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14. ABSTRACT

This Remedial Investigation (RI) Report presents the findings and conclusions of the RI field activities conducted at the RVAAP-001-R-01 Ramsdell Quarry Landfill Munitions Response Site (MRS) between May 2011 and August 2013 at the former Ravenna Army Ammunition Plant under the Military Munitions Response Program. The purpose of the RI was to determine whether the Ramsdell Quarry Landfill MRS warrants 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, 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 hazards and risks posed to likely human and ecological receptors by MEC and MC. Additional data is also presented in this RI Report to support the identification and evaluation of alternatives in the Feasibility Study (FS), if required. This RI Report was prepared in accordance with the U.S. Army's Final Munitions Response RI/FS Guidance dated November 2009.

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Reviewed/Approved by: ______________________ Date: September 9, 2014

David Crispo, P.E.
Project Manager

Reviewed/Approved by: ______________________ Date: February 5, 2014

Jody Perwak
Human Health Risk Assessor

Reviewed/Approved by: ______________________ Date: February 5, 2014

Jon Lindberg
Ecological Risk Assessor

Reviewed/Approved by: ______________________ Date: February 5, 2014

Maqsud Rahman
Project Chemist

Prepared/Approved by: ______________________ Date: February 5, 2014

Laura O'Donnell
Project Engineer

Draft Remedial Investigation Report for RVAAP-001-R-01 Ramsdell Quarry Landfill MRS Version 1.0

Former Ravenna Army Ammunition Plant
Portage and Trumbull Counties, Ohio

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US Army Corps of Engineers

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

Prepared by:

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

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Acronyms and Abbreviations

<	less than
°F	degrees Fahrenheit
µg/L	micrograms per liter
ACM	asbestos-containing material
AEDB-R	Army Environmental Database-Restoration Module
AMEC	AMEC Earth and Environmental, Inc.
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	ASTM International
BERA	baseline ecological risk assessment
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*
CFR	Code of Federal Regulations
COC	chemical of concern
COPC	chemical of potential concern
COPEC	chemical of potential ecological concern
Cr^{+3}	trivalent chromium
Cr^{+6}	hexavalent chromium
CSM	conceptual site model
DERP	Defense Environmental Restoration Program
DGM	digital geophysical mapping
DID	Data Item Description
DoD	U.S. Department of Defense
DQO	data quality objective
DQO guidance	*Data Quality Objectives Process for Hazardous Waste Site Investigations*, EPA QA/G-4HW
$e^{2}M$	engineering-environmental Management, Inc.
ELAP	Environmental Laboratory Accreditation Program
EOD	Explosive Ordnance Disposal
EPA	U.S. Environmental Protection Agency
EPC	exposure point concentration
EQM	Environmental Quality Management, Inc.
ERA	ecological risk assessment
ESA	*Endangered Species Act*
ESV	ecological screening value

Acronyms and Abbreviations (continued)

EU	exposure unit
F&T	fate and transport evaluation
FCR	field change request
FWCUG	Facility-Wide Cleanup Goal
FWSAP	*Facility-Wide Sampling and Analysis Plan for the Ravenna Army Ammunition Plant*
GP	general purpose
gpm	gallons per minute
GPS	global positioning system
HA	hazard assessment
HHRA	human health risk assessment
HHRAM	*Facility-Wide Human Health Risk Assessor Manual*
HI	hazard index
HQ	hazard quotient
HRR	*Final Military Munitions Response Program Historical Records Review*
ID	identification
IDW	investigation-derived waste
INRMP	*Integrated Natural Resources Management Plan*
IRP	Installation Restoration Program
ISM	incremental sampling methodology
IVS	instrument verification strip
K_{oc}	organic carbon/water partition coefficient
K_{ow}	octanol/water partition coefficient
lb	pound
LCS	laboratory control sample
Leidos	Leidos Engineering of Ohio, Inc.
LOD	limit of detection
MC	munitions constituents
MD	munitions debris
MDAS	material documented as safe
MDC	maximum detected concentration
MDL	method detection limit
MEC	munitions and explosives of concern
mg/kg	milligrams per kilogram
mm	millimeter(s)
MMRP	Military Munitions Response Program
MPPEH	material potentially presenting an explosive hazard
MRS	Munitions Response Site
MRSPP	Munitions Response Site Prioritization Protocol
MS	matrix spike
MSD	matrix spike duplicate
mV	millivolt(s)

Acronyms and Abbreviations (continued)

N&E	nature and extent evaluation
NA	not applicable/available
NCP	*National Oil and Hazardous Substances Pollution Contingency Plan*
ND	not detected
NGT	National Guard Trainee
NOAEL	no observed adverse effect level
OB/OD	open burning/open detonation
ODNR	Ohio Department of Natural Resources
OHARNG	Ohio Army National Guard
Ohio EPA	Ohio Environmental Protection Agency
PAH	polycyclic aromatic hydrocarbon
PBT	persistent, bioaccumulative, and toxic
PCB	polychlorinated biphenyl
PDS	post-digestion spike
Position Paper	*Ravenna Army Ammunition Plant Position Paper for the Application and Use of Facility-Wide Cleanup Goals*
QA	quality assurance
QC	quality control
QSM	Quality Systems Manual
R(A)	Resident Receptor (Adult)
R(C)	Resident Receptor (Child)
RA	risk assessment evaluation
RCRA	*Resource Conservation and Recovery Act*
RI	Remedial Investigation
RME	reasonable maximum exposure
ROD	Record of Decision
RPD	relative percent difference
RSL	Regional Screening Level
RTK	real-time kinematic
RTS	robotic total station
RVAAP	former Ravenna Army Ammunition Plant
SAIC	Science Applications International Corporation
SAP	*Sampling and Analysis Plan and Quality Assurance Project Plan Addendum for Military Munitions Response Program Remedial Investigation Environmental Services*
Shaw	Shaw Environmental & Infrastructure, Inc.
SI	Site Inspection
SLERA	screening-level ecological risk assessment
SMDP	scientific management decision point
SOP	standard operating procedure
SRC	site-related chemical
SU	standard unit

Acronyms and Abbreviations (continued)

SUXOS	Senior UXO Supervisor
SVOC	semivolatile organic compound
TBC	to be considered
TOC	total organic carbon
TRV	toxicity reference value
U.S.	United States
USACE	U.S. Army Corps of Engineers
USC	U.S. Code
USDA	U.S. Department of Agriculture
USP&FO	U.S. Property and Fiscal Officer
UXO	unexploded ordnance
UXOQCS	UXO Quality Control Supervisor
VQ	validation qualifier
Work Plan	*Final Work Plan for Military Munitions Response Program Remedial Environmental Services*, Version 1.0

EXECUTIVE SUMMARY

This Remedial Investigation (RI) Report documents the finding and conclusions of the RI field activities for the Ramsdell Quarry Landfill (RVAAP-002-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 Ramsdell Quarry Landfill MRS warrants further response action pursuant to the *Comprehensive Environmental Response, Compensation, and Liability Act* (CERCLA) of 1980 and the *National Oil and Hazardous Substances 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 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* (e^2M, 2008; hereafter referred to as the "Site Inspection (SI) Report").

The northern portion of the MRS (Area 1) is collocated with the Ramsdell Quarry Landfill Area of Concern (AOC) and data collected during previous sampling events at the AOC under the Installation Restoration Program (IRP) were also reviewed for applicability for evaluation in this RI Report. The IRP data were reviewed, and it was determined that incorporation of the data was not applicable since the IRP data were not associated with specific source areas as defined under the MMRP. Additionally, different sampling methods were used for the IRP (discrete) versus the MMRP (incremental sampling methodology [ISM]) which makes the data sets between the two events difficult to compare. The ISM samples that were collected during the RI fieldwork were considered to be more representative of current conditions and potential source areas identified at the MRS.

Information and data collected during the SI fieldwork included visual survey data, which were used to preliminarily delineate areas where MEC and/or munitions debris (MD) may been disposed of by open burn/open detonation (OB/OD) activities. Sampling for MC was conducted at the MRS during the SI fieldwork near where MD was found on the ground surface; however, incorporation of the data was not considered applicable since sufficient MC samples were collected during the RI field effort along with a more robust suite of analyses, the RI samples are considered representative of current conditions and identified source areas at the MRS, and the difference in the sampling unit sizes between the two sampling events creates various uncertainties.

The Ramsdell Quarry Landfill MRS is an approximately 13.43-acre area located on the south side of Ramsdell Road and north of Load Line 1. The MRS is composed of two sections: a 6.5-acre northern section (Area 1) where OB/OD operations took place in an old quarry, and a 6.93-acre southern section (Area 2) that contains a small, inactive soil borrow pit and wooded area where installation personnel had previously found MD (e^2M, 2008). Area 1 was initially mined to recover material for roads and construction ballast. When quarry operations were discontinued in 1941, the excavation was reportedly at a depth of 30 to 40 feet below the current surface. From 1946 to 1950, Area 1 was used to thermally treat waste explosives from Load Line 1. In addition, surface burning was performed on approximately 18,000 500-pound (lb) incendiary or napalm bombs. Starting in 1976, the area around Area 1 to the east, west, and south was used as a nonhazardous solid waste landfill. From 1978 until its closure in 1990, the adjacent area operated under a sanitary landfill permit issued by the State of Ohio (e^2M, 2007). The landfill area is not included as part of the MRS; however, small areas of the landfill overlap the southwest and southeast boundaries of Area 1 that is the northern portion of the MRS. Area 1 includes approximately 4.018 acres of moderate quality wetland with standing water as deep as 8 feet (Leidos Engineering of Ohio, Inc., 2014). Approximately 0.5 acres of wetland are present at the eastern portion of Area 2 (AMEC Earth and Environmental, Inc., 2008). There is no available information regarding historical activities that occurred at Area 2 or how MD arrived at this portion of the MRS (e^2M, 2008). Based on the debris found at Area 2 during the RI field work, this portion of the MRS may have been used as a disposal area for the munitions that were thermally treated at Area 1, along with other debris.

Cultural features that remain at the MRS consist mainly of the gravel access road at the northwest corner of the landfill and a former rail bed that bisects Area 1 and Area 2. There are no buildings or other structures present at the MRS.

Current activities at Area 1 include inspections, maintenance, sampling and remedial activities, and natural resource management activities. Current activities at Area 2 include military training and natural resource management activities (Shaw Environmental &

Infrastructure, Inc. [Shaw], 2011). Due to residual asbestos contamination under the IRP, which will require land-use controls/restrictions on the AOC that is collocated with Area 1, future use at Area 1 is anticipated to remain the same as current use (restricted access). Area 2 will be used for military training.

ES.2 Summary of Remedial Investigation Activities

The preliminary MEC and MC conceptual site models (CSMs) for the MRS were developed during the SI (e^2M, 2008) phase of the CERCLA process and were used to identify the data needs and data quality objectives (DQOs) outlined in the *Final Work Plan for Military Response Program Remedial Environmental Services*, Version 1.0 (Shaw, 2011; hereafter referred to as the "Work Plan"). The data needs and DQOs for the MRS were determined at the planning stage and included characterization of MEC and MC associated with former 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. The DQOs identified the following decision rules that were implemented in evaluating the Ramsdell Quarry Landfill MRS:

- Perform a digital geophysical mapping (DGM) investigation to identify if significant areas of buried anomalies were present at the MRS.
- Perform an intrusive investigation of anomalies identified during the geophysical investigation to evaluate if MEC/MD were present at the MRS.
- Perform and underwater investigation to identify if MEC/MD items were present in the sediment in the saturated areas at the MRS.
- Collect additional ISM or discrete soil samples if concentrated MEC/MD items were identified during the target anomaly investigation at the terrestrial portions of the MRS.
- Process the information to evaluate whether there were unacceptable risks to human and ecological receptors associated with MEC/MC and make a determination if further investigation was required under the CERCLA process.

Geophysical Investigation

From May through August of 2011, a DGM investigation was performed at the Ramsdell Quarry Landfill MRS to identify potential subsurface areas of MEC and/or MD. The DGM data were collected in all accessible areas within the MRS and the spatial coverage was calculated to be 4.19 acres. This represents an area coverage of 35 percent and exceeded the proposed sampling coverage of 4.16 acres presented in the Work Plan (Shaw, 2011). Within

Area 1, the DGM data were acquired over transects spaced approximately 3 meters (10 feet) apart over the land-based areas and shallow surface water areas which resulted in a spatial coverage of 2.05 acres. Within Area 2, approximately 2.14 acres of DGM data were acquired over six 0.25-acre grids and portions of thirteen 0.25-acre grids.

Interpretation of the geophysical data indicated that the anomaly density at Area 1 was saturated along the along the west and east portions and towards the center of the MRS that were inundated with water. The area of highest anomaly densities was at the east side of Area 1. Regions that exhibited relatively low densities were also present within Area 1, particularly at the northern portion of Area 1. At Area 1, 595 anomalies with signal intensities greater than 4 millivolts (mV) on Channel 2 were identified for potential intrusive investigation.

The anomaly density at Area 2 was found to be relatively low and distributed throughout the area; however, highly saturated linear target features were identified near the northwest corner and the southern portions of Area 2 that were believed to be a cultural features (i.e., utility lines). A total of 558 anomalies with signal intensities greater than 4 mV were identified for potential intrusive investigation at Area 2.

Anomaly Selection

Distinct zones of localized high anomaly density along the edges of Area 1 were identified during the DGM investigation, and eight trenches were proposed for intrusive investigation. No areas of high anomaly density were identified at Area 2 that required investigation using the trenching methodology.

In Area 2, 100 percent of the 558 individual target anomalies at signal intensities greater than the 4-mV threshold were selected for intrusive investigation since less than full DGM coverage was completed for this area. The anomaly selection criterion of 4 mV was in accordance with the Work Plan (Shaw, 2011). Additionally, the linear features at Area 2 were selected for intrusive investigation based on recommendations made by the USACE.

In Area 1, 595 anomalies were identified as potential targets for intrusive investigation per the anomaly selection criteria presented in the Work Plan (Shaw, 2011). Intrusive activities at Area 2 were completed prior to the anomaly selection process for Area 1 and the results indicated that nearly 30 percent of the anomalies at signal intensities less than 5 mV were “no finds.” Based on the results of the Area 2 intrusive investigation, as well as the results of the instrument verification strip installed at Load Line 7 where smaller MEC items in the near-surface produced responses exceeding 8 mV (Channel 2), it was proposed to investigate 100 percent of anomalies greater than or equal to 8 mV (491 anomalies) and to randomly select and investigate 50 percent of the anomalies between 4 and 8 mV (52 anomalies). In all, 543 anomalies were selected for intrusive investigation in Area 1. It was proposed that if any MEC/MD items were identified from the 52 randomly selected anomalies below 8 mV, then the remaining 50 percent of anomalies in Area 1 would be investigated.

