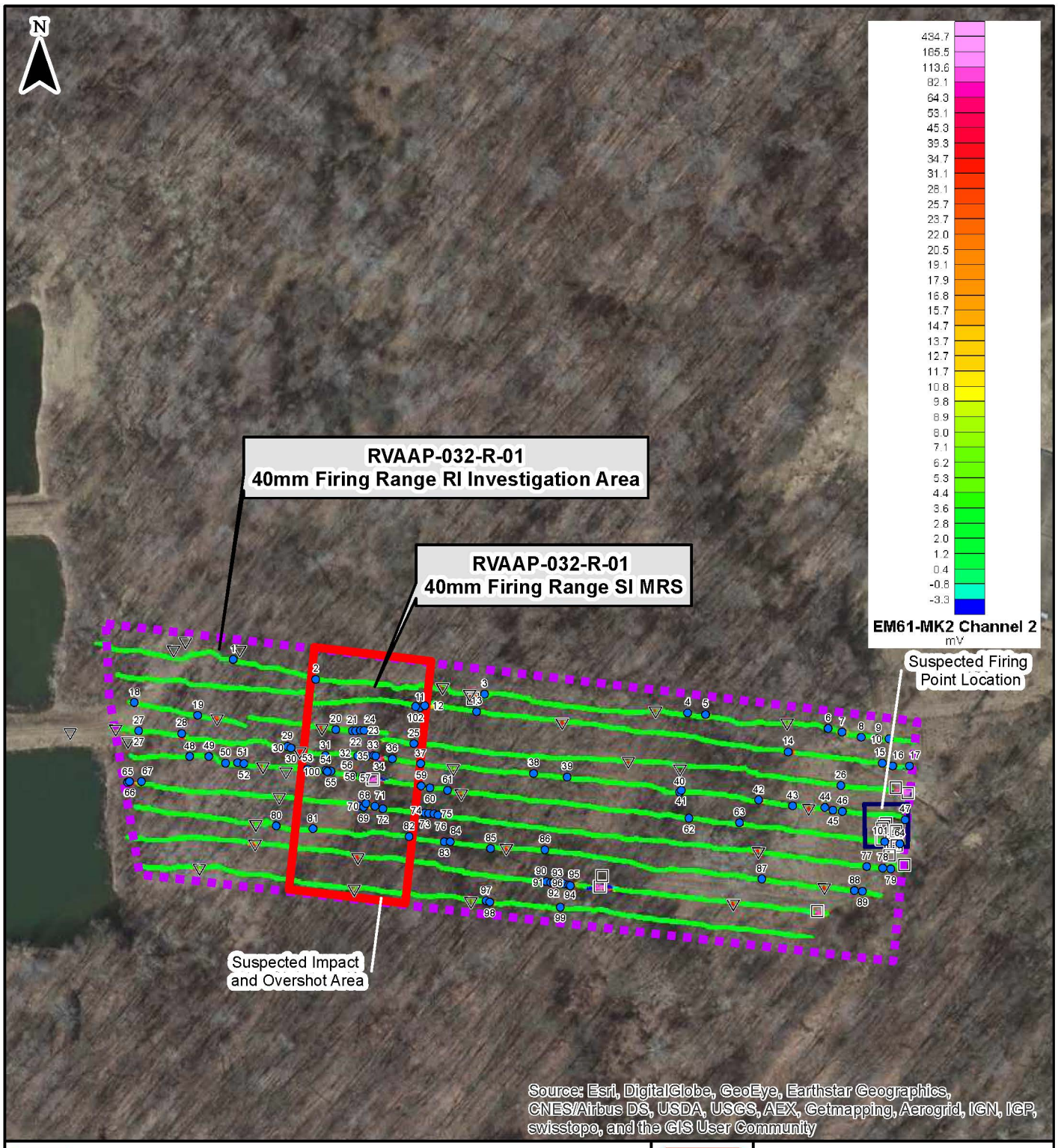
FIGURE 4-2 SENSITIVE COLOR-SCALE DGM RESULTS



40mm Firing Range SI MRS Boundary
40mm Firing Range RI Investigation Area
Suspected Firing Point Location
Anomaly Selected for Investigation
Surface Metal/Cultural Feature
Control Point (QC)

0 200 400 Feet

Projection : NAD_1983_UTM_Zone_17N

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40mm FIRING RANGE MRS
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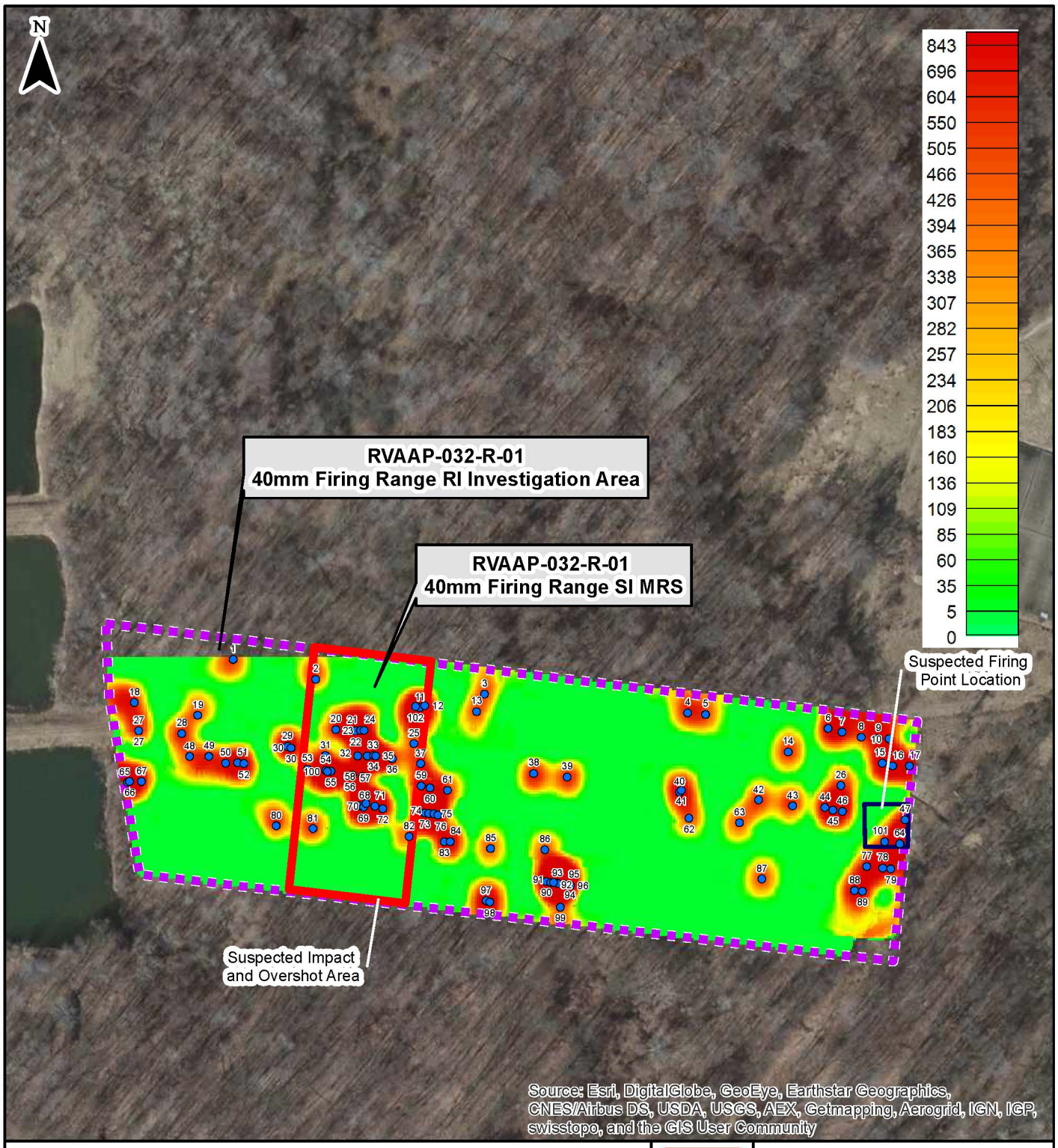
FIGURE 4-3 COURSE COLOR-SCALE DGM RESULTS



40mm Firing Range SI MRS Boundary
40mm Firing Range RI Investigation Area
Suspected Firing Point Location
Anomaly Selected for Investigation

0 200 400 Feet

Projection : NAD_1983_UTM_Zone_17N

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40mm FIRING RANGE MRS
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FIGURE 4-4 GEOSTATISTICAL ANOMALY DENSITY