Intrusive Investigations

Anomaly reacquisition and intrusive investigation activities for Area 2 were performed between July and August 2011. Within Area 2, 565 individual anomalies were selected for the intrusive investigation and 508 anomalies (90 percent) were successfully reacquired. The findings of the intrusive investigation resulted in no MEC; however, 187 MD items were found at 161 locations. The MD items found consisted of fragments and parts associated with the 20-lb AN-M41 series bomb, the 155-millimeter MK-1 series projectile, the 250-lb AN-M57 series general purpose (GP) bomb, and the 500-lb AN-M64 series GP bomb. Although not considered as MD, small arms ammunition consisting of expended 12-gauge shells was found at three of the target locations. The maximum depth of MD was 24 inches; however, most MD was encountered at depths less than 6 inches. In all, 635 lbs of MD was found during the intrusive investigation activities at Area 2. The remaining target locations consisted primarily of “Other Debris” at depths between the ground surface to a maximum depth of 48 inches. The “Other Debris” consisted of materials such as wire, pipes, nails, bolts, cables, remnants of rusted drums, slag (i.e., hot rocks), and miscellaneous scrap metal items. The combined total weight of the “Other Debris” at Area 2 was approximately 300 lbs.

Anomaly reacquisition activities were conducted at Area 1 in November 2011 and 536 of the 543 point-source anomalies identified for intrusive investigation were successfully reacquired (98.7 percent). The intrusive investigation activities were delayed at Area 1 until adequate investigation controls and procedures associated with the potential for encountering buried asbestos-containing material (ACM) were approved by the Army. The intrusive investigation activities at Area 1 commenced in August 2013; however, the water levels in the quarry pond had increased significantly since the November 2011 reacquisition activities, and only 410 of the 536 reacquired point-source anomaly locations (76 percent) and 6 of the 8 trenches at the areas of high anomaly density were successfully investigated. No MEC or MD was identified at any of the trenches or the individual target anomaly locations that were successfully investigated. Approximately 3,499 lbs of “Other Debris” items that consisted primarily of miscellaneous scrap metal and iron were identified between the investigated trench locations and the individual point-source anomaly locations. The maximum depth of the intrusive investigations at any of the target locations at Area 1 was approximately 5 feet below ground surface (bgs).

Underwater Investigation

On August 6, 2011, former Navy Explosive Ordnance and Disposal divers performed an underwater investigation for potential MEC over the bottom of the Area 1 quarry pond that covered approximately 1 acre. The underwater investigation identified small quantities of metallic debris; however, no evidence of MEC or MD was found. The metal debris consisted primarily of construction debris and miscellaneous scrap metal and iron. Most of the debris was encountered in the sediment along the southeast portion of the saturated area and is consistent with the high anomaly density areas at the land-based area at this portion of Area 1 that were intrusively investigated during the RI field activities.

MC Sampling

The determinations as to whether MC characterization was required at the Area 1 and Area 2 portions of the MRS were made based on the recommendations made in the SI Report (e^2M, 2008), historical activities that occurred at the MRS, the types of munitions that may have been treated/disposed at the MRS, and the results of the RI intrusive investigation. The DQOs stated that samples may be collected at the MRS in surface and/or subsurface soil using the ISM and/or discrete methods where concentrated MEC or MD was found, if any (Shaw, 2011). Areas of concentrated MD were encountered during the intrusive investigation activities at Area 2, and two ISM surface soil samples were collected at locations that were biased to where MC would be expected to be found. The ISM soil samples were collected at same sized sampling units (0.46 acres each) and at the same depth interval (0 to 0.5 feet). The sampling units were combined to make up the decision unit for surface soil at the Area 2 section of the Ramsdell Quarry Landfill MRS. No MEC or MD was found at Area 1 during the RI fieldwork; therefore, no samples were required to be collected for MC characterization at this portion of the MRS.

ES.3 MEC Hazard Assessment

The *Interim Munitions of Concern Hazard Assessment Methodology* (U.S. Environmental Protection Agency [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 was identified for the RI, the MEC hazard assessment (HA) would 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 was found at the MRS, then there would be no need to calculate a MEC HA score since there were no human health safety concerns. These results of the RI fieldwork indicated that no MEC source or explosive safety hazard was present at the MRS. Therefore; calculation of a MEC HA was not warranted for the Ramsdell Quarry Landfill MRS.

ES.4 MC Risk Assessment Summary

The site-related chemicals (SRCs) were determined for the surface soil samples collected at the Area 2 section of the Ramsdell Quarry Landfill MRS during the RI field activities through the data screening process as presented in the *Ravenna Army Ammunition Plant Position Paper for the Application and Use of Facility-Wide Cleanup Goals* (USACE, 2012). The surface soil samples were analyzed for the identified MC associated with historical munitions-related activities at the MRS that included metals (aluminum, antimony, barium, cadmium, chromium [total and hexavalent], copper, iron, lead, mercury, strontium, and zinc), explosives, nitrocellulose, semivolatile organic compounds (SVOCs), polychlorinated biphenyls (PCBs), total organic carbon, and pH. The detected chemicals that were retained as SRCs in the surface soil samples following the screening process included the following:

- *Explosives and Propellants:* nitroguanidine
- *Metals:* antimony, cadmium, chromium, chromium (as trivalent chromium [Cr^{+3}]), copper, lead, mercury, and strontium
- *SVOCs*: bis(2-ethylhexyl)phthalate, di-n-butyl phthalate, and fluoranthene

No PCBs were detected in the surface soil samples. The identified SRCs were then carried through the human health risk assessment (HHRA) and ecological risk assessment (ERA) process to evaluate for potential receptors. The risk assessment results are presented below.

Human Health Risk Assessment

An HHRA was conducted for the surface soil samples that were collected at the Area 2 portion of the Ramsdell Quarry Landfill MRS to determine if the SRCs identified were chemicals of concern (COCs) that may pose a risk to current or future human receptors. The future land use at Area 2 is military training and the Representative Receptor is the National Guard Trainee. The evaluation of the receptor for military training, in conjunction with the evaluation of the Resident Receptor (Adult and Child) for Unrestricted Land Use, form the basis for identifying COCs in the RI. Evaluation for Unrestricted Land Use is performed to assess for baseline conditions and the no action alternative under CERCLA, and as outlined in the *RVAAP's Facility-Wide Human Health Risk Assessor Manual* (USACE, 2005). 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.

Ecological Risk Assessment

An ERA was completed for the surface soil samples collected at Area 2 to evaluate for chemicals of potential ecological concern (COPECs) that may pose a risk to the ecological receptors. COPECs are determined in the ERA and may differ from COPCs that are identified in the HHRA. Seven COPECs were identified in the surface soil samples: five metals (antimony, cadmium, chromium [as Cr^{+3}], lead, and mercury), one propellant consisting of nitroguanidine, and one SVOC consisting of di-n-butylphthalate. Based on the COPEC evaluation process presented in the ERA and the subsequent weight of evidence discussion, no COPECs were recommended for further evaluation in a Level III Baseline for the surface soil samples collected at Area 2.

ES.5 Conceptual Site Models

The information collected during the RI field activities were used to update the CSMs for MEC and MC for the Ramsdell Quarry Landfill MRS as presented in the SI Report (e^2M, 2008). The purpose of a CSM is to identify all complete, potentially complete, or incomplete source-receptor interactions for current and 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.

MEC Exposure Analysis

A statistical approach using the UXO Estimator® module was taken for the characterization of MEC at the Ramsdell Quarry Landfill MRS and portions of the MRS were investigated by visual survey, DGM survey, and intrusive investigation to provide a statistical confidence for the proportion of MEC to non-MEC related material. The agreed upon inputs into the module was 95-percent confidence and 0.5 MEC per acre assuming 100 percent of identified targets are investigated. In actuality, not all of the selected targets were successfully investigated. At Area 1, nearly 100 percent of the selected targets were successfully reacquired; however, only 76 percent of the reacquired targets could be investigated due to the increase in water levels between the reacquisition and intrusive investigation activities. At Area 2, 90 percent of the selected targets were successfully reacquired and investigated. No MEC was encountered at the MRS during the intrusive investigation activities; however, 187 MD items were confirmed to be present either on the ground surface or in the subsurface at Area 2. The MD items were solid and/or inert, and posed no explosives safety hazards. An underwater tactile investigation was also performed at the quarry pond in Area 1 and no evidence of MEC or MD was found.

Based on the results of the RI field investigation, the use or introduction of munitions at the MRS is confirmed. However, since no MEC was found during the RI fieldwork, the calculated MEC density met the target density of 0.5 MEC per acre at a 95-percent confidence level and indicates that the performance criteria were achieved. Statistically, there is a potential for remaining MEC since not all of the target anomalies were successfully investigated; however, the uncertainty is low since no MEC was found during the fieldwork. Because no direct evidence of an explosive hazard exists, the pathways for MEC were considered incomplete for the Ramsdell Quarry Landfill MRS.

MC Exposure Analysis

The HHRA and ERA determined that the detected SRCs in surface soil at Area 2 are not present at concentrations great enough to pose risks to the human and ecological receptors. For the development of the MC CSM in Area 1, the findings of no MEC, material potentially presenting an explosive hazard (MPPEH), or even MD that would be indicative of a MC source, are taken into consideration. Low concentrations of explosives were detected in surface soil and dry sediment at Area 1 under the IRP; however, the only COCs identified for human receptors at Area 1 during previous investigations under the IRP were SVOCs. It is possible that the SVOCs originated from the historical OB/OD activities that occurred at Area 1; however, there is no evidence to suggest that they originated solely from these activities. Additionally, the Army has determined that the SVOCs identified as COCs in surface soil and dry sediment at Area 1 will continue to be addressed under the IRP. Therefore, there is no known or suspected MC hazard at the MRS and the CSM for MC has been updated to reflect incomplete pathways for all human and ecological receptors.

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 significant impact from a MEC source. A MEC source was not found during the RI field activities; however, various MD items were encountered in the surface and subsurface soil. Although SRCs were detected in environmental media that was sampled during the RI fieldwork, evaluation for fate and transport of the chemicals indicates that that groundwater has likely not been impacted from past munitions-related activities at the MRS. Additionally, it is not expected that the human or ecological receptors will come into contact with groundwater at the MRS. No groundwater samples were collected at the Ramsdell Quarry Landfill MRS during the RI fieldwork and the MC exposure pathway for groundwater was considered 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 the human and environmental receptors. The following statements can be made for the Ramsdell Quarry Landfill MRS based on the results of the RI field activities:

- DGM coverage was completed over 4.19 acres at the MRS during the RI, which exceeded the proposed spatial coverage of 4.16 acres.
- No MEC was encountered during the intrusive investigation activities at the MRS; however, MD was found at Area 2 only at depths between ground surface and 24 inches bgs.
- An underwater tactile investigation was performed at the quarry pond in Area 1, and no MEC or MD was found.
- The detected SRCs in surface soil at Area 2 do not pose potential risks to the human and ecological receptors at the MRS.

The RI included risk assessments for explosives hazards and MC that may pose threats to human and ecological receptors. The RI field work suggests that it is statistically possible that MEC or MPPEH may remain at both the Area 1 and Area 2 portions of the MRS, although no confirmed discoveries have been made to date. MD was found during the RI field work at Area 2 only; however, the items were solid and/or inert and posed no explosives safety hazard. The risk assessments for MC prepared for this RI Report indicated the detected SRCs at Area 2 did not pose risks to any human or ecological receptors. MC at Area 1 will continue to be addressed under the IRP.

A Feasibility Study is recommended under the MMRP as the next course of action for the Area 2 portion of the MRS to assess possible response action alternatives where concentrated areas of MD were found and some statistical uncertainty remains for MEC. No Further Action is recommended under the MMRP for Area 1, since there is no evidence of MEC/MD. Following a No Further Action determination for Area 1, the Ramsdell Quarry Landfill MRS should be reduced to include the 6.93-acre Area 2 only.

1.0 INTRODUCTION

This Remedial Investigation (RI) Report documents the finding and conclusions of the RI field activities for the Ramsdell Quarry Landfill (RVAAP-001-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 Ramsdell Quarry Landfill MRS between July 2011 and August 2013. This RI Report was developed in accordance with the *Final Work Plan for Military Munitions Response Program Remedial Environmental Services*, Version 1.0 (Shaw Environmental & Infrastructure, Inc. [Shaw], 2011; hereafter referred to as the "Work Plan") 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* (CERCLA) of 1980 prescribed sequence of RI, Feasibility Study, Proposed Plan, and Record of Decision (ROD). 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 health and the environment 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. 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 Ramsdell Quarry Landfill 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 human and ecological receptors by MEC and MC.

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

1.2 Problem Identification

The Ramsdell Quarry Landfill MRS is comprised of two sections: a northern section (Area 1) and southern section (Area 2). Area 1 was initially mined to recover material for roads and construction ballasts. When quarry operations were discontinued in 1941, the excavation was reportedly at a depth of 30 to 40 feet below the current surface. Between 1946 and 1950, Area 1 was used for open burning/open detonation (OB/OD) operations such as the thermal treatment of waste explosives from Load Line #1 and surface burning of approximately 18,000 500-pound (lb) incendiary or napalm bombs. Numerous spent 81-millimeter (mm) mortar rounds have been reportedly observed lying on the ground surface at Area 1; however, the date the rounds were found and the locations of the rounds are unknown. Area 2 contained a small inactive soil borrow pit and wooded area where facility personnel had found munitions debris (MD) (engineering-environmental Management, Inc. [e^2M], 2007).

A Site Inspection (SI) was conducted at the MRS in 2007 and the field activities included a meandering path magnetometer and metal detector–assisted unexploded ordnance (UXO) survey. These activities were completed in the northern quarry area at Area 1 and at the southern soil borrow pit at Area 2 where little historical data exists. Subsurface anomalies were detected at Area 1, specifically around the pond; however, no evidence of MEC was observed at any of the areas at the MRS. One empty 105mm ceremonial shot cartridge and one empty 155mm shot round were found at two locations at Area 2 during the SI field work. Four surface soil samples were collected using the incremental sampling methodology (ISM) within Area 2, and lead and manganese were identified to be potential MC at one of the sample locations (e^2M, 2008).

The *Final Site Inspection Report* (e^2M, 2008; hereafter referred to as the “Site Inspection (SI) Report”) recommended “Further Characterization” for MC at Area 2 where the detected chemicals considered as MC was identified and “Further Characterization” for the presence of MEC buried at the land-based areas and submerged in the quarry pond at Area 1.

1.3 Physical Setting

This section presents the physical characteristics of the facility, the Ramsdell Quarry Landfill MRS, and the surrounding environments that are factors in understanding fate and transport, conceptual site models (CSMs), and exposure scenarios for potential human health and ecological hazards and 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 MRS and the *Integrated Natural Resources Management Plan and Environmental Assessment for the Ravenna Training and Logistics Site and the Ravenna Army Ammunition Plant* (AMEC Earth and Environmental, Inc. [AMEC], 2008; hereafter referred to as the "Integrated Natural Resources Management Plan [INRMP])" 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. The facility is surrounded by the communities of Windham, Garrettsville, Newton Falls, Charlestown, and Wayland (**Figure 1-1**).