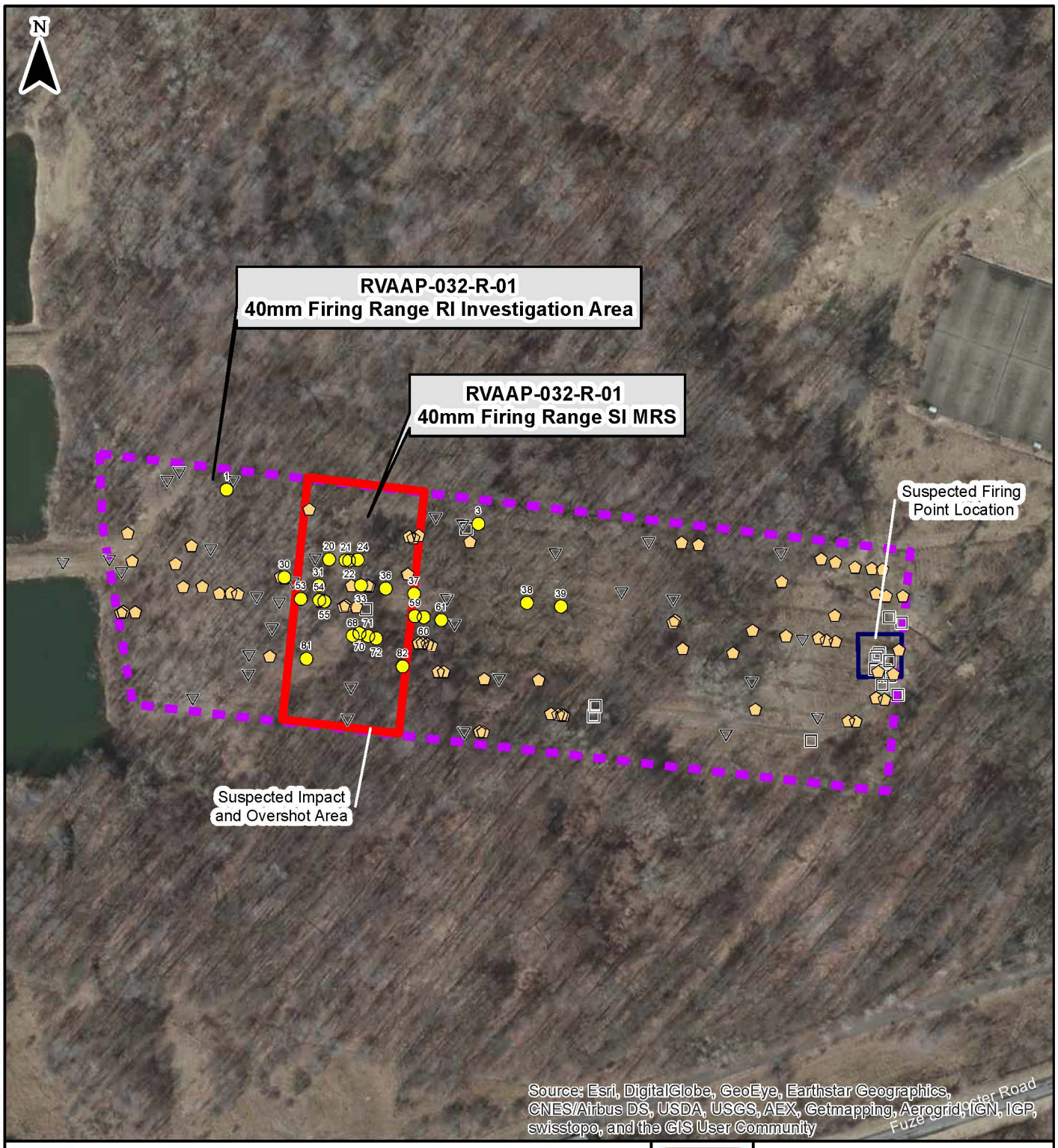
4.1.5 Intrusive Investigation Results

This section presents the results of the intrusive activities performed for the 102 anomalies identified for reacquisition and intrusive investigation at the 40mm Firing Range Investigation Area. The anomalies selected for intrusive investigation were manually investigated by hand digging. All anomalies found were inspected by the UXO-qualified personnel in the field to determine whether there was an explosive safety hazard or the item was safe (i.e., MDAS).

All 102 anomaly locations were successfully reacquired and intrusively investigated. A total of 53 MPPEH items were encountered at 23 of the 102 target anomaly locations. All of the MPPEH was determined to be MDAS (i.e., MD) following inspection by the UXO-qualified personnel. No MEC was found during the intrusive investigation. The majority of the MD items (24) consisted of small pieces of 40mm practice grenade fragments that were found in an 8-inch-deep pit at target 36. This anomaly location is situated at the front portion of the impact area. The remainder of the locations containing MD had less than three items each. An MD item associated with a M781 series 40mm practice grenade was also found at one location. No evidence of 40mm HE grenades that were reported to have been fired at the former test range was identified during the investigation. The UXO-qualified personnel estimated the combined weight of the MD items encountered to be 11.8 lbs. The anomaly locations containing MD correspond with the high-density anomaly areas in the suspected impact area and downrange portion of the Investigation Area that were identified during the geostatistical analysis of the DGM data presented in Section 4.1.5.

The high-density anomaly areas located in proximity to the firing point were found to be other debris and/or non-munitions-related metallic items located on the surface. Anomalies at three of the target areas were defined as “Other Debris” where the anomaly was either attributed to another source (target 12 was determined to be a fence post that was the same source as target 11), reinforced concrete located on the surface (target 99), or excavated to a depth of 48 inches bgs and no item identified (target 77 was determined to be the result of a large rut that caused “noise” in the EM61-MK2 coils). Among the remaining 74 anomalies that were intrusively investigated, approximately 360 lbs of “Other Debris” consisting primarily of slag, former buried water main line, scrap metal, rebar, and other construction debris were determined by the UXO-qualified personnel in the field.

The intrusive investigation locations and results are presented on **Figure 4-5**. A summary of the intrusive investigation data results collected for each of the anomaly locations is presented in **Appendix H**.



40mm Firing Range SI MRS Boundary
40mm Firing Range RI Investigation Area
Suspected Firing Point Location

Single Anomaly Results

- Munitions Debris
- Other Debris
- Surface Metal/Cultural Feature
- Control Point (QC)

0 200 400 Feet

Projection : NAD_1983_UTM_Zone_17N

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40mm FIRING RANGE MRS
FORMER RVAAP/CAMP RAVENNA
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FIGURE 4-5 SINGLE ANOMALY INVESTIGATION RESULTS

4.1.6 Post-Excavation Field Quality Control

A total of 42 anomaly locations were randomly selected for post-excavation QC with the EM61-MK2 following intrusive investigation in accordance with the DID WERS-004.01, *Geophysics, Attachment D,* "Table D-1 Performance Requirements for Remedial Investigation/Feasibility Study Using DGM Methods" (USACE, 2010). The purpose of the post-excavation QC activities were to ensure that at a 90 percent confidence, less than 5 percent of the remaining anomalies are "unresolved" (i.e., there is a low probability that a significant item related to MEC is present within the dig locations that were not checked post-excavation).

At five locations, the residual signal for Channel 2 of the EM61-MK2 exceeded 4 mV; three of the anomalies were reinforced concrete or slag that was not removed from the excavation and two locations were underground utilities. At all of the remaining locations the residual signal from the sensor was less than 4 mV (Channel 2) and no additional excavation locations were required to be checked.

4.1.7 Management and Disposal of Munitions Debris

This section presents the management and disposal practices for the MD items that were found during the RI intrusive investigation activities at the 40mm Firing Range Investigation Area. All MD items found were managed and disposed in accordance with the *Explosives Management Plan* in Section 5.0 of the Work Plan Addendum (Shaw, 2011).

Once an MPPEH item was inspected and determined to be MDAS by the UXO-qualified personnel, it was then removed and placed into 55-gallon steel drums as MD for disposal as scrap steel. The drums were classified by the Senior UXO Supervisor as MDAS and were transported to Building 1501 at the Open Demolition Area #2 MRS for temporary storage. The drums of MD were shipped off site on May 11, 2012, for demilitarization at Demil Metals, Inc. in Glencoe, Illinois. Waste shipment documentation for MD disposal is presented in **Appendix I** and is inclusive of all MD that was generated by CB&I at the 40mm Firing Range Investigation Area and other facility MRSs investigated under the MMRP between September 8, 2011, and May 11, 2012.

4.2 MC Data Evaluation

This section presents the results of the RI data screening process for MC that may be indicative of impacts from historical munitions events which have occurred at the 40mm Firing Range and to evaluate the occurrence and distribution of SRCs in surface soil. The data evaluated for the 40mm Firing Range Investigation Area are inclusive of the results of the RI sampling event only. No sampling activities were conducted under either the IRP or SI field activities as summarized in Section 2.4, "Data Incorporated into the RI."

The data reduction and screening process presented herein describes the statistical methods and facility-wide background screening criteria used to distinguish constituents present at ambient concentrations from those present at concentrations that indicate potential impacts related to historical operations at the former test range. The nature and extent of identified SRCs within the sampled environmental media (surface soil) established for this RI Report are also presented below. A summary of the complete laboratory analytical results for the RI data and the laboratory data reports are presented in **Appendix E**.

4.2.1 Data Evaluation Methods

Data evaluation methods for the 40mm Firing Range Investigation Area are consistent with those established in the *Final Facility-Wide Human Health Cleanup Goals for the Ravenna Army Ammunition Plant* (SAIC, 2010), hereafter referred to as the FWCUG guidance. These methods consist of three general steps: (1) define data aggregates; (2) data verification, reduction, and screening; and (3) data presentation.

4.2.1.1 Definition of Aggregate

The data aggregate for the RI consists of the ISM surface soil samples that were collected at the three sampling units and at similar depths, and do not include the field duplicate or QC samples. The combined sampling units are considered as the surface soil decision unit for the 8.55-acre Investigation Area. The surface soil decision unit for the Investigation Area is based on locations where MPPEH that was inspected and determined to be MD was historically identified, where SRCs associated with historical activities are expected, are locations that have the same receptor exposure scenarios, and is the area in which a decision regarding MC in surface soil at the Investigation Area will be made. Two ISM surface soil samples were collected at evenly sized sampling units (0.63 acres each) at the impact area and 100 feet beyond that is the actual MRS. One ISM surface soil sample was collected at a smaller 0.05-acre sampling unit in the vicinity of the firing point of the former firing range that is outside of the actual MRS boundaries. The 0- to 0.5-foot (6-inch) sample depth for the sampling units is considered the maximum depth that MC associated with MEC or MD on or just below the ground surface would be expected to vertically migrate in the soil column, in accordance with U.S. Army guidance (2009). The data results for this aggregate are considered suitable for comparison against established screening values for the evaluation of the nature and extent of contamination associated with previous activities at the former firing range and for MC exposure analysis for the evaluation of risks to human and ecological receptors.

4.2.1.2 Data Validation

Data validation was performed on all ISM surface soil samples collected from the 40mm Firing Range Investigation Area (including field duplicates and QC samples) during the RI

field activities to ensure the precision and accuracy of the analytical data were adequate for their intended use. The review constituted comprehensive validation of 100 percent of the primary dataset and data reviews as discussed in Sections 3.2.5 and 3.2.6 of this report.