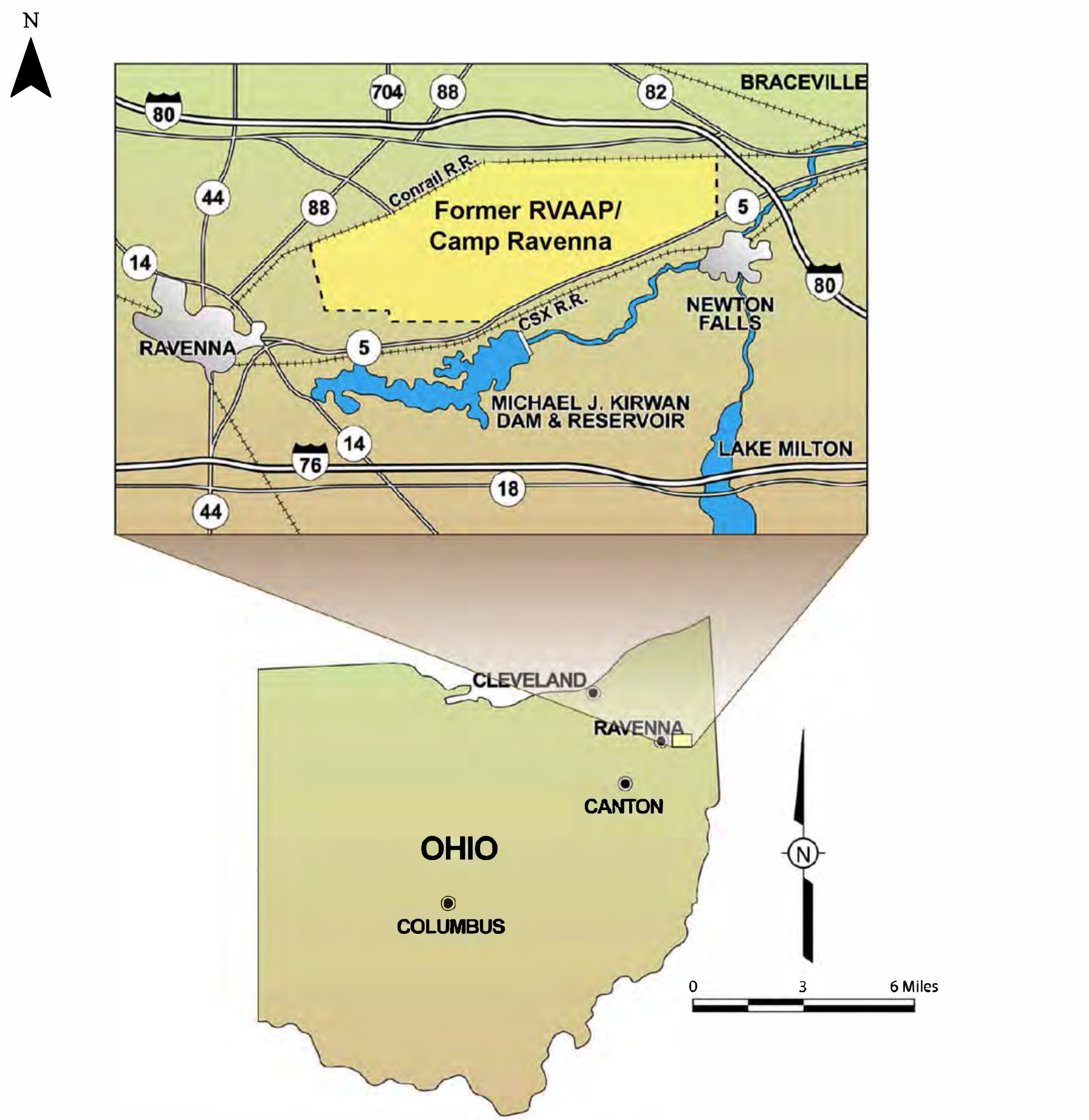
Administrative control of the 21,683-acre facility has been transferred to the U.S. Property and Fiscal Officer for Ohio (USP&FO) and subsequently licensed to the OHARNG for use as a training site, Camp Ravenna. The restoration program involves cleanup of former production areas across the facility related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

The Ramsdell Quarry Landfill MRS is located in the central portion of the facility and consists of two separate sections (Area 1 and Area 2) that total approximately 13.43 acres (**Figure 1-2**). The northern portion of the MRS (Area 1) is collocated with the Ramsdell Quarry Landfill Area of Concern (AOC). 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 Ramsdell Quarry Landfill MRS. The table includes the RVAAP Army Environmental Database-Restoration Module numerical designation for the MRS, the current MRS acreage, and the agencies responsible for the MRS.

Table 1-1
Administrative Summary of the Ramsdell Quarry Landfill MRS

MRS Name	AEDB-R MRS Number	MRS Area (acres)	Property Owner	MRS Management Responsibility
Ramsdell Quarry Landfill	RVAAP-001-R-01	13.43	USP&FO	ARNG/OHARNG

AEDB-R denotes Army Environmental Database-Restoration Module.
ARNG denotes Army National Guard.
MRS denotes Munitions Response Site.
OHARNG denotes Ohio Army National Guard.
USP&FO denotes U.S. Property and Fiscal Officer.



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

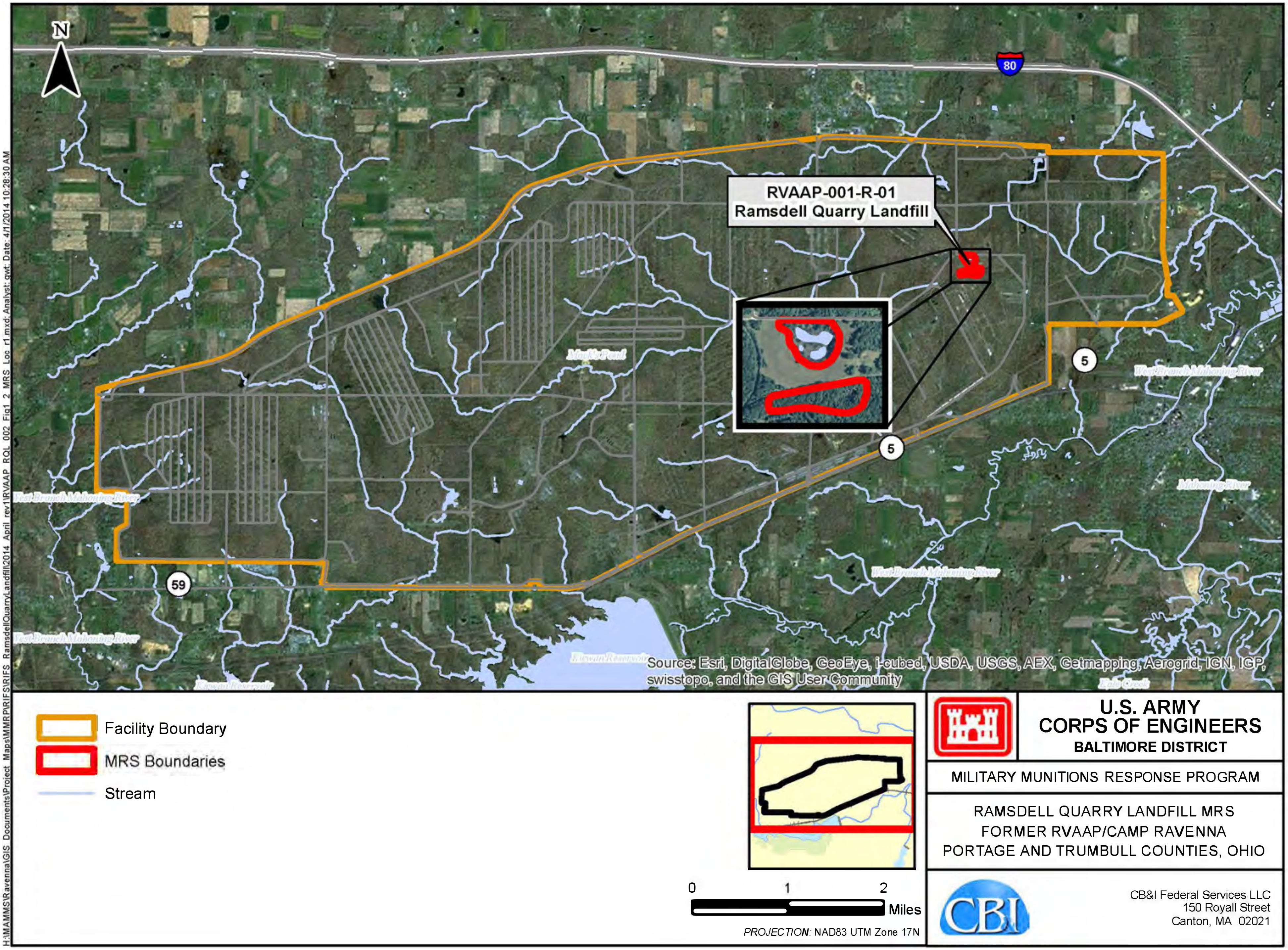

FIGURE 1-2 MRS LOCATION MAP

1.3.2 Current and Projected Land Use

This section presents the current and future land use for the Ramsdell Quarry Landfill MRS. The future land use description is based on information provided in the *RVAAP's Facility-Wide Human Health Risk Assessor Manual* (USACE, 2005; hereafter referred to as the "Human Health Risk Assessor Manual" [HHRAM]) and information provided by the OHARNG during preparation of the Work Plan (Shaw, 2011).

Current activities at Area 1 include inspections, maintenance, sampling and remedial activities, and natural resource management activities. Current activities at Area 2 include military training and natural resource management activities. Potential users associated with the current land uses at the MRS include facility personnel, contractors, and potential trespassers (e^2M, 2008).

The future land use of Area 1 is anticipated to remain the same as the current use (restricted access), and the Representative Receptor for Area 1 is the Security Guard/Maintenance Worker. The future land use of Area 2 will be military training, and the Representative Receptor for Area 2 is the National Guard Trainee (Shaw, 2011).

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. 20 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 is prevalent in the province. Rounded ridges, filled major valleys, and areas covered with glacially derived unconsolidated deposits were the products 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).

Ramsdell Quarry Landfill MRS Topography

The majority of Area 1 at the MRS is located in a depressed area that was the former quarry. The topography in Area 1 ranges from approximately 960 feet above mean sea level (amsl) at the bottom of the former quarry to approximately 980 feet amsl along Ramsdell Road at the northern boundary of Area 1. The remainder of Area 1 is surrounding by the closed landfill that has a topographical high of approximately 995 feet amsl. In Area 1, natural drainage at the land-based portions of the MRS and the surrounding landfill is toward the quarry pond.

The topography at the Area 2 portion of the MRS is relatively flat with ground surface elevation gradually ranging upgradient to the west from approximately 975 to 990 feet amsl. A topographical low of 970 feet amsl is presented in the former soil borrow pit at the eastern portion of Area 2. Natural drainage at Area 2 appears to follow the local topography.

A former rail bed bisects Area 2 and the southern portion of the closed landfill that is between Area 1 and Area 2. The elevation of the former rail bed is approximately 10 feet lower than the surrounding topography and presents a definitive separation between the two areas. The topographical features at and in the vicinity of the Ramsdell Quarry Landfill MRS are presented in **Figure 1-3**.

1.3.5 Geology and Soils

Based on regional geology, the facility consists of Mississippian and Pennsylvanian-age bedrock strata, which dip 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-aged 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.

FIGURE 1-3 TOPOGRAPHY

Bedrock is present near the ground surface in many locations at the facility, including Load Line #1 at the east end of 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 a 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 (informally referred to as the Sharon Conglomerate) is identified as a 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 (informally referred to as the Sharon Shale) is identified as light to dark gray fissile shale. This unit 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 a sporadic, relatively thin channel of 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 a well-sorted, coarse-grained, white-quartz sandstone to a 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 (e^2M, 2008).

The soils identified at the facility are generally derived from the Wisconsin-age silty clay glacial till and are silt or clay loams ranging in permeability from 6.0×10^{-7} to 1.4×10^{-3} centimeters per second (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).

Ramsdell Quarry Landfill MRS Geology and Soils

The Ramsdell Quarry Landfill MRS is located over the Sharon Sandstone conglomerate unit, and the bedrock elevation is relatively level at just over 950 feet amsl. The bedrock elevation gradually declines to the south. Soil depth at the quarry bottom in Area 1 varies from exposed bedrock to greater than 2 feet. The average depth of soil overlying bedrock at the quarry bottom is approximately 7 inches (SAIC, 2013). The average depth to bedrock at Area 2 is approximately 5 feet bgs with areas of exposed bedrock at the former soil borrow pit (SAIC, 2005). **Figure 1-4** presents the bedrock geology at the MRS.

The native soil types at the MRS were substantially reworked and surface soils were removed during former operation as a rock quarry at Area 1 and a soil borrow pit at the eastern portion of Area 2. The soil classification for Area 1 is described as pits and quarries. The native soils at Area 1 consist of the Loudonville silt loam with 2 to 6 percent slopes and the only native soils that remain here are located at the northern portion of Area 1, along the slope adjacent to the south of Ramsdell Road. The native soils at Area 2 are the Mitiwanga silt loam with 0 to 2 percent slopes. **Figure 1-5** presents the soil types identified at the MRS (AMEC, 2008).

The Loudonville silt loam with 2 to 6 percent slopes is a gently sloping soil on the upper part of the hillsides and on hill crests. This soil series consists of moderately deep gently sloping to steep soils that formed partly in glacial till and in residuum weathered from the underlying sandstone bedrock. These soils are found on uplands throughout Portage County. Loudonville soils have a moderate deep root zone and a moderate to low available water capacity. Permeability above the sandstone bedrock is moderate. These soils warm up and dry out quickly in spring (USDA et al., 1978).