4.2.1.3 Data Reduction and Screening

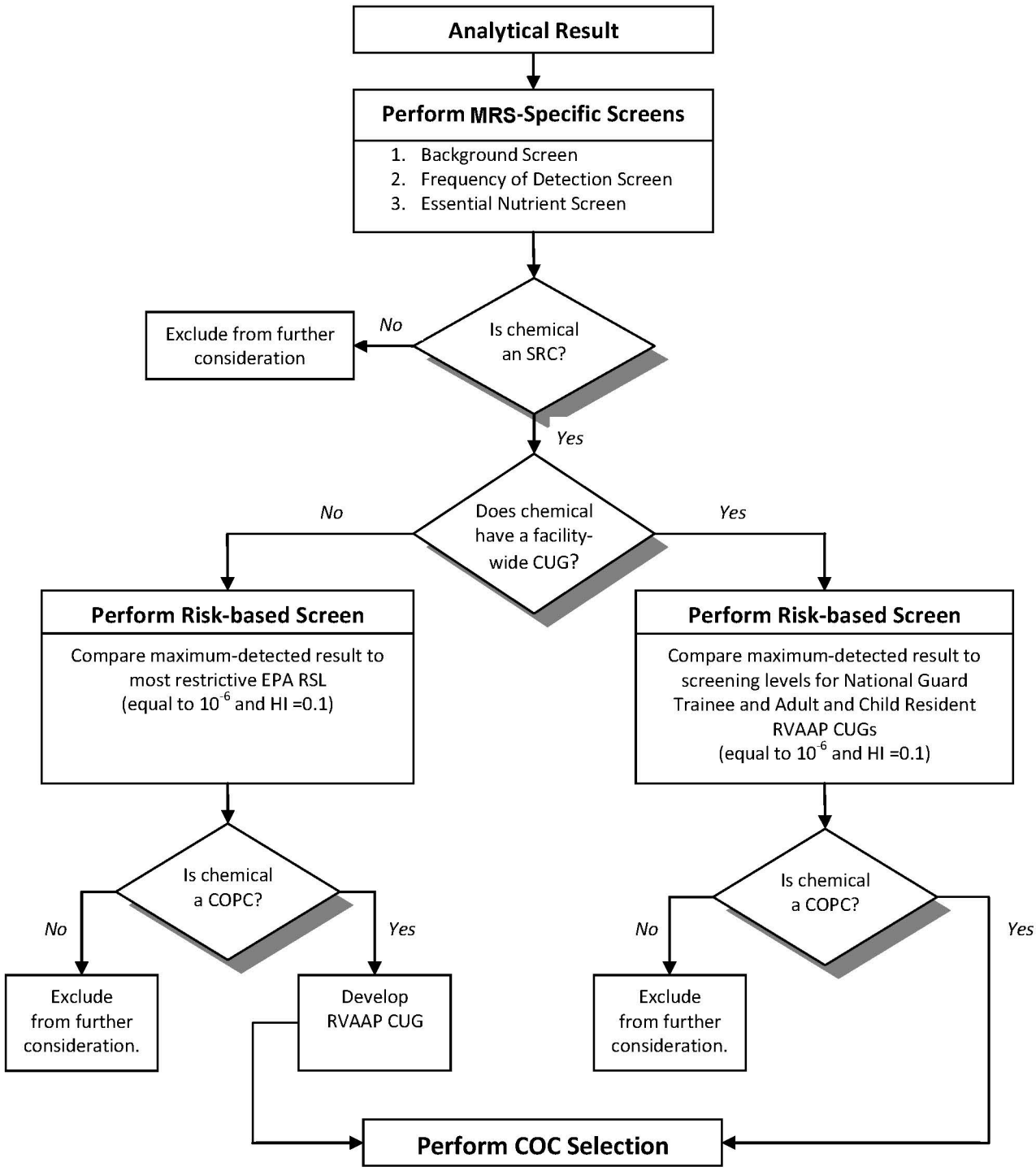
The data reduction process employed to identify SRCs involves identifying frequency of detection summary statistics, comparison to facility-wide background screening values (BSVs) for metals only, and evaluation of essential nutrients. QC and field duplicates were excluded from the screening data sets. All analytes having at least one detected value was included in the data reduction process. Summary statistics calculated for each data aggregate included the minimum, maximum and average (mean) detected values and the proportion of detected results to the number of samples collected. For calculation of mean detected values, nondetected results were included by using one-half of the reported detection limit as a surrogate value for each compound. Following data reduction, the data was screened to identify SRCs using the processes outlined in the following sections. **Figure 4-6** shows the RVAAP data screening process to identify SRCs and chemicals of potential concern (COPCs) and perform selection for chemicals of concern, as necessary. The process for the determination of COPCs and chemicals of concern at the facility is presented in the FWCUG guidance (SAIC, 2010) and is for human health evaluation only.

Frequency of Detection

Chemicals that are detected infrequently, except explosives and propellants, may be artifacts in the data due to sampling, analytical, or other problems, and therefore may not be related to the site activities or disposal practices. For sample aggregations, except for explosives and propellants, with at least 20 samples and frequency of detection of less than 5 percent, a weight of evidence approach may be used to determine if the chemical is MRS related. Since surface soil samples were collected at only three locations (three ISM sampling units), frequency of detection was not utilized to support a weight of evidence approach for the 40mm Firing Range Investigation Area data set.

Facility-Wide Background Screen

Detected concentrations were compared against established facility-wide BSVs if applicable. For metals, if the maximum detected concentration exceeded its respective BSV, it was considered to be a SRC. It should be noted that not all metals, analyzed as part of the RI sampling event have established screening levels or BSVs. Therefore, in the event a constituent metal was not detected in the background data set, the BSV was set to zero, and any detected result for that constituent was considered above background. This conservative process ensures that detected constituents are not eliminated as SRCs simply because they



COC = Chemical of Concern
COPC = Chemical of Potential Concern
CUG = Cleanup Goal
EPA = Environmental Protection Agency
HI = Hazard Index
RSL = Regional Screening Level
SRC = Site Related Chemical

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FIGURE 4-6 RVAAP DATA SCREENING PROCESS

are not detected in the background data set. All detected organic compounds were considered to be above background because this class of compound does not occur naturally.

For the RI field efforts across MRSs at the facility being investigated under the MMRP, analyses were conducted for calcium, magnesium, and manganese to be potentially used for geochemical analysis. Iron has typically been identified as an MC associated with past activities at these MRSs; however, iron is not considered as an MC at the Investigation Area and was analyzed for geochemical purposes as well. Geochemical analysis is typically used when metals are found to be only slightly elevated above background levels and risk assessment identifies potential risk to receptors due to metals. A geochemical analysis is then used to determine if metals are background related or actually elevated due to site history. Use of the geochemical evaluation in this manner requires approval from the USACE and Ohio EPA prior to implementing geochemical evaluation results as a comparison tool for background results. A geochemical analysis was not required for the 40mm Firing Range Investigation Area based on the evaluation of the metal results in the following sections.

Essential Nutrient Screen

Chemicals that are considered to be essential nutrients (calcium, chloride, iodine, iron, magnesium, potassium, phosphorus, and sodium) are an integral part of the food supply and are often added to foods as supplements. The EPA recommends that these chemicals not be evaluated as COPCs as long as they are: (1) present at low concentrations (i.e., only slightly elevated above naturally occurring levels), and (2) toxic at very high doses (i.e., much higher than those that could be associated with contact at the MRS). Recommended daily allowance and recommended daily intake values are available for most of the metals identified as essential nutrients (USACE, 2005).

For the RI field effort, analyses were conducted for essential nutrients that included calcium, iron, and magnesium. These constituents were eliminated as SRCs in the environmental media since they are not considered as MC associated with historical activities at the former firing range.

4.2.1.4 Data Presentation

The designated use for 40mm Firing Range Investigation Area samples are discussed in Section 4.2.2, “Data Use Evaluation” and summarized in **Table 4-1**. The summary of surface soil results is presented in **Table 4-2**. Data summary statistics and screening results for the surface soil sampled are presented in **Table 4-3**. The complete data summary tables and the laboratory data report for the samples collected at the 40mm Firing Range Investigation Area during the RI field activities is presented in **Appendix E**.

Table 4-1
Data Use Summary and Sample Collection Rationale

Sample Location ID	Collection Date	Depth (feet bgs)	Sample Type	Data Use Type	Comments
40FSS-001m-0001-SO	2/8/12	0–0.5	ISM	N&E, F&T, RA	Characterize southern portion of impact area and 100 feet beyond
40FSS-002m-0001-SO	2/8/12	0–0.5	ISM	N&E, F&T, RA	Characterize northern portion of impact area and 100 feet beyond
40FSS-004m-0001-SO	2/8/12	0–0.5	ISM	N&E, F&T, RA	Characterize the firing point

bgs denotes below ground surface.
F&T denotes data can be used for fate and transport evaluation.
ID denotes identification.
ISM denotes incremental sample methodology.
mm denotes millimeter.
N&E denotes data can be used for nature and extent evaluation.
RA denotes data can be used for risk assessment evaluation for human and ecological receptors.

Table 4-2
Summary of Surface Soil Results

		Location ID	**40FSS-001M**		**40FSS-002M**		**40FSS-004M**	
		Sample ID	**40FSS-001M-0001-SO**		**40FSS-002M-0001-SO**		**40FSS-004M-0001-SO**	
		Sample Date	**2/8/2012**		**2/8/2012**		**2/8/2012**	
		Sample Type	**REG**		**REG**		**REG**	
		Depth (feet bgs)	**0–0.5**		**0–0.5**		**0–0.5**	
Analyte	**Units**	**BSV**	**Result**	**VQ**	**Result**	**VQ**	**Result**	**VQ**
Explosives and Propellants								
1,3,5-Trinitrobenzene	mg/kg	*NA*	<0.25	UJ	<0.25	U	NS	
1,3-Dinitrobenzene	mg/kg	*NA*	<0.2	U	<0.2	U	NS	
2,4,6-Trinitrotoluene	mg/kg	*NA*	<0.2	U	<0.2	U	NS	
2,4-Dinitrotoluene	mg/kg	*NA*	<0.25	U	<0.25	U	NS	
2,6-Dinitrotoluene	mg/kg	*NA*	<0.25	U	<0.25	U	NS	
2-Amino-4,6-Dinitrotoluene	mg/kg	*NA*	<0.2	U	<0.2	U	NS	
3,5-Dinitroaniline	mg/kg	*NA*	<0.2	U	<0.2	U	NS	
4-Amino-2,6-Dinitrotoluene	mg/kg	*NA*	<0.2	U	<0.2	U	NS	
HMX	mg/kg	*NA*	<0.2	U	<0.2	U	NS	
m-Nitrotoluene	mg/kg	*NA*	<0.2	U	<0.2	U	NS	
Nitrobenzene	mg/kg	*NA*	<0.2	U	<0.2	U	NS	
Nitroglycerin	mg/kg	*NA*	<1	U	<1	U	<1	U
Nitroguanidine	mg/kg	*NA*	<0.125	U	<0.125	U	**0.077**	**J**