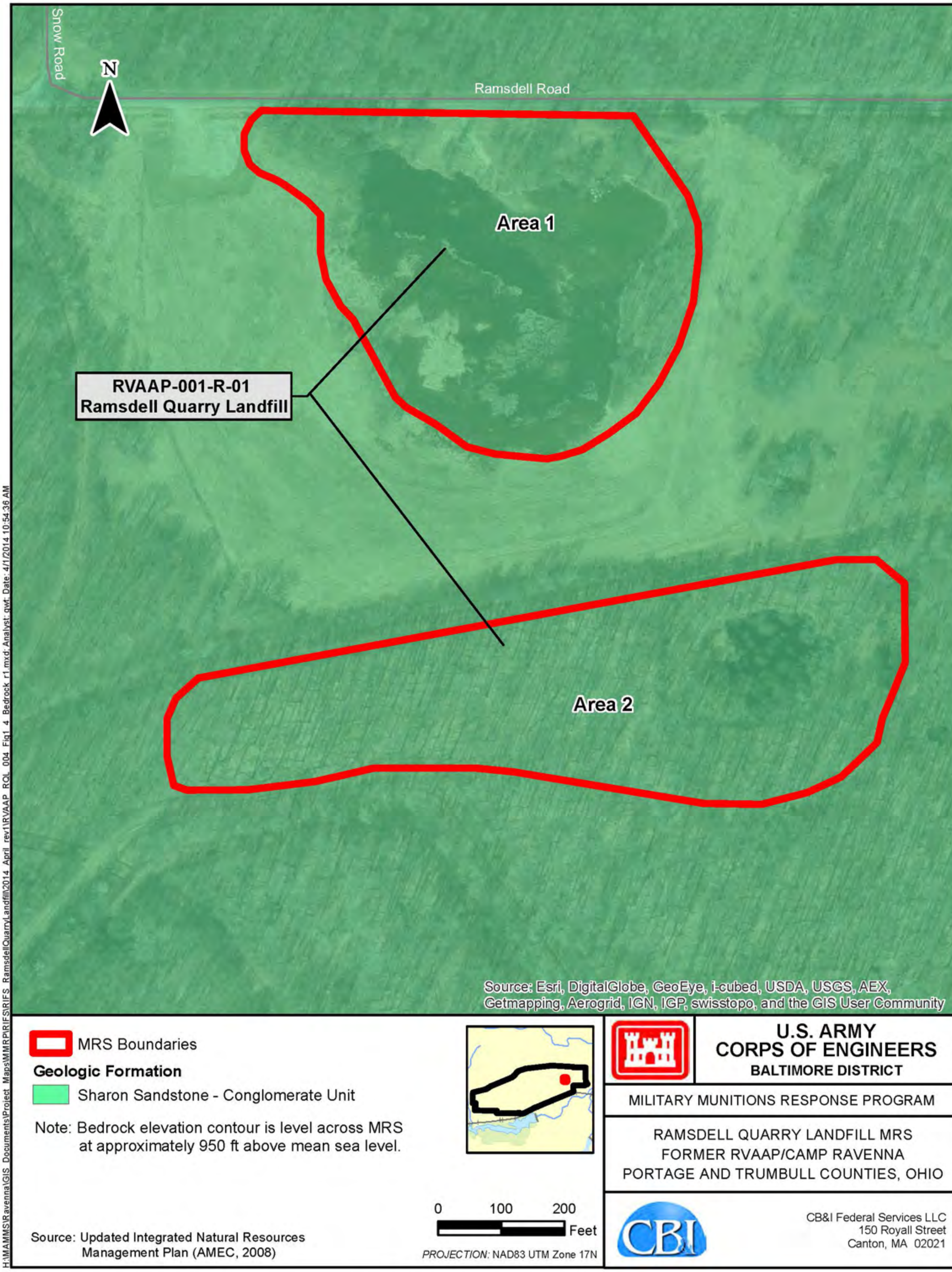

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FIGURE 1-4 BEDROCK MAP

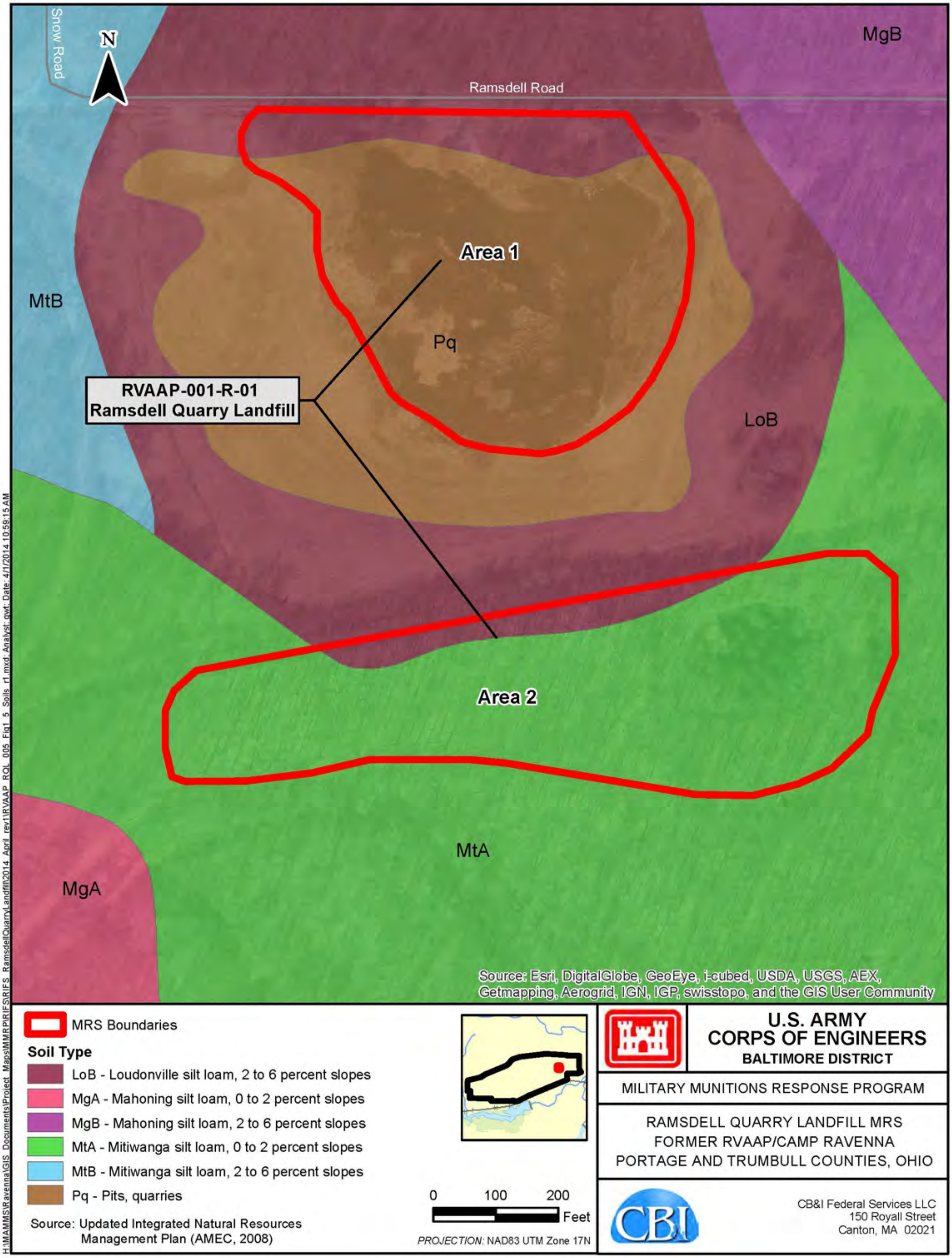

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FIGURE 1-5 SOILS MAP

The Mitiwanga silt loam consists of moderately deep, somewhat poorly drained, nearly level to gently sloping soils that formed in glacial till 20 to 40 inches thick overlying sandstone bedrock. These soils are on undulating uplands. Mitiwanga soils have a moderately deep root zone and a moderate available water capacity. Permeability is moderate. These soils have a water table near the surface late in winter and in spring (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).

Three primary watercourses drain the facility: (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 Ramsdell Quarry Landfill MRS. 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 (AMEC, 2008).

Ramsdell Quarry Landfill MRS Surface Water Features

In 2008, EnviroSciences, Inc., under contract to SAIC, performed a delineation of wetlands and other waters at three sites at the facility, including the Ramsdell Quarry Landfill/Ponds. This effort identified 4.039 acres of isolated palustrine emergent wetland which developed in the abandoned quarry (Area 1) within the MRS (EnviroSciences, Inc., 2008). The wetland delineation activities conducted by EnviroSciences, Inc. at the Ramsdell Quarry Landfill/Ponds did not include Area 2.

A planning-level survey for wetlands was conducted at the facility and included both Area 1 and Area 2 at the MRS (AMEC, 2008). In addition to the wetlands and open water identified in Area 1, approximately 0.5 acres of wetland were identified in the former soil borrow pit at the eastern portion of Area 2 and along the Area 2 eastern boundary. No bogs, kettle lakes, or kames have been identified as being present within the MRS. Wetland areas identified at the MRS between the 2008 wetland delineation and the planning-level survey are shown on **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.

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 its south-central portion. 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 as well as 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 permeabilities than surrounding clay or silt-rich material (USACE, 1998).

Depending on the existence and depth of overburden, the Sharon Member ranges from an unconfined to a leaky artesian aquifer. Water yields from water supply wells at the facility that were completed in the Sharon Member were 30 to 400 gallons per minute (gpm) (U.S. Army Toxic and Hazardous Materials Agency, 1978). Well yields of 5 to 200 gpm were reported for on-site bedrock wells completed in the Sharon Member (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 and White, 1966).

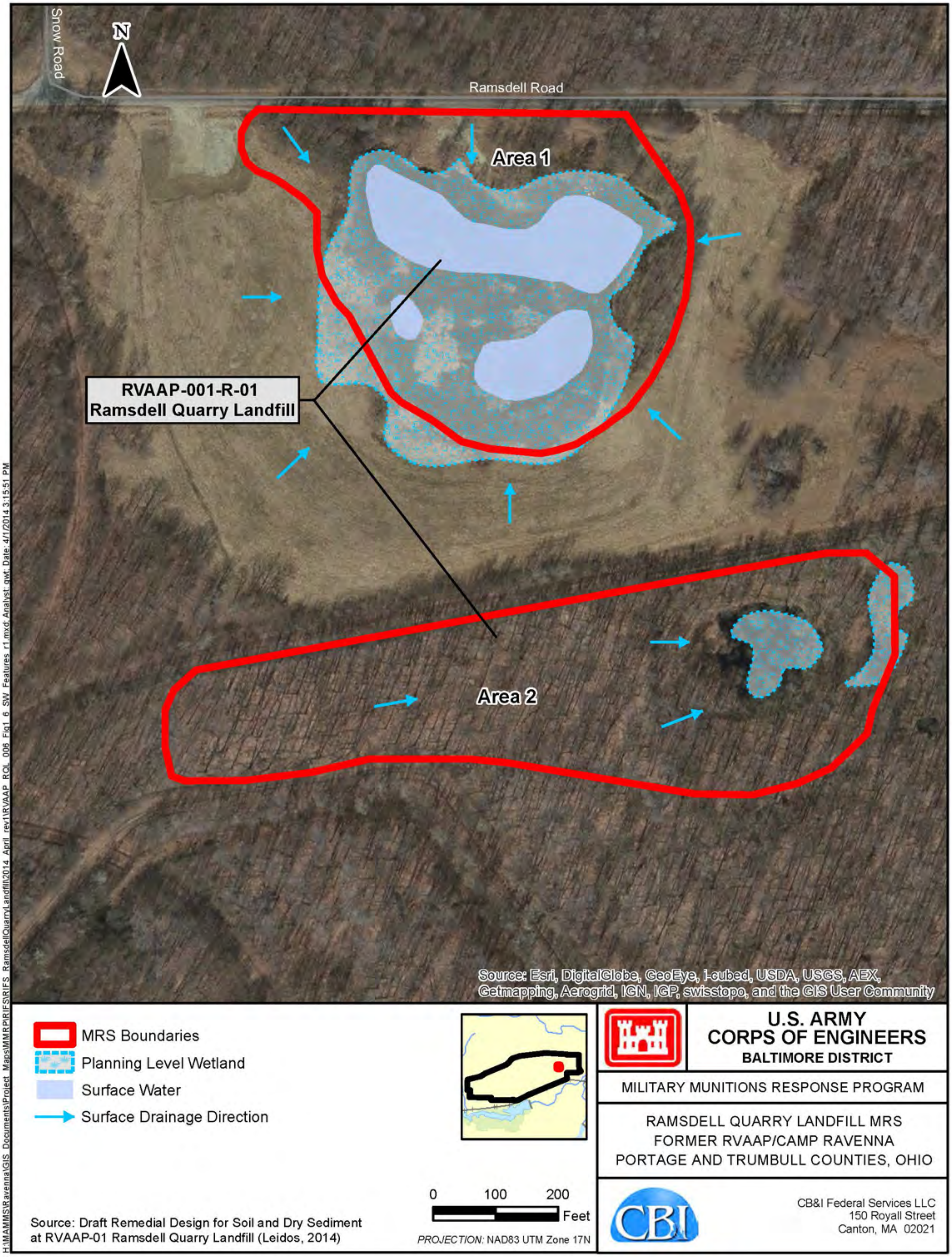

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FIGURE 1-6 SURFACE WATER FEATURES MAP

Ramsdell Quarry Landfill MRS Hydrology and Hydrogeology

Although groundwater recharge and discharge areas have not been delineated at the facility, it is assumed that the extensive uplands areas, 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 Ramsdell Quarry Landfill MRS is located in the central, more level portion of the facility and is not presumed to be in a groundwater recharge area.

The depth to groundwater at the MRS ranges from approximately 0 to 39.5 feet bgs with groundwater elevations between 971 and 994 feet amsl. The quarry pond at Area 1 is significantly lower than the surrounding landfill and groundwater and surface water has the potential to interact at this portion of the MRS. Groundwater at Area 2 is consistently deeper at approximately 30 feet bgs across this portion of the MRS. The depth-to-groundwater measurements were taken from existing monitoring wells that are primarily installed in shallow bedrock at the collocated AOC under the IRP (SAIC, 2005) and from potentiometric data presented under the facility-wide groundwater monitoring program (Environmental Quality Management, Inc. [EQM], 2012). Many of these wells are still used as part of the facility-wide groundwater monitoring program and as part of the *Resource Conservation and Recovery Act* (RCRA) monitoring requirements for the closed landfill portion of the AOC.

During the wet season of the year, a sufficient reservoir of water exists in the quarry pond at Area 1 to induce a downward vertical hydraulic gradient (recharge) and produce flat hydraulic gradients across the site. Groundwater at the Ramsdell Quarry Landfill MRS generally flows to the northeast; however, rainfall events during the wet period of the year produce slight, localized flow gradient reversals between the pond and hydrologic upgradient locations for short periods of time (SAIC, 2005).

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).

Ramsdell Quarry Landfill MRS Vegetation

The plant communities at the Ramsdell Quarry Landfill MRS are predominantly characterized as Mixed Swamp Forest and Wetfields. Portions of the Red Maple Woods and Submergent Marsh plant communities are found along the eastern edge of Area 2 and northern edge of Area 1, respectively (AMEC, 2008). The wetlands and other waters delineation conducted by EnviroSciences, Inc. identified the predominant vegetation in the quarry bottom at Area 1 to consist of invasive species such as *Typha angustifolia* (narrowleaved cattail), *Phragmites australis* (reed grass), and reed canary grass (EnviroSciences, Inc., 2008). Wetland delineation was completed at the former quarry at Area 1 in September 2013 by Leidos Engineering of Ohio, Inc. (Leidos). The delineation effort determined the size of the wetland to be approximately 4.081 acres and it scored 39.5 on the Ohio Rapid Assessment Method for wetlands, which classifies it as a Modified Category 2 wetland (Leidos, 2014). **Figure 1-7** illustrates the plant communities at the Ramsdell Quarry Landfill MRS.

1.3.9 Threatened, Endangered, and Other Rare Species

Federal status as a threatened or endangered species is derived from the *Endangered Species Act* (ESA; 16 U.S. Code [USC] § 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 listed species or critical habitats at the facility. State-listed plant and animal species are determined by the Ohio Department of Natural Resources (ODNR). Biological inventories have not occurred within the MRS boundary and no confirmed sightings of state-listed species have been reported; however, there is the potential for state-listed or rare species to be within the MRS boundary. Information regarding federal- and state-listed endangered, threatened, and candidate species at the facility was obtained from the *2013 Federal and State Listed Species* (Camp Ravenna, 2013). **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 Federal and State Listed Species

Common Name	Scientific Name
State Endangered	
American bittern	*Botaurus lentiginosus*
Brush-tipped emerald	*Somatochlora walshii*
False arrow-feather	*Aristida necopina*
Graceful underwing	*Catocala gracilis*
Handsome sedge	*Carex formosa*

Table 1-3 (continued)
Camp Ravenna Federal and State Listed Species

Common Name	Scientific Name
Mountain brook lamprey	*Ichthyomyzon greeleyi*
Narrow-necked Pohl's moss	*Pohlia elongata var. Elongata*
Northern harrier	*Circus cyaneus*
Philadelphia panic-grass	*Panicum philadelphicum*
Sandhill crane	*Grus canadensis*
Tufted Moisture-loving moss	*Philonotis fontana var. Caespitosa*
Variegated scouring-rush	*Equisetum variegatum*
State Threatened	
Barn owl	*Tyto alba*
Bobcat	*Felis rufus*
Caddisfly	*Psilotreta indecisa*
Hobble-bush	*Viburnum alnifolium*
Least bittern	*Ixobrychus exilis*
Lurking leskea	*Plagiothecium latebricola*
Simple willow-herb	*Epilobium strictum*
Trumpeter swan	*Cygnus buccinator*
Strict blue-eyed grass	*Sisyrinchium montanum*
State Potentially Threatened Plants	
Arborvitae[1]	*Thuja occidentalis*
False hop sedge	*Carex lupuliformis*
Greenwhite sedge	*Carex albolutescens*
Long beech fern	*Phegopteris connectilis*
Pale sedge	*Carex pallescens*
Sharp-glumed manna-grass	*Glyceria acutifolia*
Shining ladies-tresses	*Spiranthes lucida*
Straw sedge	*Carex straminea*
Water avens	*Geum rivale*
Woodland horsetail	*Equisetum sylvaticum*

Table 1-3 (continued)
Camp Ravenna Federal and State Listed Species

Common Name	Scientific Name
Federal Species of Concern	
Bald eagle	*Haliaetus leucocephalus*
Butternut	*Juglans cinerea*
Handsome sedge	*Carex formosa*
State Species of Concern	
Big brown bat	*Eptesicus fuscus*
Bobolink	*Dolichonyx oryzivorus*
Cerulean warbler	*Dendroica cerulea*
Common moorhen	*Gallinula chloropus*
Creek heelsplitter	*Lasmigona compressa*
Deer mouse	*Peromyscus maniculatus*
Eastern box turtle	*Terrapene carolina*
Eastern garter snake	*Thamnophis sirtalis*
Eastern red bat	*Lasiurus borealis*
Eastern sand darter	*Ammocrypta pellucida*
Four-toed salamander	*Hemidactylium scutatum*
Great egret	*Ardea alba*
Henslow's sparrow	*Ammodramus henslowii*
Hoary bat	*Lasiurus cinereus*
Little brown bat	*Myotis lucifugus*
Marsh wren	*Cistothorus palustris*
Mayfly	*Stenonema ithica*
Moth	*Apamea mixta*
Moth	*Brachylomia algens*
Northern bobwhite	*Colinus virginianus*
Northern long-eared bat	*Myotis septentrionalis*
Prothonotary warbler	*Protonotaria citrea*
Pygmy shrew	*Sorex hovi*
Scurfy quaker	*Homorthodes furfurata*
Sedge wren	*Cistothorus platensis*

Table 1-3 (continued)
Camp Ravenna Federal and State Listed Species

Common Name	Scientific Name
Sharp-shinned hawk	*Accipiter striatus*
Smooth green snake	*Opheodrys vernalis*
Sora rail	*Porzana carolina*
Southern Bog Lemming	*Svnaptomys cooperi*
Star-nosed mole	*Condylura cristata*
Tri-colored bat	*Perimyotis subflavus*
Virginia rail	*Rallus limicola*
Woodland jumping mouse	*Napaeozapus insignis*
Yellow-bellied sapsucker	*Sphyrapicus varius*
State Special Interest	
American Black Duck	*Anas rubripes*
Blackburnian warbler	*Dendroica fusca*
Black-throated blue warbler	*Dendroica caerulescens*
Brown creeper	*Certhia americana*
Canada warbler	*Wilsonia Canadensis*
Dark-eyed junco	*Junco hyemalis*
Gadwall	*Anas strepera*
Golden-crowned kinglet	*Regulus satrapa*
Green-winged teal	*Anas crecca*
Hermit thrush	*Catharus guttatus*
Least flycatcher	*Empidonax minimus*
Magnolia warbler	*Dendroica magnolia*
Mourning warbler	*Oporornis philadelphia*
Northern shoveler	*Anas clypeata*
Northern waterthrush	*Seiurus noveboracensis*
Pine siskin	*Carduelis pinus*
Purple finch	*Carpodacus purpureus*
Red-breasted nuthatch	*Sitta canadensis*
Redhead duck	*Aythya americana*
Ruddy duck	*Oxyura jamaicensis*

Table 1-3 (continued)
Camp Ravenna Federal and State Listed Species

Common Name	Scientific Name
Subflava sedge borer moth	*Archanara subflava*
Wilson's Snipe	*Gallinago delicata*
Winter wren	*Troglodytes troglodytes*
State Extirpated	
Golden-winged warbler	*Vermivora chrysoptera*

Source: Camp Ravenna Joint Military Training Center Federal and State Listed Species, May 16, 2013.
[1] *denotes Arborvitae was planted and does not occur naturally within the facility.*

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. The Area 1 portion of the MRS has not been previously surveyed for cultural or archeological resources; however, due to the disturbed nature of the area from former activities, it is unlikely that cultural and/or archeological resources are present at Area 1. The Area 2 portion of the MRS was surveyed for archeological resources in 2008, and no significant resources were found (AMEC, 2008).

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 former RVAAP consisted of 12 munitions assembly facilities, referred to as "load lines." Load Lines 1 through 4 were used to melt and load 2,4,6-trinitrotoluene 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 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 2,4,6-trinitrotoluene 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. Potential contaminants in these load lines include lead compounds, mercury compounds, and explosives. 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.

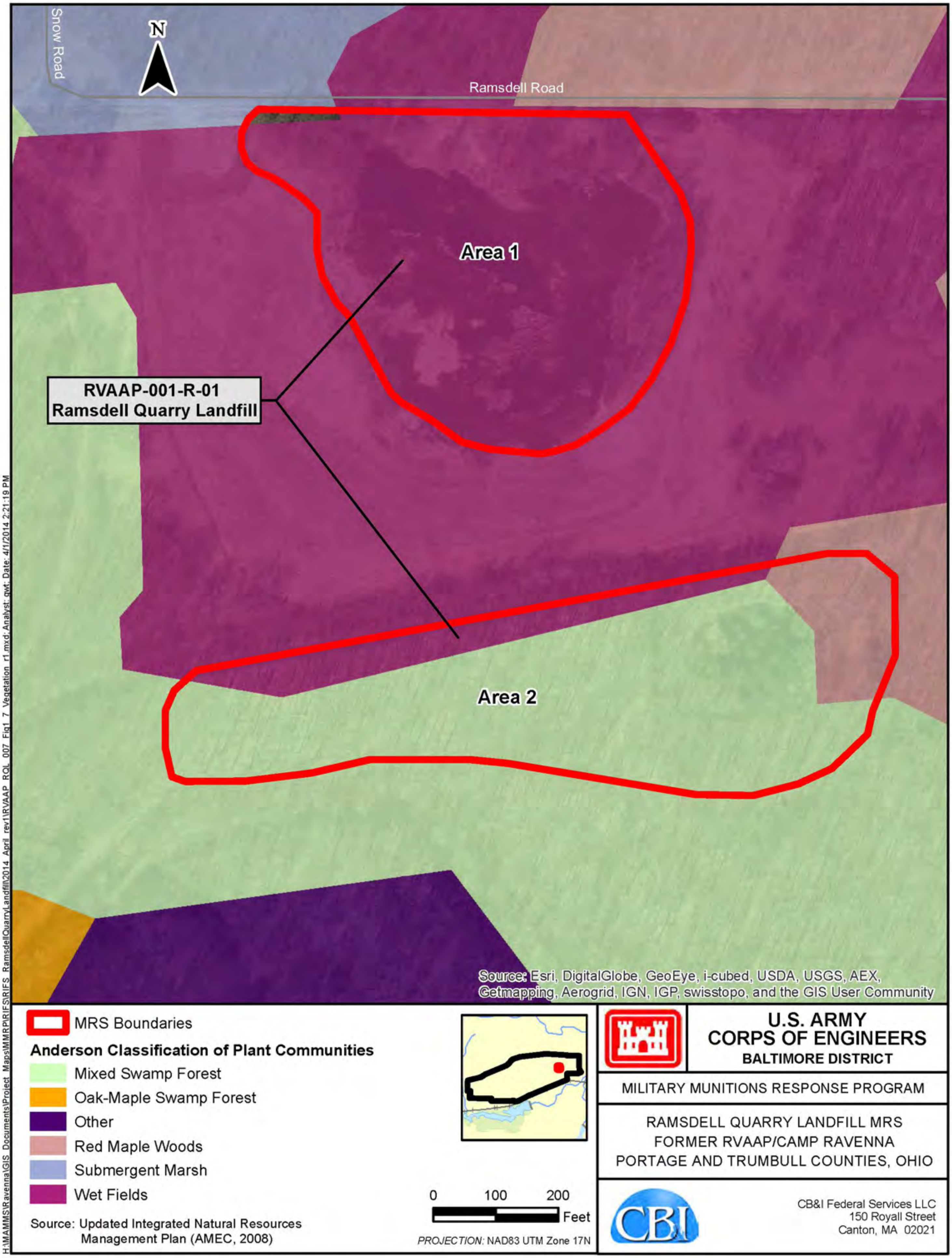

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FIGURE 1-7 VEGETATION MAP

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, 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 RVAAP 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. Potential contaminants at these MRSs include explosives, propellants, metals, and waste oils. Other AOCs present at the facility include landfills, an aircraft fuel tank testing facility, and various general industrial support and maintenance facilities (SAIC, 2011b).

Ramsdell Quarry Landfill MRS History and Background

The Ramsdell Quarry Landfill MRS is an approximately 13.43-acre area located on the south side of Ramsdell Road and north of Load Line 1. The MRS is composed of two sections: a 6.5-acre northern section (Area 1) where OB/OD operations took place in an old quarry, and a 6.93-acre southern section (Area 2) that contains a small, inactive soil borrow pit and wooded area where installation personnel had previously found MD (e^2M, 2008). Area 1 was initially mined to recover material for roads and construction ballasts. When quarry operations were discontinued in 1941, the excavation was reportedly at a depth of 30 to 40 feet below the current surface. Between 1946 and 1950, Area 1 was used for OB/OD operations such as the thermal treatment of waste explosives from Load Line #1 and surface burning of approximately 18,000 500-lb incendiary or napalm bombs. Starting in 1976, the area around Area 1 to the east, west, and south was used as a nonhazardous solid waste landfill. From 1978 until its closure in 1990, the adjacent area operated under a sanitary landfill permit issued by the State of Ohio (e^2M, 2007). The landfill area is not included as part of the MRS; however, small areas of the landfill overlap the southwest and southeast boundaries of Area 1 that is the northern portion of the MRS. Area 1 includes approximately 4.018 acres of moderate quality wetland with standing water as deep as 8 feet (Leidos, 2014). Approximately 0.5 acres of wetland are present at the eastern portion of Area 2 (AMEC, 2008). There is no available information regarding historical activities that occurred at Area 2 or how MD arrived at this portion of the MRS (e^2M, 2008). Based on the debris found at Area 2 during the RI field work, this portion of the MRS may have been used as a disposal area for the munitions that were thermally treated at Area 1, along with other debris.

Cultural features that remain at the MRS consist mainly of the gravel access road at the northwest corner of the landfill and a former rail bed that bisects Area 1 and Area 2. There are no buildings or other structures present at the MRS. Current conditions and features that are associated with the Ramsdell Quarry Landfill MRS are presented in **Figure 1-8**.

1.5 Previous Investigations and Actions

This section briefly summarizes the investigations and actions as it pertains to the Ramsdell Quarry Landfill MRS. This information was obtained primarily from the *Final Military Munitions Response Program Historical Records Review* (e^2M, 2007; hereafter referred to as the HRR), the SI Report (e^2M, 2008), and the *Record of Decision Amendment for Soils and Dry Sediment at the RVAAP-01 Ramsdell Quarry Landfill* (SAIC, 2013).

1.5.1 2004 USACE Final 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 *Final Archives Search Report* (USACE, 2004; hereafter referred to as the ASR) identified 12 AOCs as well as 4 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 MRSs 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. The assessment team reported that the Ramsdell Quarry Landfill MRS was considered to have "potential explosives ordnance presence" (USACE, 2004).

1.5.2 2007 e^2M Final Historical Records Review

The HRR was prepared by e^2M 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 MRSs 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.