Table 4-2 (continued)
Summary of Surface Soil Results

		Location ID	40FSS-001M		40FSS-002M		40FSS-004M	
		Sample ID	40FSS-001M-0001-SO		40FSS-002M-0001-SO		40FSS-004M-0001-SO	
		Sample Date	2/8/2012		2/8/2012		2/8/2012	
		Sample Type	REG		REG		REG	
		Depth (feet bgs)	0–0.5		0–0.5		0–0.5	
Analyte	**Units**	**BSV**	**Result**	**VQ**	**Result**	**VQ**	**Result**	**VQ**
o-Nitrotoluene	mg/kg	*NA*	<0.25	U	<0.25	U	NS	
p-Nitrotoluene	mg/kg	*NA*	<0.2	U	<0.2	U	NS	
PETN	mg/kg	*NA*	<1	U	<1	U	NS	
RDX	mg/kg	*NA*	<0.25	U	<0.25	U	NS	
Tetryl	mg/kg	*NA*	<.2	U	<.2	U	NS	
Metals								
Aluminum	mg/kg	*17,700*	9,090		10,800		NS	
Calcium	mg/kg	*15,800*	346		609		NS	
Iron	mg/kg	*23,100*	19,500		22,200		NS	
Lead	mg/kg	*26.1*	14.9		14.6		NS	
Magnesium	mg/kg	*3,030*	1,710		2,160		NS	
Manganese	mg/kg	*1,450*	558		652		NS	
General Chemistry								
Nitrocellulose	mg/kg	*NA*	<100	U	<100	U	<100	U

Table 4-2 (continued)
Summary of Surface Soil Results

		Location ID	**40FSS-001M**		**40FSS-002M**		**40FSS-004M**	
		Sample ID	**40FSS-001M-0001-SO**		**40FSS-002M-0001-SO**		**40FSS-004M-0001-SO**	
		Sample Date	**2/8/2012**		**2/8/2012**		**2/8/2012**	
		Sample Type	**REG**		**REG**		**REG**	
		Depth (feet bgs)	**0–0.5**		**0–0.5**		**0–0.5**	
Analyte	**Units**	**BSV**	**Result**	**VQ**	**Result**	**VQ**	**Result**	**VQ**
Total Organic Carbon	mg/kg	*NA*	14,000		16,000		NS	
pH	SU	*NA*	5.1		5.24		NS	
Total Solids	%	*NA*	99		98.6		98.9	

[1] *Background values as presented in the Final Facility-Wide Human Health Cleanup Goals for the Ravenna Army Ammunition Plant, Ravenna, Ohio (SAIC, 2010).*

For metals bold numbering indicates concentration is greater than the facility background value. For organics, bold numbering indicates a detected value.

< denotes less than.

bgs denotes below ground surface.

BSV denotes background screening value.

ID denotes identification.

J denotes the reported result is an estimated value.

mg/kg denotes milligrams per kilogram.

NA denotes that a BSV is not available.

NS denotes not sampled.

RDX denotes research department explosive.

RVAAP denotes former Ravenna Army Ammunition Plant.

SAIC denotes Science Applications International Corporation.

SU denotes standard unit.

U denotes result is not detected or the concentration is below the detection limit.

UJ denotes result is not detected. The detection limits and quantitation limits are approximate.

VQ denotes validation qualifier.

Table 4-3
SRC Screening Summary in Surface Soil Samples

Analyte	CAS Number	Frequency of Detection	Minimum Detect (mg/kg)	Maximum Detect (mg/kg)	Mean Result (mg/kg)	BSV (mg/kg)	SRC?	SRC Justification
Explosives and Propellants								
Nitroguanidine	556-88-7	1/3	0.077 J	0.077 J	0.10	NA	No	Not an MC
Metals								
Aluminum	7429-90-5	2/2	9,090	10,800	9,945	17,700	No	Below BSV
Lead	7439-92-1	2/2	14.6	14.9	14.75	26.1	No	Below BSV

[1] *Background values as presented in the Final Facility-Wide Human Health Cleanup Goals for the Ravenna Army Ammunition Plant, Ravenna, Ohio (SAIC, 2010).*

BSV denotes background screening value.

CAS denotes Chemical Abstracts Service.

J denotes the reported result is an estimated value.

MC denotes munitions constituent associated with the 40mm grenade.

mg/kg denotes milligrams per kilogram.

mm denotes millimeter.

NA denotes that a BSV is not available.

RVAAP denotes former Ravenna Army Ammunition Plant.

SAIC denotes Science Applications International Corporation.

SRC denotes site-related chemical.

4.2.2 Data Use Evaluation

During the RI field effort, surface soil samples were collected at three predetermined ISM sampling units to evaluate the nature and extent of SRCs associated with previous activities at the MRS. Available sample data were evaluated to determine suitability for use in the various key RI data screens that include evaluation of nature and extent of SRCs, fate and transport, and human and ecological risk assessments. Evaluation of data suitability for use in this RI Report involved two primary considerations: (1) representativeness with respect to current MRS conditions, and (2) the sample collection methods used (i.e., ISM).

No samples were collected during the SI field activities or during previous IRP investigations, and there was no applicable data to be incorporated into the RI data set. Therefore, only the samples collected during the RI field effort were screened for SRCs. As discussed in Section 2.4, the RI sample results are intended to further characterize the nature and extent of contamination associated with previous activities at the Investigation Area.

4.3 Nature and Extent of SRCs

This section presents a summary of the nature and extent of SRCs for the environmental samples collected during the RI field activities at the 40mm Firing Range Investigation Area. Data from the RI surface soil samples were screened to identify SRCs representing current conditions at the 40mm Firing Range Investigation Area. The SRC screening data for surface soil (not including field duplicates or QC samples) included ISM surface soil samples 40FSS-001m-0001-SO, 40FSS-002m-0001-SO and 40FSS-004m-0001-SO, where the sample depth for all three samples were taken from 0 to 0.5 feet bgs.

The ISM surface soil samples collected at the impact area and 100 feet beyond (40FSS-001m-0001 and 40FSS-002m-0001) were submitted for laboratory analysis for lead and aluminum, explosives, nitrocellulose, TOC, and pH. These samples were also submitted for geochemical parameters that included calcium, magnesium, manganese, and iron for the rationale discussed in Section 4.2.1.3, “Data Reduction and Screening.” The ISM surface soil sample collected from the firing point (40FSS-004m-0001) was submitted for laboratory analysis for propellants (nitrocellulose, nitroglycerine, and nitroguanidine) only.

4.3.1 Explosives and Propellants

Nitroguanidine is the only propellant or explosive that was detected in any of the surface soil samples and was identified at only one sample location, 40FSS-004m-0001-SO. This sample was collected at the firing point. The detected nitroguanidine concentration was 0.077J milligrams per kilogram. The “J”-flagged data are considered estimated and are retained as detected values. No other propellants or explosives were detected at any of the other ISM surface soil sample locations.

The propellant type used in the 40mm grenades fired at the former 40mm Firing Range was the M9 series propellant. The M9 series propellant is a double-base propellant and consists primarily of nitrocellulose (57 weight percent) with nitroglycerine (40 weight percent) (USACE, 2006). Nitroguanidine is not an MC associated with the M9 series propellant used in the 40mm grenades reported to have been fired at the former test range (i.e., the M407A1 series practice round and M406 series HE round) or in the 40mm practice grenades identified as having been fired at the former test ranged based on the MD encountered during the RI field activities (i.e., the M382 series and M781 series rounds). The detection for nitroguanidine may be the result of the presence of guanine, a naturally occurring substance typically found in the excrement of bats and birds (guano), and from which nitroguanidine is manufactured. Nitroguanidine is also used in insecticide applications (ChemicalBook, 2010). Therefore, the detected nitroguanidine concentration is removed from further considered as an MC-related SRC at the 40mm Firing Range Investigation Area. The Munitions Data Sheets for the 40mm cartridges historically known to have been used at the former test range or identified during the RI field activities are presented in **Appendix C**.

4.3.2 Inorganics

Aluminum and lead were detected in both ISM surface soil samples collected at the impact area and 100 feet beyond. The maximum detected concentrations for both metals were below the applicable BSVs and were not retained as SRCs within the Investigation Area.

4.3.3 Summary of MC Data Evaluation

Based on the results of the RVAAP data evaluation process, no MC-related SRCs were identified in the surface soil samples collected at the 40mm Firing Range Investigation Area during the RI field activities. Detected aluminum and lead concentrations were below the applicable BSVs. Nitroguanidine was detected at the firing point sampling unit but is not an MC associated with the 40mm grenades used at the former test range and is removed from further consideration as a SRC. Therefore, no SRCs were carried through for further evaluation for fate and transport or risks associated with human health and the environment.

5.0 FATE AND TRANSPORT

The intent of this section is to describe the fate of chemicals in the environment and potential transport mechanisms for any MEC and MC identified at the 40mm Firing Range Investigation Area. Chemical fate refers to the expected final state that an element, compound, or group of compounds will achieve following release of MEC and/or MC to the environment. Chemical transport refers to migration mechanisms MEC and/or MC away from the source area.

5.1 Fate and Transport of MEC

Transport of MEC at an MRS is dependent on many factors, including precipitation, soil erosion and freeze/thaw events. These natural processes, in addition to human activity, may result in some movement (primarily vertical) of MEC if present at the MRS. The result of these mechanisms and processes is a potentially different distribution of MEC than the one that may have existed at the time of original release. In addition, MEC items may corrode or degrade based on weather and climate conditions and thereby release MC into the environment.

Two surface MPPEH and 53 buried MPPEH items were encountered during the RI field work. The buried MPPEH was found at nearly 25 percent of the 102 anomaly locations investigated. All of the surface and buried MPPEH were inspected by the UXO-qualified personnel in the field and were determined to be MDAS (i.e., MD). Although no MEC was found during the RI field work, the number of MD found during the RI field activities is taken into consideration and it is possible that the MD found are represented by a larger population of MPPEH and potentially MEC. Any remaining MEC at the Investigation Area would represent a potential explosive hazard and have the potential to release MC to the surrounding environment. It would be expected that if a significant releases of MC were to occur, it would happen at areas with concentrated (i.e., bulk burial or clustered) MEC, which was not the case for the Investigation Area based on the results of the RI field work.