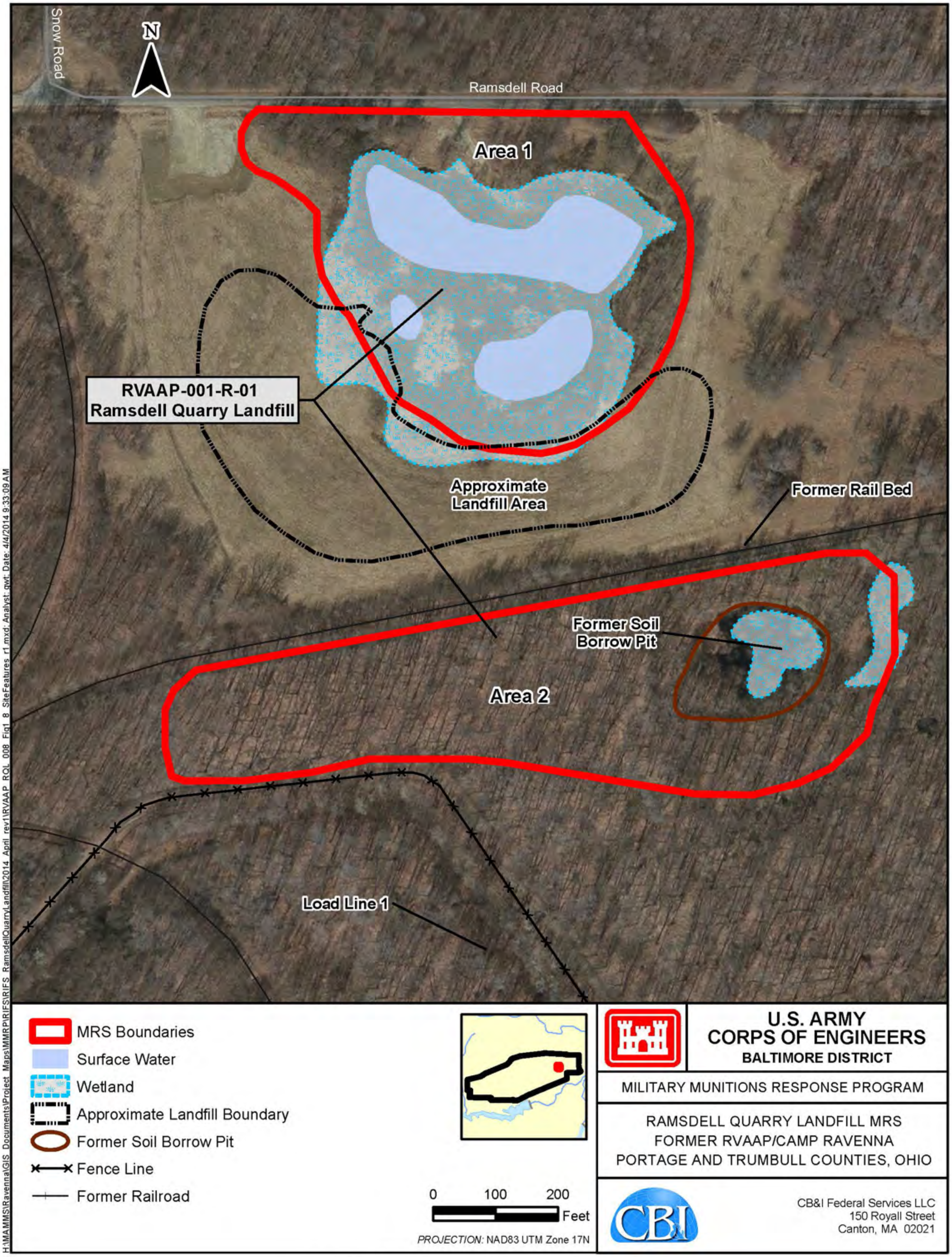

FIGURE 1-8 SITE FEATURES MAP

Of the 19 MMRP-eligible MRSs 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 which resulted in the possible presence of MEC and/or MC, and where the releases occurred prior to September 2002 (e^2M, 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.

During the U.S. Army Closed, Transferring, and Transferred Range/Site Inventory, the Ramsdell Quarry Landfill MRS was identified as a 3.79-acre unlined landfill that was situated at the bottom of the former quarry. The landfill portion of the site was being covered under the IRP. Additionally, the original footprint of the MRS did not include the OB/OD area. During the HRR, the MRS boundary was revised to the current 13.43-acre boundary, which includes the entire quarry area where OB/OD activities occurred (Area 1) as well as the area to the south of the quarry (Area 2) where facility personnel reportedly observed potential MEC items on the ground surface (e^2M, 2007).

1.5.3 2008 e^2M Final Site Inspection Report

In 2007, e^2M conducted a SI at each of 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 of the MRSs. 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, which included the Ramsdell Quarry Landfill MRS (RVAAP-001-R-01). A summary of the SI Report (e^2M, 2008) recommendations for the MRS is presented in **Table 1-4** and are discussed below.

Table 1-4
Site Inspection Recommendation Summary

MRS	MRSPP Priority	Recommendation	Basis for Recommendation	
			MEC	MC
Ramsdell Quarry Landfill (RVAAP-001-R-01)	5	Further characterization of MEC at Area 1 and MC at Area 2 required.	MEC potentially present at Area 1.	MC detected above screening criteria at Area 2. Area 1 will continue to be addressed under the IRP AOC RVAAP-01.

AOC denotes area of concern.
IRP denotes Installation Restoration Program.
MC denotes munitions constituents.
MEC denotes munitions and explosives of concern.
MRS denotes Munitions Response Site.
MRSPP denotes Munitions Response Site Prioritization Protocol.

The SI field activities included a meandering-path magnetometer and metal-detector-assisted UXO survey that was conducted at all accessible dry areas of the MRS. The total area of the surveys covered approximately 5 acres, of which 3 acres were located in Area 1 and 2 acres were located in Area 2. The survey instruments used included a Schonstedt handheld magnetic gradiometer and a White Matrix M6 metal detector. Subsurface anomalies were recorded at several locations surrounding the pond within Area 1; however, no MEC was observed at these locations. The nature of anomalies was not determined, since an intrusive investigation was not performed as part of the SI. Within Area 2, two MD items consisting of 105mm and 155mm rounds were encountered on the ground surface.

As part of the SI, four soil samples were collected from Area 2 using ISM and were analyzed for explosives, propellants, and Target Analyte List metals. Low (estimated) concentrations of 1,3,5-trinitrobenzene were detected at two of the sample areas (MC2 and MC3). Concentrations of lead (40.9 milligrams per kilogram [mg/kg]) and manganese (1,860 mg/kg) were detected at sample area MC3 at concentrations that exceeded the facility background values and one-tenth the U.S. Environmental Protection Agency (EPA) Residential Soil Preliminary Remediation Goals; the screening criteria used at that time. The lead and manganese concentrations were considered to be munitions-related for the purposes of the SI.

Prior to the SI field work, sampling investigations at Area 1 were previously performed under the IRP. It was determined in the SI Report (e^2M, 2008) that the chemicals that were detected under the IRP represented potential widespread MC contamination across the entire former OB/OD area that constitutes most of Area 1. No additional samples were collected at Area 1 during the SI field work.

Based on the results of the SI field activities, “Further Characterization” for MEC in Area 1 and for MC in Area 2 was recommended (e^2M, 2008). The SI Report did not recommend “Further Characterization” for MC in Area 1 since it was already being addressed under the IRP. **Figure 1-9** presents the areas investigated and locations of significant findings that were identified during the SI field activities.

The Ramsdell Quarry Landfill MRS was assigned a Munitions Response Site Prioritization Protocol (MRSPP) priority of 5. The MRSPP is a funding mechanism that is typically initially performed during the preliminary assessment/SI stage to prioritize funding for MRSs and is updated after every phase of the MMRP (i.e., RI, feasibility study, and removal action completion). The MRSPP has a priority scale of 1 to 8 with a Priority of 1 being the highest relative priority. Based on the MRSPP priority identified for the MRS in the SI Report (e^2M, 2008), the Ramsdell Quarry Landfill MRS was selected for inclusion for “Further Characterization” under the MMRP.

1.5.4 2010 USACE MEC Investigation

An investigation for MEC was conducted by the USACE—Rock Island and Louisville Districts in 2010 in support of IRP remediation activities that were proposed for the bottom of the quarry at the Ramsdell Quarry Landfill AOC. The portion of the site that was

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FIGURE 1-9 SI FIELD WORK AND FINDINGS

investigated constituted Area 1 under the MMRP. The MEC investigation consisted of a visual surface survey and a magnetometer sweep at the proposed excavation areas at the southwest, northeast, and northwest portions of the quarry bottom. No MEC was found during the investigation; however, items considered as MD were found that included plastic shipping containers for 81mm mortar projectiles, the rotating band protective rings for 155mm projectiles, and the remains of several AN-M76 500-lb incendiary bombs. The locations within the quarry bottom and the depths at which the items were encountered were not specified in the report for the MEC investigation (USACE, 2010a); however, the photographs in the report suggest the items were on or just below the ground surface at the land-based portions of the site. It was concluded in the report for the MEC investigation (USACE, 2010a) that the probability of encountering MEC at this portion of the AOC was low.

1.5.5 2013 SAIC Final ROD Amendment for Soil and Dry Sediment

Risk assessments were completed for the samples collected under the IRP at the Ramsdell Quarry Landfill AOC and only human health risks associated with semivolatile organic compounds (SVOCs) were identified in soils and dry sediment at the portion of the AOC that constitutes Area 1 at the collocated MRS. In a 2008, a ROD was prepared for contaminated soils and dry sediment at the AOC under the IRP, and the proposed remedy was the removal of approximately 423 cubic yards of soils and dry sediment from two locations at the quarry bottom. The removal activities commenced in July 2010; however, roofing material and transite that were found to be asbestos-containing material (ACM) was encountered shortly after the excavation activities began. Furthermore, additional sampling at the quarry bottom identified other soil areas with SVOC contamination that exceeded the human health screening criteria which nearly quadrupled the amount of soil requiring removal. A ROD Amendment was prepared by SAIC in 2013 that presented a revised alternative for the soils at the former quarry where SVOCs and ACM remained. This alternative remedy included installation of a fence that encompassed the closed landfill, quarry bottom, and wetlands; and the implementation of best management practices to remove surficial ACM through non-intrusive/no-digging methods. Since the human and environmental receptors are the same at the collocated AOC and MRS, implementation of the remedy under the IRP will address any health risks associated with contamination in soil and dry sediment that may be considered MC under the MMRP. As of the printed date of this RI Report, the ROD Amendment that presents the revised remedy was still waiting on approval by the stakeholders (SAIC, 2013).

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 of MEC and MC
- **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—**Ohio EPA Correspondence
- **Appendix C—**Field Documentation
- **Appendix D—**Data Evaluation Report
- **Appendix E—**Summary of Laboratory Data Results
- **Appendix F—**Investigation-Derived Waste Management
- **Appendix G—**Photograph Documentation Log
- **Appendix H—**Intrusive Investigation Data Sheets
- **Appendix I—**Asbestos Abatement Report
- **Appendix J—**Munitions Debris Waste Shipment and Disposal Records
- **Appendix K—**Ecological Screening Values
- **Appendix L—**Munitions Response Site Prioritization Protocol Worksheets

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2.0 PROJECT OBJECTIVES

This section presents the preliminary CSM for MEC and MC at the Ramsdell Quarry Landfill MRS based on historical information and identifies data gaps associated with the preliminary CSM and the data quality objectives (DQOs) necessary to achieve the project objectives.

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 material potentially presenting an explosive hazard (MPPEH) or ordnance is situated or is 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 be exposed to 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 and associated MC in subsurface soils 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 OHARNG/facility personnel, contractors, visitors, trespassers, and biota.

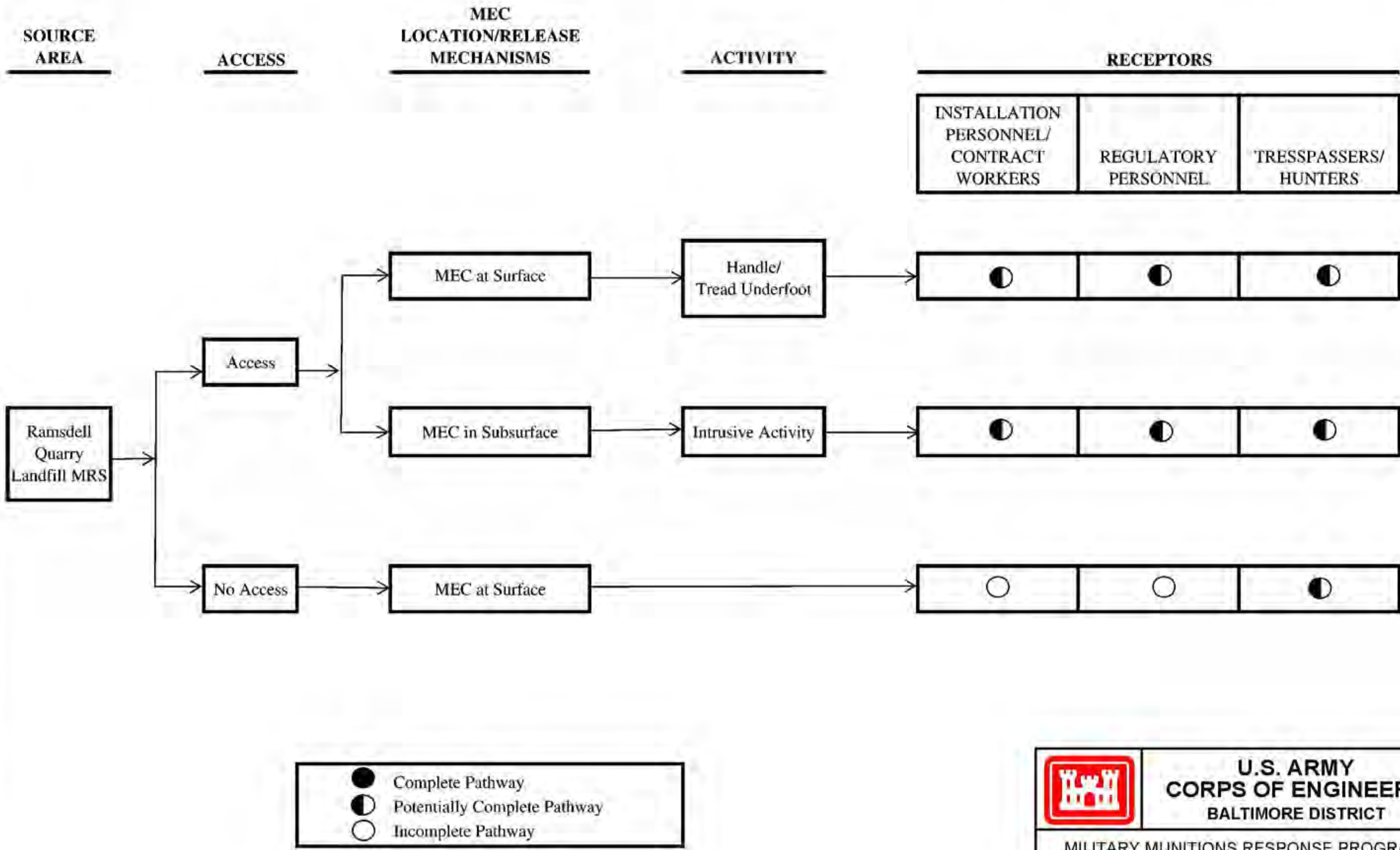
The preliminary CSM developed during the SI identified ecological receptors (biota) to be state-listed species identified as being present at the facility and listed in **Table 1-3**. For the purposes of the CSMs revised or created based on the RI, biota is identified as the listed and unlisted mammals, birds, and wetland species known to be present at the facility and, based on the MRS's physical setting, are reasonably anticipated to be present on either a permanent or transient basis.

In general, the CSM for each MRS is intended to assist in planning, interpreting data, and communicating MRS-specific information. The CSMs are 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 Ramsdell Quarry Landfill 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 sections and incorporated into this model as discussed in Section 9.0, "Revised Conceptual Site Models."

2.1 Preliminary CSM and Project Approach

The preliminary CSM for the Ramsdell Quarry Landfill 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 process 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 diagrams provided on **Figure 2-1** and **Figure 2-2** for MEC and MC, respectively. A summary of each of the factors evaluated for the preliminary CSM is discussed below.