5.2 Fate and Transport of MC

No MEC was encountered during the RI field activities and a significant release of MC from the areas where the individual or small amounts of MD were found is unlikely. This assertion is supported by the data results for the surface soil samples that were collected for the RI. Two ISM surface soil samples were collected at the former impact area and 100 feet beyond where the majority of the MD was encountered during the visual survey and intrusive investigation. In addition, an ISM sample was collected at the former firing point. These locations are considered as the likely areas of release for MC at the former test range and no

evidence of MC-related SRCs was identified following the RVAAP data screening process. Therefore a discussion of fate and transport of MC at the Investigation Area was unwarranted.

6.0 MEC HAZARD ASSESSMENT

In accordance with the Work Plan Addendum (Shaw, 2011), an evaluation of the MEC hazard at the 40mm Firing Range Investigation Area was to be prepared in accordance with the *Interim Munitions and Explosives of Concern Hazard Assessment (MEC HA) Methodology* (EPA, 2008). The MEC HA allows a project team to evaluate the potential explosive hazard associated with an MRS given current conditions and under various cleanup, land-use activities, and land-use control alternatives. It was developed through a collaborative, consensus approach to promote consistent evaluation of potential explosive hazards at MRSs (EPA, 2008). The MEC HA methodology addresses human health and safety concerns associated with potential exposure to MEC at a MRS but does not address hazards (explosive or toxic) posed by chemical warfare materiel, MEC that is present underwater, nor environmental or ecological hazards that may be associated with MEC.

MPPEH was observed at the 40mm Firing Range Investigation Area during the RI field activities. The MPPEH items were confirmed to be present on the ground surface and at approximately 25 percent of the target anomaly locations that were investigated during the RI. All of the MPPEH items were inspected and determined to be solid and/or inert and posed no explosive safety hazard (i.e., MDAS). No MEC was found during the RI field work. Based on the findings of the RI field work, the calculation of a MEC HA score was not warranted for the 40mm Firing Range Investigation Area.

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7.0 HUMAN HEALTH RISK ASSESSMENT

The purpose of a HHRA is to document whether MRS conditions may pose a potential risk to current or future Investigation Area receptors and to identify which, if any, Investigation Area conditions need to be addressed further in the CERCLA process. As no detected analytes were identified as SRCs at the 40mm Investigation Area during RI field activities, a HHRA was not required for inclusion in this RI Report.

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8.0 ECOLOGICAL RISK ASSESSMENT

An ERA evaluates the potential for adverse effects posed to ecological receptors from potential releases of MC at an MRS. As no SRCs were identified at the 40mm Investigation Area, it was determined that an ERA was not required for inclusion in this RI Report.

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9.0 REVISED CONCEPTUAL SITE MODELS

This section presents the revised CSM for MEC and the preliminary CSM for MC at the 40mm Firing Range Investigation Area based on the results of the data collected for the RI and information provided in the HRR (e^2M, 2007) and the SI Report (e^2M, 2008). The preliminary CSM for MEC was discussed in Section 2.0, "Project Objectives" and the summary of the RI results were presented in Section 4.0, "Remedial Investigation Results." Following the integration of the RI results into the CSMs for MEC and MC, the MRSPP evaluation for the MRS was reevaluated to include the results of the RI and is discussed at the end this section.

9.1 MEC Exposure Analysis

This section summarizes the RI data for the MEC exposure pathway analyses for the 40mm Firing Range Investigation Area. As discussed in Section 2.1, "Preliminary CSM and Project Approach," each pathway includes a source, activity, access, and receptor, with complete, potentially complete, and incomplete exposure pathways identified for each receptor. A pathway is considered complete when a source (MEC) is known to exist and when receptors have access to the MRS while engaging in some activity which results in contact with the source. A pathway is considered potentially complete when a source has not been confirmed, but is suspected to exist and when receptors have access to the MRS while engaging in some activity which results in contact with the source. Lastly, an incomplete pathway is any case where one of the four components (source, activity, access, or receptors) is missing from the MRS.

9.1.1 Source

A MEC source is the location where MPPEH or ordnance is situated or expected to be found. The principle sources of any potential remaining MEC at the 40mm Firing Range Investigation Area was the testing of 40mm practice and HE grenades between 1969 and 1971. These activities resulted in the potential for MEC to be present in surface and subsurface soils at the Investigation Area at a maximum anticipated depth of 5 inches (e^2M, 2008).

Two MPPEH items were identified on the ground surface during the DGM survey. The MPPEH was inspected by the UXO-qualified personnel in the field and were determined to be MDAS (i.e., MD). The MD consisted of aluminum ballistic windscreens from the M382 series 40mm practice grenade.

A total of 53 MPPEH items were encountered at 23 of the 102 intrusive investigation target anomaly locations. All of the MPPEH was determined to be MDAS (i.e., MD) following

inspection by the UXO-qualified personnel in the field. The MD consisted primarily of remnants associated the M382 series 40mm practice grenade. An MD item associated with a M781 series 40mm practice grenade was found at one location during the RI field work. The maximum depth of MD encountered was to 8 inches bgs in what appeared to be a man-made burial pit.

Although the M406 series 40mm grenade that contained HE was reportedly fired at the former test range, no evidence of this munitions was found during any of the RI field work. No MEC was found at the MRS during any of the RI field activities.

9.1.2 Activity

Activity describes ways that receptors come into contact with a source. Current activities at the 40mm Firing Range Investigation Area include maintenance and natural resource management activities. Biota activities may include occasional meandering and occupation at the Investigation Area by assorted species as well as burrowing activities. The future use at the MRS and surrounding area that is inclusive of the Investigation Area is for military training (OHARNG, 2008).

9.1.3 Access

Access describes the degree to which a MEC source or environment containing MEC is available to potential receptors. The actual MRS is bound by Siebert stakes and signage warning receptors about the MRS to help deter access. There are no access restrictions to the area outside of the MRS where the MD was found during the RI field activities.

9.1.4 Receptors

A receptor is an organism (human or ecological) that comes into physical contact with MEC. Human receptors identified for the 40mm Firing Range Investigation Area include both current and future users. Ecological receptors (biota) for the purposes of the revised MEC CSM are based on plant and animal species that are likely to occur in the terrestrial habitats at the MRS.

Potential users for the current activities at the 40mm Firing Range Investigation Area include facility personnel, contractors, and potential trespassers (e^2M, 2007). The National Guard Trainee has been identified as the potential user for military training and is identified as the Representative Receptor for both current and future activities. This receptor has the greatest opportunity for exposure to MEC and MC that may be present at the MRS.

In the absence of an ERA, which identifies potential ecological receptors to be evaluated for exposure risks associated with MC, the facility has chosen general ecological receptors that provide a range of potential exposures, including high exposures under a variety of

conditions. The terrestrial receptors identified include terrestrial invertebrates (earthworms), voles, shrews, robins, foxes, and hawks (USACE, 2003b).

9.1.5 MEC Exposure Conclusions

The information collected during the RI was used to update the preliminary MEC CSM for the 40mm Firing Range Investigation Area, inclusive of the current MRS boundaries identified in the SI Report (e^2M, 2008), and to identify all actual, potentially complete, or incomplete source-receptor interactions for the Investigation Area for current and future uses. Evaluation of the end use receptors for future use in the revised CSM is consistent with the facility-wide HHRA approach (USACE, 2005). The revised MEC exposure pathway analysis is presented as **Figure 9-1**.

No MEC was identified within the 40mm Firing Range Investigation Area during the RI field activities; however, MD associated with the 40mm practice grenades discharged at the former firing range were encountered on the ground surface and subsurface soils. The MD was found on the ground surface at two locations and at nearly 25 percent of the target anomaly locations at a maximum depth of 8 inches bgs.

Based on the results of the RI field investigations, the use or introduction of munitions at the MRS is confirmed. Because no direct evidence of an explosive hazard exists, the pathways for MEC were considered incomplete for all receptors; however, the amount of various MD found during the RI field work suggests a low potential for MEC to be present at the MRS.

9.2 MC Exposure Analysis

A MC is defined as any material originating from MPPEH or munitions, or other military munitions including explosive and non-explosive material, and emission degradation, or breakdown elements of such ordnance and munitions (10 U.S. Code 2710(e)(4)). The information collected during the RI was used to create the CSM for MC and identify all complete, potentially complete, or incomplete source-receptor interactions for the MRS for current and reasonably anticipated future land-use activities. The MC Exposure Pathway Analysis is presented as **Figure 9-2**.

A MC source is an area where MC has entered (or may enter) the environment. MC contamination may result from a corrosion of munitions or from low-order detonation. Additionally, MC that is found at concentrations high enough to pose an explosive hazard is considered MEC.

The defined MC exposure depths for surface soil and subsurface soil at the facility for the National Guard Trainee are 0 to 4 feet and 4 to 7 feet, respectively (SAIC, 2010). The MC exposure scenario for the environmental receptors is evaluated as 0 to 1 foot bgs.