- **Sources—**Thermal treatment of explosives waste and munitions was the primary source of potential MEC and MC at the Ramsdell Quarry Landfill MRS. Based on review of the archival records and available documentation, the principal sources of MEC and MC at the Ramsdell Quarry Landfill MRS would be due to intentional disposal/demilitarization of munitions and related items.



Source: *Final Site Inspection Report, Ravenna Army Ammunition Plant, Ravenna, Ohio (e² M, 2008)*

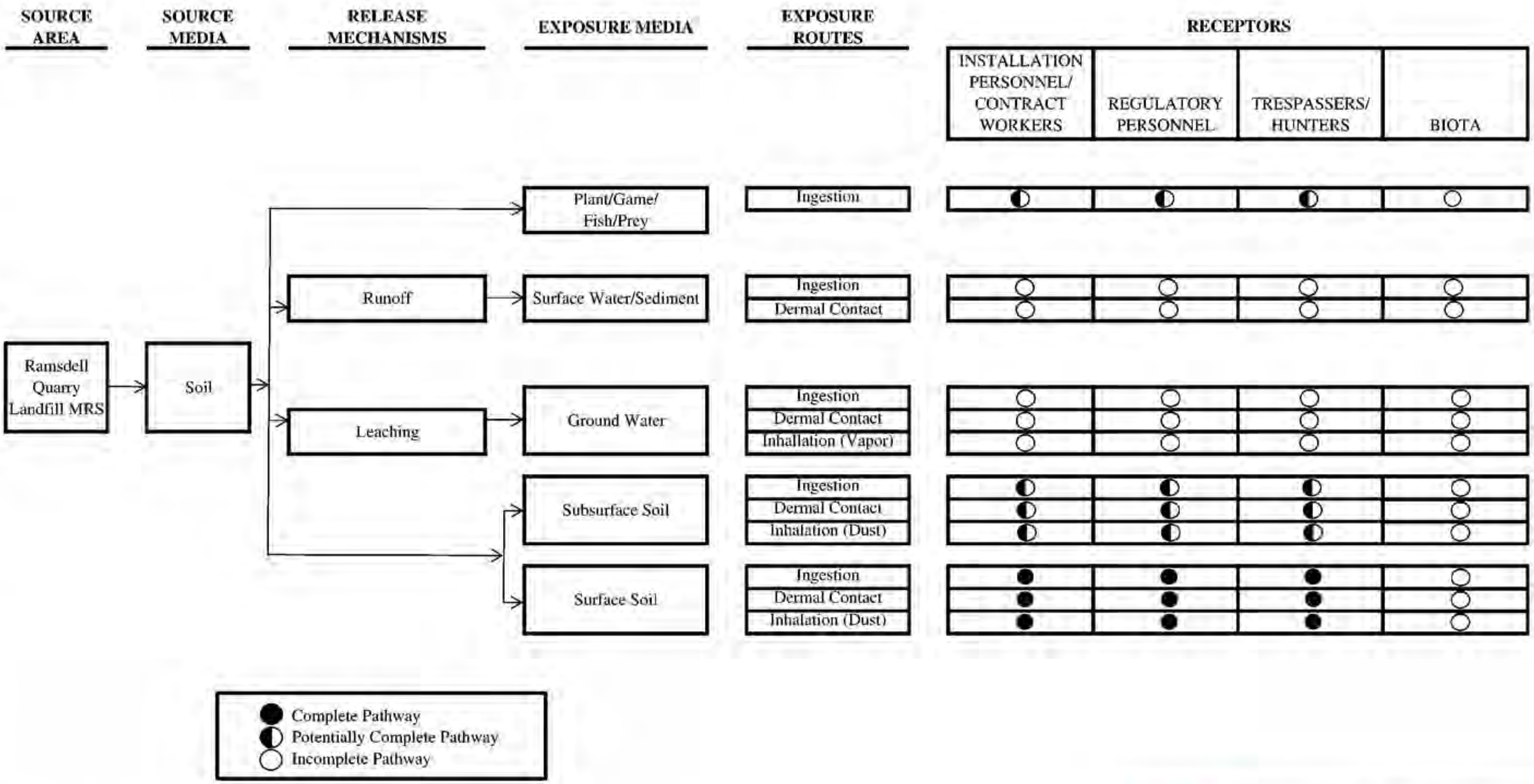
U.S. ARMY CORPS OF ENGINEERS
BALTIMORE DISTRICT

MILITARY MUNITIONS RESPONSE PROGRAM

RAMSDELL QUARRY LANDFILL MRS
FORMER RVAAP/CAMP RAVENNA
PORTAGE AND TRUMBULL COUNTIES, OHIO

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

FIGURE 2-1 PRELIMINARY MEC CONCEPTUAL SITE MODEL



Source: *Final Site Inspection Report, Ravenna Army Ammunition Plant, Ravenna, Ohio* (e[2] M, 2008)

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FIGURE 2-2 PRELIMINARY MC CONCEPTUAL SITE MODEL

- **Activity—**Human activities considered for the preliminary CSM included maintenance, long term monitoring of groundwater, and landfill cap inspections, which may result in moving or somehow disturbing MEC that could cause it to detonate.
- **Access—**At the time of the SI, there was no fence or any other type of physical barrier surrounding the MRS. The MRS was not physically restricted and was readily accessible to facility personnel. Access conditions have not changed since the SI field activities. Receptors would have direct access to MEC lying on the ground surface or exposure to MC during use of the MRS.
- **Receptors**—At the time of the SI, current and future land use receptors included facility personnel, contract workers, regulatory personnel, trespassers, hunters, and biota (MC only). The biotas are considered to be federal- and/or state-listed identified as being present at the facility.

Although no evidence of MEC was observed at Area 1 during the SI field work, the potential presence for MEC was not dismissed in the evaluation of the preliminary CSM. No MEC was found at Area 2 during the SI field work; however, two MD items were found on the ground surface during that event. The activities associated with the presence of the MD at Area 2 are unknown. The primary exposure pathway for human receptors was considered to be contact with MEC lying on the ground surface by handling or treading underfoot and the disturbance of subsurface soil during any intrusive activities. As such, the MEC exposure pathway for human receptors was considered to be potentially complete. It was determined in the preliminary CSM that transport and migration of MEC was not likely. The preliminary CSM for MEC at the Ramsdell Quarry Landfill MRS, as presented in the SI Report (e^2M, 2008), is shown in **Figure 2-1**.

During the SI field work, lead and manganese that were considered as potential MC were detected in surface soil at Area 2 above the applicable screening criteria. Chemicals that were detected at Area 1 under the IRP investigations and were considered as potential MC included explosives and propellants, metals, and SVOCs (SAIC, 2005). Only SVOCs in surface soil and dry sediment were identified to present potential health risks to the Security Guard/Maintenance Worker that is the Representative Receptor for Area 1. None of the chemicals detected under the IRP presented potential health risks to ecological receptors in Area 1 (SAIC, 2006). The exposure pathways for both Area 1 and Area 2 were dermal contact and ingestion/inhalation. Complete exposure pathways were considered to be present for surface soil and potentially complete pathways were identified for subsurface soil. The preliminary CSM for MC at the Ramsdell Quarry Landfill MRS, as presented in the SI Report (e^2M, 2008), is shown in **Figure 2-2**.

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 and TBC guidance will be included in the follow-on documents to this RI Report as required per the CERCLA process.

2.3 Data Quality Objectives and Data Needs

The DQOs and data needs were determined at the planning stage and are outlined in the Work Plan (Shaw, 2011). The data needs included characterization for MEC and MC associated with former 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* (SAIC, 2011b; hereafter referred to as the "Facility-Wide Sampling and Analysis Plan [FWSAP])" and the *Data Quality Objectives Process for Hazardous Waste Site Investigations*, EPA QA/G-4HW (EPA, 2000; hereafter referred to as the "DQO guidance"). **Table 2-1** identifies the DQO process developed in the Work Plan (Shaw, 2011).

Table 2-1
Data Quality Objectives Process at the Ramsdell Quarry Landfill MRS

Step	Data Quality Objective
1. State the problem.	Ramsdell Quarry Landfill originally served as a quarry. At the end of quarry activities, thermal treatment of waste explosives from Load Line 1 and surface burning of 18,000 500-pound incendiary or napalm bombs reportedly occurred. Several MD (155mm projectiles and 105mm cartridges) items have been observed on the surface. Therefore, there is a potential for MEC/MD and MC at the MRS. Based on its use and previous investigations, there is a potential for MEC/MD on the ground surface and subsurface. In addition, there is a potential for environmental impacts from MC at the MRS.
2. Identify the decision.	The goal of the investigation at the Ramsdell Quarry Landfill MRS is to identify the areas impacted with MEC/MD. In addition, MC sampling will be performed in order to further characterize the nature and extent of contamination associated with munitions activities at the MRS. The information obtained during the RI will be used to assess the risk and hazards posed to human and environmental receptors.

Table 2-1 (continued)
Data Quality Objectives Process at the Ramsdell Quarry Landfill MRS

Step	Data Quality Objective
3. Identify inputs to the decision.	• Historical information • Geophysical investigation • Intrusive inspection • Discrete and incremental sampling of environmental media
4. Define the study boundaries.	The RI investigation will be performed in the Ramsdell Quarry Landfill MRS boundaries as defined at the conclusion of the SI (e^2M, 2008).
5. Develop a decision rule.	Although formal visual survey transects are not planned at the Ramsdell Quarry Landfill MRS, a visual survey of the surface will be performed during the geophysical investigation. A geophysical survey will be performed at the MRS to assess the presence of buried MEC/MD. The geophysical transects were placed using the UXO Estimator® module. The agreed-upon inputs into the module were 95-percent confidence, 0.5 MEC per acre, and 100 percent of the anomalies over 4 millivolts will be investigated. Incremental samples and discrete samples (surface and subsurface soil) will be collected in areas with concentrated MEC/MD.
6. Specify limit of decision errors.	QC procedures are in place so that all field work is performed in accordance with all applicable standards. Further details on the QC process during the RI are located in Section 4.0.
7. Optimize the design for obtaining data.	The information gathered as part of the field investigation at the Ramsdell Quarry Landfill MRS will be used to determine what risks or hazards, if any, are present. A MEC HA will be performed to identify the potential MEC hazards. In addition, a site-specific HHRA and ERA will be performed on the analytical results. If unacceptable risks or hazards to human and environment receptors are determined to exist at the MRS at the conclusion of the investigation, then the MRS will be identified for further evaluation under the CERCLA process.

CERCLA denotes Comprehensive, Environmental Response, Compensation, and Liability Act of 1980.
e^2m denotes engineering-environmental Management, Inc.
ERA denotes ecological risk assessment.
HA denotes hazard assessment.
HHRA denotes human health risk assessment.
MC denotes munitions constituents.
MD denotes munitions debris.
MEC denotes munitions and explosives of concern.
mm denotes millimeter(s).
MRS denotes Munitions Response Site.
QC denotes quality control.
RI denotes Remedial Investigation.
SI denotes site inspection.
UXO denotes unexploded ordnance.

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 receptors can be assessed and remedial decisions can be made. The DQOs were developed in accordance with the FWSAP (SAIC, 2011b), the DQO guidance (EPA, 2000), and past experience with MRSs containing MEC. These data needs for MEC were evaluated using the most applicable methods and technologies, such as UXO Estimator® (USACE, 2003b), which are discussed in the following sections.

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 site-related chemicals (SRCs) in environmental media at the MRS where concentrated areas of MEC and/or MD are found. Data quality was assessed through the evaluation of sampling activities 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 regard to the proper design of the sampling program and quality of the dataset, respectively. The reporting limits (a.k.a. method detection limits [MDLs] or limits of detection [LODs]) should be equal to or less than the screening levels 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 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 were used to identify the expected baseline conditions and other hazards that may be present (e^2M, 2007).
- **IRP Data—**Data collected under the IRP at various MRSs include analytes considered MC associated with previous activities at the MRS, although it should be noted that not all analytes are considered as MC. The IRP data sets may be incorporated with sampling data collected under the MMRP on a site-specific basis in order to close data gaps. For the Ramsdell Quarry Landfill MRS, the IRP data were reviewed, and it was determined that incorporation of the data in the RI Report was not applicable since the IRP data were not associated with specific source areas as defined under the MMRP. Additionally, different sampling

methods were used for the IRP (discrete) versus the MMRP (ISM) which makes the data sets between the two events difficult to compare. The ISM samples that were collected during the RI field work were considered to be more representative of current conditions and potential source areas identified at the MRS.

- **SI Data—**The SI field work conducted at the facility in 2007 (e^2M, 2008) provides visual survey data that were used to preliminarily delineate areas where MEC and/or MD may have been disposed following OB/OD activities. MC sampling was conducted at Area 2 during the SI field work; however, incorporation of the data was not considered applicable since sufficient MC samples were collected during the RI field effort along with a more robust suite of analyses. The RI samples are considered representative of current conditions and identified source areas; whereas, the samples collected for the SI encompassed the entire Area 2 portion of the MRS and may underestimate the actual MC concentrations at source areas. The difference in the sampling unit sizes between the two sampling events creates various uncertainties and the data sets are not considered comparable.

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3.0 CHARACTERIZATION OF MEC AND MC

This section documents the approaches used to investigate MEC and MC at the Ramsdell Quarry Landfill 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 (Shaw, 2011).

3.1 MEC Characterization

The following sections summarize the geophysical, anomaly reacquisition, and subsequent intrusive investigation activities that were performed at the Ramsdell Quarry Landfill MRS during the RI field activities. Based on the historical OB/OD and disposal activities that occurred at the MRS, it was determined in the SI reporting stage that there is a potential for MEC/MD on the ground surface and subsurface at the MRS. The initial step in evaluating for buried MEC at the Ramsdell Quarry Landfill MRS consisted of performing a digital geophysical mapping (DGM) investigation throughout the MRS as presented in the Work Plan (Shaw, 2011). Visual surveys of surface conditions were performed in conjunction with the geophysical investigation. The results of the DGM survey and intrusive investigation activities are discussed in Section 4.0, "Remedial Investigation Results."

3.1.1 Geophysical Survey Activities

From May through August of 2011, a DGM investigation was performed at the Ramsdell Quarry Landfill MRS to identify potentially buried MEC and/or MD. The approved sampling coverage presented in the Work Plan (Shaw, 2011) utilized the UXO Estimator® software (USACE, 2003b) to determine the proposed sampling strategy based on the size of the MRS and the expectation that MEC was randomly distributed throughout the MRS. The UXO Estimator® module required a minimum of 4.16 acres of DGM data to be collected over the 11.88-acre land-based portion of the MRS (35 percent) based on inputs of 95-percent confidence that there is less than 0.5 MEC per acre. If the proposed area was investigated based on these inputs and the suggested DGM coverage, and no MEC was found at the proposed investigation areas, the software was then used to evaluate whether the performance criteria have been met based on the actual field data results.