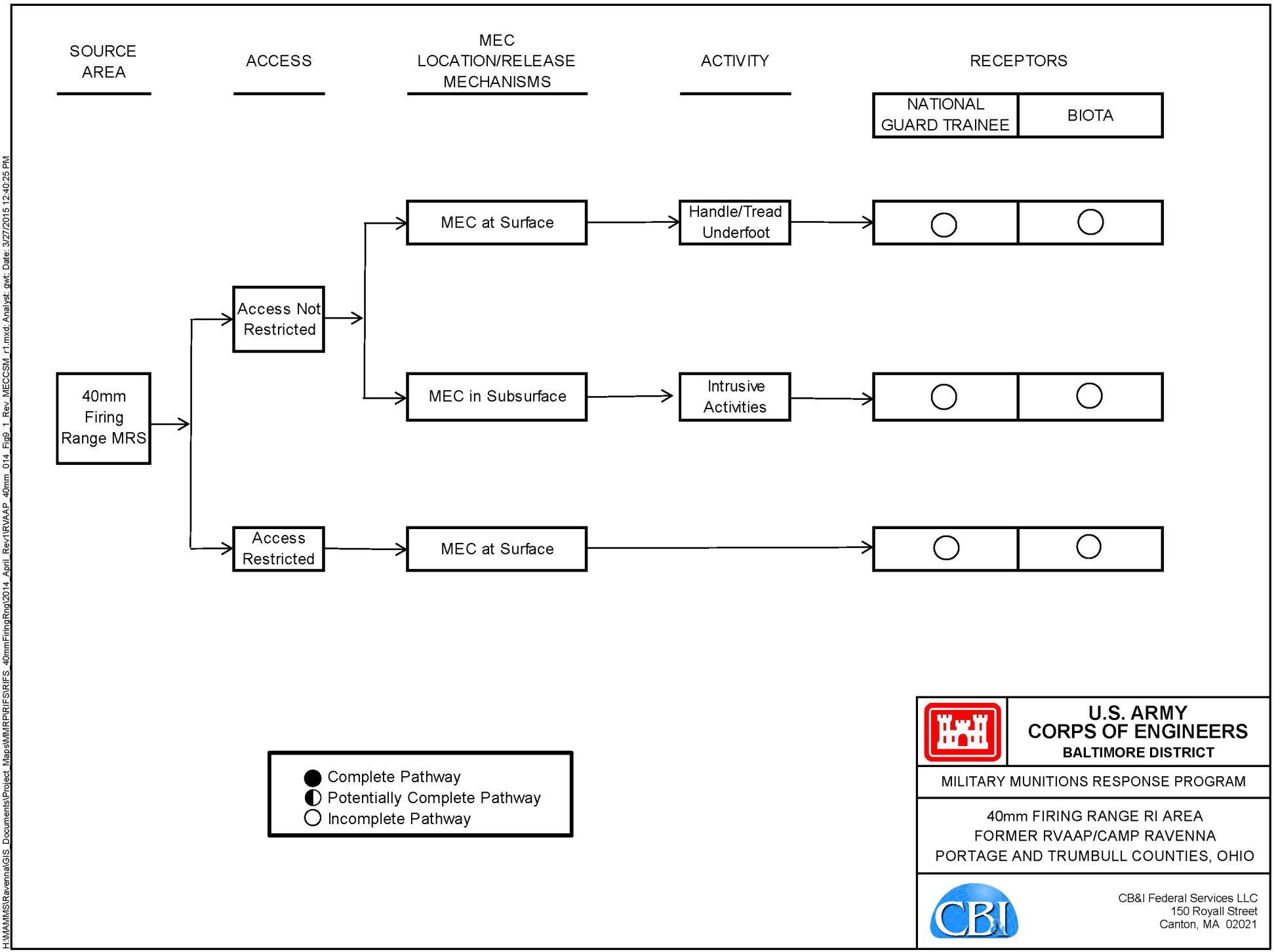
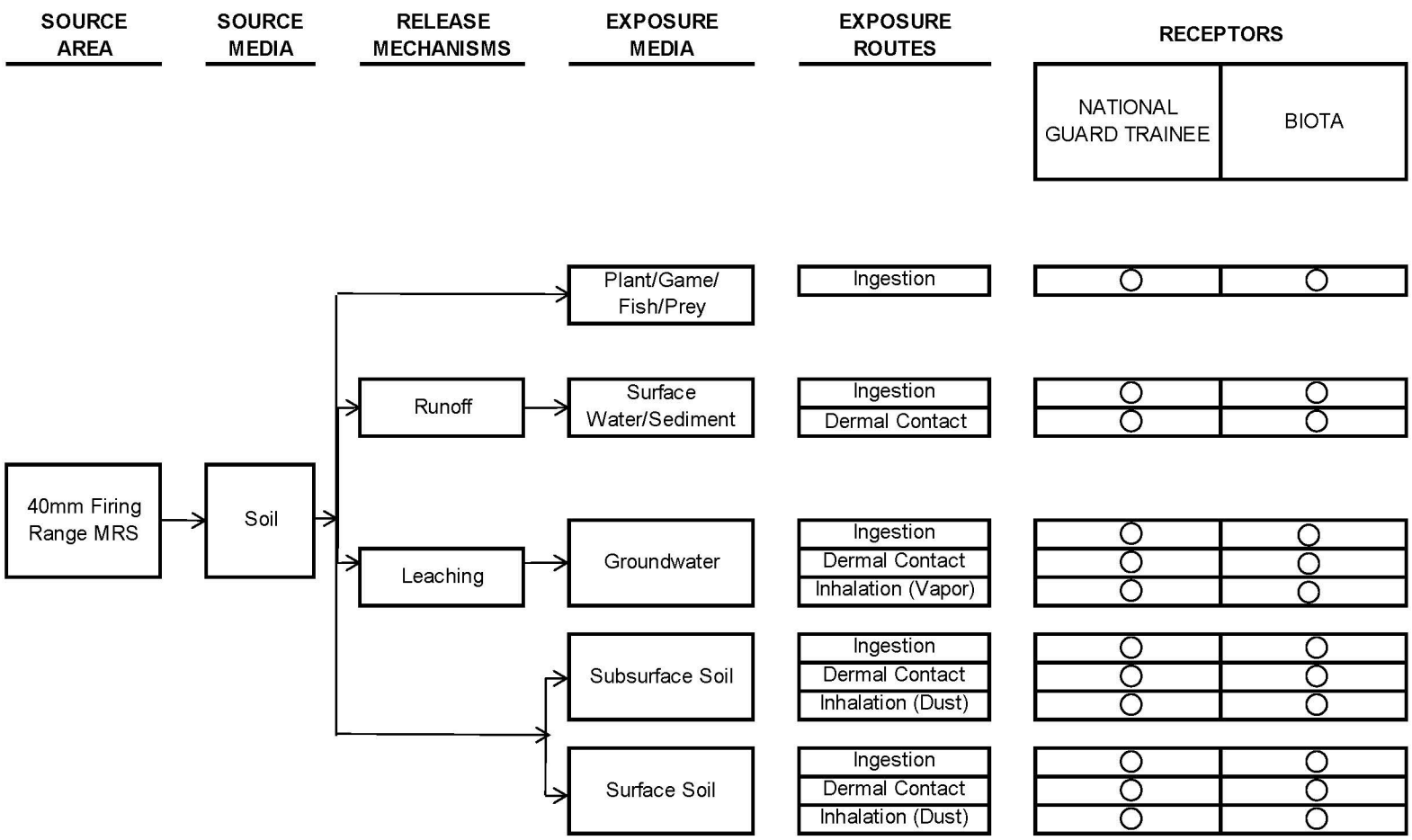


FIGURE 9-1 REVISED MEC EXPOSURE PATHWAY ANALYSIS



Receptor Exposure Scenarios		
Receptor	Surface Soil (ft bgs)	Subsurface Soil (ft bgs)
National Guard Trainee	0-4	4-7
Biota	0-1	>1

● Complete Pathway
◐ Potentially Complete Pathway
○ Incomplete Pathway

U.S. ARMY
CORPS OF ENGINEERS
BALTIMORE DISTRICT

MILITARY MUNITIONS RESPONSE PROGRAM

40mm FIRING RANGE RI AREA
FORMER RVAAP/CAMP RAVENNA
PORTAGE AND TRUMBULL COUNTIES, OHIO

CB&I Federal Services LLC
150 Royall Street
Canton, MA 02021

H:\MMM\St\Ravenna\GIS Documents\Project Maps\MMRP\RIFS\RIFS 40mmFiringRng\2014 April Rev1\RVAAP 40mm 015 Fig9_2 MCCSM r1.mxd Analyst: gwf Date: 3/27/2015 12:37:44 PM

FIGURE 9-2 MC EXPOSURE PATHWAY ANALYSIS

Sampling for MC was performed at the 40mm Firing Range Investigation Area at likely areas of release to further characterize the nature and extent of contamination associated with previous activities at the former firing range. No SRCs were identified following the data evaluation process, and there are no current risks associated with potential MC at the Investigation Area. Although MD was verified during the RI field activities, given the extent of environmental media coverage achieved for the sampling activities for the RI and the results for the MC characterization, it is unlikely that SRCs will leach from the MD. The CSM for MC has been updated to reflect incomplete pathways for all receptors in the terrestrial environments.

There are no surface water features at the Investigation Area. Therefore, the MC exposure pathways for all receptors at the Investigation Area to the aquatic environments, including surface water and sediment, and the plant/game/fish/prey exposure media are considered incomplete.

Groundwater beneath the RVAAP is evaluated on a facility-wide basis and MRS-specific sampling was not intended for an MRS being investigated under the MMRP unless there is a likely impact from a MEC source. The soil conditions at the Investigation Area are considered to have low permeability, and the depth to groundwater may be as deep as 50 feet bgs. No SRCs were detected in the surface soil samples collected during the RI field activities, and it is not expected that the likely human and ecological receptors will come into contact with groundwater beneath the Investigation Area. Therefore, the MC exposure pathway for groundwater is considered to be incomplete for all receptors.

9.3 Uncertainties

The purpose of the DQO process is to adequately characterize and define the hazards/risks posed by the MRS; however, the RI process does not remove all uncertainty associated with the MRS. There are minimal levels of uncertainties an limitations associated with the characterization results at the 40mm Firing Range Investigation Area that are presented in this section.

There is uncertainty and limitations associated with the delineation of the 40mm Firing Range Investigation Area based on the results of the DGM survey and the intrusive investigation. The DGM survey encompassed 0.86 acres of the 8.55-acre Investigation Area, which equates to approximately 10 percent coverage. The “Transect Sampling for UXO Target Traversal” module of VSP® suggested a transect spacing based on the anticipated target size for a typical 40mm Firing Range that ranges from 2 to 10 meters (U.S. Army, 2003). In order to ensure the footprint of the target area was traversed with 100 percent certainty, CB&I proposed a 10-meter transect spacing assuming that not every round hits its intended target when the range was in operation. Two MPPEH items were found on the

ground surface during the visual survey and 53 MPPEH items were identified in subsurface soil at nearly 25 percent of the target anomaly locations. All of the MPPEH items were inspected and determined to be MDAS (i.e., MD) by the UXO-qualified personnel in the field. No MEC was found during the RI field activities which validates the VSP® assumptions; however, the presence of MD at so many of the target locations provides an uncertainty regarding the presence of MEC at the 40mm Firing Range Investigation Area. The ASR (USACE, 2004) states that 2,500 rounds of the 40mm HE rounds were fired at the range when it was in operation and all rounds were accounted for which reduces the uncertainty that MEC is present at the 40mm Firing Range Investigation Area. This is further supported by the RI field results where no evidence of the 40mm HE rounds was identified.

There is uncertainty and limitations associated with the delineation of MD and potential MEC, particularly along the northern portion of the Investigation Area boundary. Two MD items were encountered within approximately 20 feet of the northern boundary; however, no visual surveys or intrusive investigation step outs were performed outside of the Investigation Area. The nature of a 40mm test range in general is to fire the rounds in a relative straight line at down-range targets; therefore, it is unlikely that many of the 40mm rounds deviated far from the lateral boundaries (north and south) when the test range was active. Furthermore, MD is more prevalent at the central portion of the Investigation Area than compared with the MD along the Investigation Area boundary. It is possible that the lateral extent of MD that may be representative of potential MEC for the 40mm Firing Range Investigation Area is underestimated and may extend beyond the northern boundary; however, based on the use of the area as a down-range target area and the prevalent concentration of MD within the expected central portions of the Investigation Area, the uncertainties are minimal.

9.4 Munitions Response Site Prioritization Protocol

The DOD proposed the MRSPP (32 U.S. Code of Federal Regulations Part 179) to assign a relative risk priority to each defense MRS in the MMRP Inventory for response activities. These response activities are to be based on the overall conditions at each location and taking into consideration various factors related to explosive safety and environmental hazards (68 Federal Regulations 50900 [32 U.S. Code of Federal Regulations 179.3]). The revised MRSPP document for the 40mm Firing Range MRS is included in **Appendix J** for reference only.

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10.0 SUMMARY AND CONCLUSIONS

This section summarizes the results of the RI field activities conducted at the 40mm Firing Range Investigation Area that includes the 1.27-acre MRS. The purpose of the RI was to determine whether the Investigation Area warrants further response action pursuant to CERCLA and the NCP. More specifically, the RI was intended to determine the nature and extent of MEC and MC and subsequently determine the hazards and risks posed to likely human and ecological receptors by MEC and MC. Additional data were also presented in this RI Report to assist in the identification and evaluation of alternatives in the Feasibility Study, if required. A summary of the RI results is presented in **Table 10-1**.

Table 10-1
Summary of Remedial Investigation Results

40mm Firing Range	Proposed Investigation Area (Acres)	Actual Investigation Area (Acres)	MEC Found?	MC Detected?	MC Risk Analysis
Investigation Area	0.75	0.86	No	No	No Further Action

MC denotes munitions constituents.
MEC denotes munitions and explosives of concern.

10.1 Summary of Remedial Investigation Activities

The information available for the 40mm Firing Range Investigation Area relating to the potential presence of MEC and MC is compiled and evaluated in this RI Report. The sources of this information were information obtained during previous investigations, including the ASR (USACE, 2004), the HRR (e^2M, 2007), and the SI Report (e^2M, 2008).

The preliminary MEC and MC CSMs were developed during the SI (e^2M, 2008) phase of the CERCLA process and were used to identify the data needs and DQOs as outlined in the Work Plan Addendum (Shaw, 2011). The data needs and DQOs were determined at the planning stage and included characterization of MEC and MC associated with historical activities at the former test range. The DQOs were developed to ensure the reliability of field sampling, chemical analyses, and physical analyses; the collection of sufficient data; the acceptable quality of data generated for its intended use; and the inference of valid assumptions from the data. The DQOs for the 40mm Firing Range MRS identified the following decision rules that were implemented in evaluating the Investigation Area:

- Perform a geophysical investigation to identify if MEC was present.

- Perform an intrusive investigation of anomalies identified during the geophysical investigation to evaluate if MEC was present.
- Collect ISM surface soil samples at three predetermined sampling units at the Investigation Area.
- Process the information to evaluate whether there were unacceptable risks to human health and the environment associated with MEC and/or MC and make a determination if further investigation was required under the CERCLA process.

10.1.1 Geophysical Investigation

Between November and December of 2011, a DGM survey was conducted at the 40mm Firing Range Investigation Area to evaluate for potential buried MEC. The DGM data were collected in all accessible areas within the MRS, and the spatial coverage was 0.86 acres, or approximately 10 percent, of the 8.55-acre Investigation Area. Two MPPEH items were identified on the ground surface during the DGM survey. The MPPEH was inspected by the UXO-qualified personnel in the field, were determined to be MDAS, and were considered MD. The MD consisted of aluminum ballistic windscreens from the M382 series 40mm practice grenade, a munitions item not previously reported to have been used at the former firing range.

10.1.2 Anomaly Selection

Evaluation of the data collected during the DGM survey identified 102 anomalies that had signal strength greater than or equal to 8 mV (Channel 2). In general, the geophysical data indicate that the anomaly density at the Investigation Area is relatively low and dispersed. The majority of the anomalies were encountered in the impact and overshot area that is the defined boundaries of the actual MRS. All of the 102 anomalies that were identified throughout the Investigation Area were selected for intrusive investigation.

10.1.3 Intrusive Investigations

Following the completion of the DGM survey in December 2011, an intrusive investigation was conducted for the locations identified as potentially containing buried MEC based on an analysis of the DGM survey data. All 102 of the identified anomalies were successfully investigated. A total of 53 MPPEH items were encountered at 23 of the 102 target anomaly locations. All of the MPPEH was determined to be MDAS (i.e., MD) following inspection by the UXO-qualified personnel in the field. The MD consisted primarily of remnants associated with M382 series 40mm practice grenades. The maximum depth of MD found was 8 inches bgs in what appeared to be a small burial pit. The total weight of the MD items found during the RI field activities was estimated at 11.8 lbs.

10.1.4 MC Sampling

Environmental samples for MC were collected at the 40mm Firing Range Investigation Area following completion of the DGM survey. Two ISM surface soil samples, each comprising 0.63 acres, were collected at the impact area and 100 feet beyond that constitutes the current 1.27-acre MRS (e^2M, 2008). A third ISM sample was collected at the 0.05-acre firing point at the east end of the former firing range. This sampling unit is located outside of the current MRS boundary. All three ISM samples were collected at depths between 0 and 0.5 feet. The combined ISM surface soil sampling units are considered as the decision unit for the Investigation Area. The surface soil decision unit for the Investigation Area is based on locations where MD was historically identified, where SRCs associated with historical activities are expected, are locations that have the same receptor exposure scenarios, and is the area in which a decision regarding MC in surface soil at the Investigation Area will be made.

10.2 Nature and Extent of SRCs

Based on the results of the data evaluation process, no MC-related SRCs were identified in the surface soil samples collected at the 40mm Firing Range Investigation Area during the RI field activities. In the absence of any identified SRCs, evaluation for risks associated with human and ecological receptors, including the Resident Receptor (Adult and Child) that is evaluated for Unrestricted (Residential) Land Use, was not required for the RI.

10.3 Fate and Transport

Two surface MPPEH and 53 buried MPPEH items were encountered during the RI field work. The buried MPPEH was found at nearly 25 percent of the 102 anomaly locations investigated. All of the surface and buried MPPEH were inspected by the UXO-qualified personnel in the field and were determined to be MDAS (i.e., MD). Although no MEC was found during the RI field work, the number of MD found during the RI field activities is taken into consideration and it is possible that the MD found are represented by a larger population of MPPEH and potentially MEC. Any remaining MEC at the Investigation Area would represent a potential explosive safety hazard and have the potential to release MC to the surrounding environment. It would be expected that if a significant releases of MC were to occur, it would happen at areas with concentrated (i.e., bulk burial or clustered) MEC, which was not the case for the Investigation Area based on the results of the RI field work.

Since no MEC was encountered during the RI field activities, a significant release of MC from the areas where individual or small amounts of MD were found is unlikely. Additionally, no MC-related SRCs were identified during the RI and a discussion of fate and transport of MC at the Investigation Area was unwarranted.

10.4 MEC Hazard Assessment

The *Interim Munitions and Explosives of Concern Hazard Assessment (MEC HA) Methodology* (EPA, 2008) addresses human health and safety concerns associated with potential exposure to MEC at a MRS under a variety of site conditions, including various cleanup scenarios and land-use assumptions. If an explosive hazard is identified for this RI, the MEC HA evaluation will include the information available for the MRS up to and including the RI field activities and provide a scoring summary for the current and future land-use activities. If no explosive hazard is found at the MRS, then there is no need to calculate a MEC HA score because there are no human health safety concerns. No MEC was identified at the MRS during the RI field activities. These results indicate that no MEC source or explosive safety hazard is present at the MRS. Therefore, calculation of a MEC HA score was not warranted for the 40mm Firing Range Investigation Area.

10.5 Conceptual Site Models

The information collected during the RI field activities was used to update the CSM for MEC and to develop the MC CSM for the 40mm Firing Range Investigation Area. The purpose of the CSMs is to identify all complete, potentially complete, or incomplete source-receptor interactions for anticipated future activities at the MRS. An exposure pathway is the course a MEC item or MC takes from a source to a receptor. Each pathway includes a source, activity, access, and receptor.

The National Guard Trainee is identified as the Representative Receptor for both the current and future activities and has the greatest opportunity for exposure to MEC and MC that may be present at the MRS. The defined MC exposure depths for surface soil and subsurface soil at the facility for the National Guard Trainee are 0 to 4 feet and 4 to 7 feet, respectively (SAIC, 2010). Since this RI Report was initiated before the finalization of the U.S. Army's *Final Technical Memorandum: Land Uses and Revised Risk Assessment Process for the Ravenna Army Ammunition Plant Installation Restoration Program* (ARNG, 2014), the Commercial Industrial Land Use using the Industrial Receptor was not included or considered in this RI Report.

The facility has chosen general ecological receptors that provide a range of potential exposures, including high exposures under a variety of conditions. These terrestrial receptors include terrestrial invertebrates (earthworms), voles, shrews, robins, foxes, and hawks (USACE, 2003b). The MC exposure scenario for the environmental receptors is evaluated for the 0-to-1-foot-bgs interval.

10.5.1 MEC Exposure Analysis

No MEC was identified within the 40mm Firing Range Investigation Area during the RI field activities; however, MD associated with the 40mm practice grenades discharged at the former firing range were encountered on the ground surface and subsurface soils. The MD items were found on the ground surface at two locations and at nearly 25 percent of the target anomaly locations at a maximum depth of 8 inches bgs.

Based on the results of the RI field investigations, the use or introduction of munitions at the MRS is confirmed. Because no direct evidence of an explosive hazard exists, the pathways for MEC were considered incomplete for all receptors; however, the amount of various MD found during the RI field work suggests a low potential for MEC to be present at the MRS.

10.5.2 MC Exposure Analysis

Sampling for MC was performed at the 40mm Firing Range Investigation Area at likely areas of release to further characterize the nature and extent of contamination associated with previous activities at the former firing range. No SRCs were identified following the RVAAP data evaluation process, and there are no current risks associated with potential MC at the Investigation Area. Although MD was verified during the RI field activities, given the extent of environmental media coverage achieved for the sampling activities for the RI and the results for the MC characterization, it is unlikely that SRCs will leach from the MD. The CSM for MC has been updated to reflect incomplete pathways for all receptors in the terrestrial environments.

There are no surface water features at the Investigation Area. Therefore, the MC exposure pathways for all receptors at the Investigation Area to the aquatic environments, including surface water and sediment, and the plant/game/fish/prey exposure media are considered incomplete.

Groundwater beneath the RVAAP is evaluated on a facility-wide basis and MRS-specific sampling was not intended for an MRS being investigated under the MMRP unless there is a likely impact from a MEC source. The soil conditions at the Investigation Area are considered to have low permeability, and the depth to groundwater may be as deep as 50 feet bgs. No SRCs were detected in the surface soil samples collected during the RI field activities, and it is not expected that the likely human and ecological receptors will come into contact with groundwater beneath the Investigation Area. Therefore, the MC exposure pathway for groundwater is considered to be incomplete for all receptors.

10.6 Uncertainties

There is uncertainty and limitations associated with the delineation of the 40mm Firing Range Investigation Area based on the results of the DGM survey and the intrusive

investigation. The DGM survey encompassed 0.86 acres of the 8.55-acre Investigation Area, which equates to approximately 10 percent coverage. The "Transect Sampling for UXO Target Traversal" module of VSP® suggested a transect spacing based on the anticipated target size for a typical 40mm Firing Range that ranges from 2 to 10 meters (U.S. Army, 2003). In order to ensure the footprint of the target area was traversed with 100 percent certainty, CB&I proposed a 10-meter transect spacing assuming that not every round hits its intended target when the range was in operation. Two MPPEH items were found on the ground surface during the visual survey and 53 MPPEH items were identified in subsurface soil at nearly 25 percent of the target anomaly locations. All of the MPPEH items were inspected and determined to be MDAS (i.e., MD) by the UXO-qualified personnel in the field. No MEC was found during the RI field activities, which validates the VSP® assumptions; however, the presence of MD at so many of the target locations provides an uncertainty regarding the presence of MEC at the 40mm Firing Range Investigation Area. The ASR (USACE, 2004) states that 2,500 rounds of the 40mm HE rounds were fired at the range when it was in operation and all rounds were accounted for, which reduces the uncertainty that MEC is present at the 40mm Firing Range Investigation Area. This is further supported by the RI field results where no evidence of the 40mm HE rounds was identified.

There is uncertainty and limitations associated with the delineation of MD and potential MEC, particularly along the northern portion of the Investigation Area boundary. Two MD items were encountered within approximately 20 feet of the northern boundary; however, no visual surveys or intrusive investigation step outs were performed outside of the Investigation Area. The nature of a 40mm test range in general is to fire the rounds in a relative straight line at down-range targets; therefore, it is unlikely that many of the 40mm rounds deviated far from the lateral boundaries (north and south) when the test range was active. Furthermore, MD is more prevalent at the central portion of the Investigation Area than compared with the MD along the Investigation Area boundary. It is possible that the lateral extent of MD that may be representative of potential MEC for the 40mm Firing Range Investigation Area is underestimated and may extend beyond the northern boundary; however, based on the use of the area as a down-range target area and the prevalent concentration of MD within the expected central portions of the Investigation Area, the uncertainties are minimal.

10.7 Conclusions

This RI was prepared in accordance with the project DQOs and included evaluations for explosives hazards and potential sources of MC that may pose threats to likely receptors. The following statements can be made for the 40mm Firing Range Investigation Area based on the results of the RI field activities:

- A total of 0.86 acres were investigated at the 8.55-acre Investigation Area during the RI, which exceeds the proposed spatial coverage of 0.7 acres.
- No MEC was encountered during the RI field work at the Investigation Area; however, MD was found on the ground surface and at nearly 25 percent of the target locations at a maximum depth of 8 inches bgs.
- No SRCs were identified in surface soil and there are no hazards associated with MC to the human or ecological receptors at the Investigation Area, including the Resident Receptor (Adult and Child) that is evaluated at the facility for Unrestricted (Residential) Land Use.

The RI included risk assessments for explosives hazards and MC that may pose threats to likely receptors. The field work results suggest it is statistically possible that MEC may be present at the Investigation Area, although confirmed discoveries of MEC have not been made to date. It is recommended that the 1.27-acre MRS be increased to include the 8.55-acre Investigation Area that includes the former firing point location and the impact and overshot areas that made up the former firing range. A Feasibility Study is recommended as the next course of action for the revised MRS to assess possible response action alternatives because some statistical uncertainty remains for MEC. The recommended revised boundaries to the 40mm Firing Range MRS is presented in **Figure 10-1**.

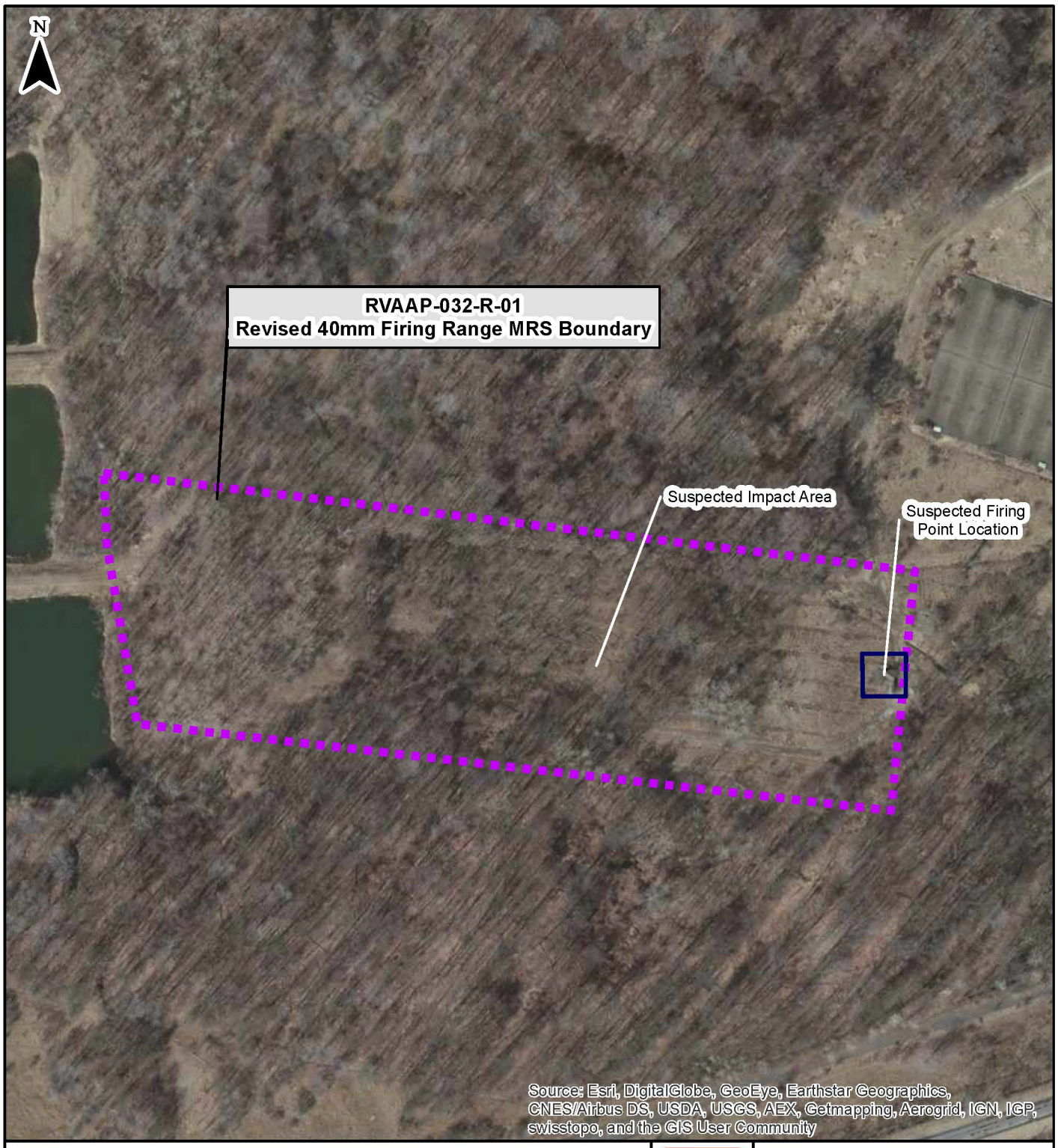

FIGURE 10-1 REVISED MRS BOUNDARY

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Appendix A
Digital Geophysical Mapping Report

Appendix B
Field Documentation

Appendix C
Munitions Data Sheets

Appendix D
Data Validation Report

Appendix E
Laboratory Data Reports

Note: Appendix E is provided electronically on the CD included with this report.

Appendix F
IDW Management

Appendix G
Photograph Documentation Log

Appendix H
Intrusive Investigation Results

Appendix I
Munitions Debris Waste Shipment and Disposal Records

Appendix J
Munitions Response Site Prioritization Protocol Worksheets

Appendix K
Ohio EPA Correspondence

Appendix L
Responses to Ohio EPA Comments

Appendix M
Ohio EPA Approval Letter

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