The DGM survey was completed using the EM61-MK2, manufactured by Geonics, Ltd. The EM61-MK2 is a four-channel, high-sensitivity time-domain electromagnetic induction sensor designed to detect ferrous and nonferrous metallic objects with good spatial resolution and minimal interference from adjacent metallic features. The EM61-MK2 consists of two 1- by 0.5-meter rectangular coils arranged in a coaxial geometry and separated by 40 centimeters. The DGM platform consisted of a standard wheeled configuration with the lower coil 16 inches above the ground surface.

At locations at Area 1 where surface water was shallow (i.e., water depths less than 1 to 2 feet), a floating platform was used for the EM61-MK2. The floating platform consisted of an Otter brand Pro Series Magnum plastic snowmobile sled. The sled measures approximately 74 inches long by 35 inches wide by 14 inches high. When mounted on the sled, the bottom coil of the EM61-MK2 was approximately 13 inches above the water surface.

The EM61-MK2 was coupled with a Leica 1200 real-time kinematic (RTK) global positioning system (GPS) or Leica TPS1200 robotic total station (RTS) for positioning. The RTS was used to provide position in areas of heavy canopy and the RTK GPS was used in "open" areas void of canopy (tree cover). The team that performed the DGM survey consisted of two geophysicists and a UXO-qualified escort.

The *Digital Geophysical Mapping Report for RVAAP-001-R-01 Ramsdell Quarry Landfill Munitions Response Site*, hereafter referred to as the "DGM Report," is presented in **Appendix A**. The DGM Report provides a comprehensive review of the DGM survey at the Ramsdell Quarry Landfill MRS with regard to data acquisition, processing and analysis, and results of the DGM quality control (QC) program.

The DGM system used for the Ramsdell Quarry Landfill MRS investigation and other MRSs at the facility was validated during the startup phase of the project at an instrument verification strip (IVS) located at 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*. The IVS technical memorandum is included as an attachment to the DGM Report in **Appendix A**.

Prior to the DGM survey at the Ramsdell Quarry Landfill MRS, a civil survey and vegetation clearance were performed to prepare the MRS for DGM activities.

3.1.1.1 Civil Survey

A licensed Ohio surveyor established 2 survey monuments at Area 1 and 23 grid corner nails in Area 2. Each monument/grid corner nail was established with third order horizontal accuracy (residual error less than or equal to 1 part in 10,000). The survey monuments were used to provide positional data to set up the RTS, which streamed positional data directly to the EM61-MK2. All of the survey data documenting MRS features and obstructions are referenced to the established survey monuments.

For QC purposes, the RTS positioning system was used to reacquire a known, fixed location each time the system was set up on one of the four survey monuments. Per the project metrics defined in the Work Plan (Shaw, 2011), static measurements for the positioning system were required not to exceed 0.5 feet. The RTS system provides centimeter (or better) accuracy and 100 percent of the location checks satisfied the project metric. All mapping was developed in the Universal Transverse Mercator Zone 17 North Coordinate System, North American Datum 1983.

3.1.1.2 Vegetation Clearance

The Area 1 portion of the MRS is situated in a low-lying area and contains low quality wetland vegetation. The Area 2 portion of the MRS is mostly heavily wooded with areas of thick ground cover. Vegetation removal was required along transects in Area 1 and select grid locations in Area 2 in order to provide accessibility for the DGM equipment. Vegetation removal was minimized to the extent possible to allow for the execution of work. Vegetation removal was conducted in the month of December to ensure that grassland nesting species were not impacted and was minimized to the extent possible to allow for the execution of work.

Since Area 1 contained wetland vegetation species along the proposed DGM transects, any vegetation clearance required approval from the Ohio Environmental Protection Agency (Ohio EPA) prior to initiating the activities. CB&I organized two walkovers that were conducted in April 2011 and November 2011 with the Ohio EPA at several of the MRSs that contained potentially environmentally sensitive areas. Representatives from the Army were present for the November 2011 walkover event. The intent of the walkovers was to discuss the proposed methodologies for vegetation clearance and to get feedback regarding any concerns or conditions the Ohio EPA may have. Following the walkovers, CB&I received approval to perform vegetation clearance and intrusive investigation activities at the Ramsdell Quarry Landfill MRS. Correspondence with the Ohio EPA regarding identification of sensitive areas at the MRSs, including the Ramsdell Quarry Landfill MRS, is provided in **Appendix B**.

3.1.1.3 Data Collection and Site Coverage

It was originally proposed in the Work Plan (Shaw, 2011) that 11.45 miles of transects would be traversed using the DGM equipment over the entire areas of the MRS with the exception of the quarry pond and saturated areas in Area 1. Assuming a 3-foot-wide survey area per transect, the total area of DGM coverage equates to 4.16 acres that would be required to meet the proposed coverage at the MRS. The coverage required at Area 1 and Area 2 was 2.02 acres and 2.14 acres, respectively.

The DGM survey in Area 1 was performed at all accessible areas and the spatial coverage was calculated to be 2.05 acres, which exceeds the required DGM coverage of 2.02 acres. A total of 63 transects spaced 3 meters apart were completed at Area 1.

Although the area of DGM coverage in Area 2 required the collection of the DGM data using transects, it was determined in the field that the very thick vegetation conditions and difficult terrain at the former soil borrow pit at Area 2 would limit the ability to collect the data in this manner. An alternative methodology for the collection of the DGM data in Area 2 was subsequently proposed to USACE and the Ohio EPA. This alternative methodology included the collection of the DGM data over six 0.25-acre grids and portions of thirteen 0.25-quarter acre grids in Area 2. This resulted in a total DGM area coverage of 2.14 acres, which met the proposed areas of coverage. The alternative methodology was submitted to USACE and the Ohio EPA in a Field Change Request (FCR) that is discussed in greater detail in Section 3.1.1.4.

In all, 4.19 acres of DGM coverage was achieved for the Ramsdell Quarry Landfill MRS, which exceeds the proposed sampling coverage of 4.16 acres that is presented in the Work Plan (Shaw, 2011). The general DGM procedures performed for data acquisition at the Ramsdell Quarry Landfill MRS consisted of the following:

- The DGM survey area was reviewed by performing a MRS walkover. Special attention was given to difficult terrain and other MRS conditions that could cause potential safety issues.
- The positioning system was set up at a documented control point or at a location determined by using a minimum of two known control points (i.e., RTS or RTK). The location control was verified by at least one "checkshot" at a different control point of known location.
- The DGM system instrument functional checks were performed at the start and end of each day and the results were documented.
- The 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 MRS 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 MRS features related to terrain, vegetation, and cultural features so these features could be accounted for during the interpretation of the data.

The DGM data were uploaded to a field computer at the end of each day and transferred to the CB&I corporate server for archiving and daily review and processing by the data processor. Raw and final processed data were transferred to USACE at intervals specified in Data Item Description (DID) MMRP-09-004, *Geophysics* (USACE, 2009a).

Figure 3-1 provides the area of DGM coverage proposed in the Work Plan (Shaw, 2011). The actual area covered during the DGM survey is discussed and presented in Section 4.0.

3.1.1.4 Field Change Request

The DGM survey methodology originally proposed in the Work Plan (Shaw, 2011) at Area 2 consisted of transects to be spaced approximately 3 meters apart. Prior to the initiation of the field work, the existing vegetation, that included large diameter trees (greater than 4 inches) and thick ground cover, along with difficult terrain that included the former soil borrow pit, made Area 2 inaccessible for performing DGM transects as originally intended. An alternative method using grids was proposed that was based on the UXO Estimator® module. The alternative method would cover the same area as the originally proposed transects, could be placed in accessible locations in Area 2 which weren't as impacted by the vegetation or difficult terrain, would require minimal vegetation clearance, and would accomplish the same objectives as the transects. The FCR that outlines the description of the proposed alternative and the justification and impact of not implementing the alternative was submitted to the USACE Project Geophysicist and the Ohio EPA Project Manager for review and concurrence. The approved FCR is presented in the DGM Report in **Appendix A**. The Ohio EPA correspondence regarding the FCR is presented in **Appendix B**.

3.1.1.5 Data Processing and Interpretation

The geophysical data were processed, analyzed, and interpreted using the methods and approach outlined in the Work Plan (Shaw, 2011). A 4-millivolt (mV) threshold for Channel 2 of the EM61-MK2 was used to initially select anomalies as presented in the Work Plan (Shaw, 2011). Important factors that were considered during the interpretation process included the following:

- Data acquisition methodology (one dimensional for Area 1 and two dimensional for Area 2)
- Types of MEC most likely present at the MRS based on historical data
- Anomaly shape and signal intensity in relation to the spatial sample density (along track and across track)
- Local background conditions
- Presence of surrounding anomalies (anomaly density)
- Presence of cultural features and sources of interference

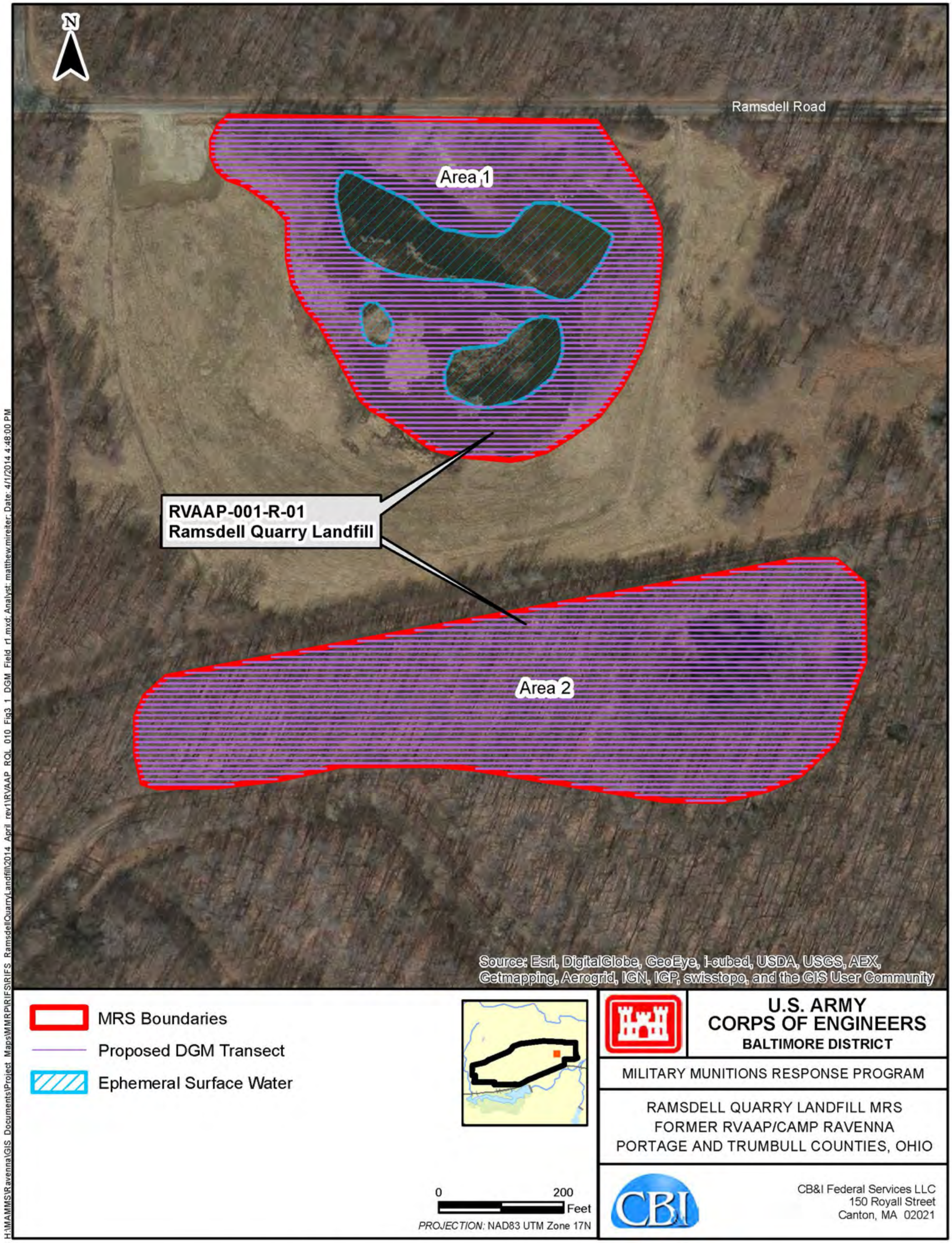


FIGURE 3-1 PROPOSED DGM TRANSECTS MAP

- Anomaly characteristics from the IVS items

Detailed processing and interpretation procedures are provided in the DGM Report in **Appendix A**.

3.1.1.6 Geophysical Field Quality Control Procedures

Instrument tests were 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 (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 Method*, which is presented in *Geophysics,* DID WERS-004.01 (USACE, 2010b). Quality objectives and metrics associated with MRS 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. The Microsoft© Excel spreadsheet is included in the DGM Report in **Appendix A**.

3.1.2 Anomaly Investigation Activities

The DGM surveys were completed at Area 2 in June 2011 and at Area 1 in August 2011. Anomaly selection, reacquisition, and intrusive investigation activities were conducted following the DGM surveys to assess the potential for buried MEC and/or MD at each of the areas of the Ramsdell Quarry Landfill MRS. These locations were identified as potentially containing subsurface MEC and/or MD based on the interpreted results of the DGM data review. Since full DGM coverage was not performed at either area at the MRS, the intrusive investigation activities required 100 percent reacquisition of individual non-culturally related anomalies that exceeded the 4-mV threshold as presented in Section 3.3.10 of the Work Plan (Shaw, 2011).

The results of the DGM surveys and proposed intrusive investigation locations were submitted to the USACE and the Ohio EPA for review and approval in technical memorandums for each of the areas at the MRS. The technical memorandums titled *DGM Survey Results and Proposed Dig Locations for the Ramsdell Quarry Landfill, Area 1 (RVAAP-001-R-01)* and *DGM Survey Results and Proposed Dig Locations for the Ramsdell Quarry Landfill, Area 2 (RVAAP-001-R-01)* are included as attachments to the DGM Report in **Appendix A**.

The target locations were evaluated to determine if they were areas of high anomaly density that required excavation using mechanical equipment or were point-source anomalies that could be manually investigated (hand-dug). All anomaly investigation activities were conducted by UXO-qualified personnel that included a Senior UXO Supervisor (SUXOS), a UXO QC Specialist (UXOQCS), and at least one Level I or II UXO Technician in accordance with the Work Plan (Shaw, 2011).

3.1.2.1 Individual Anomaly Reacquisition and Investigation Procedures

The UXO-qualified personnel used a Schonstedt magnetometer to first reacquire and then investigate ferrous anomalies identified during the DGM survey as single-point anomalies at the land-based portions of the MRS. These personnel then used hand tools to unearth an item and as the excavation progressed toward the anomaly source, the UXO technicians continued to use the Schonstedt magnetometer to determine the item location both horizontally and vertically. Mechanical excavation was used at locations where intrusive investigation activities using hand tools proved to be difficult (i.e., locations difficult to dig in or the anomalies was at depths that were difficult to access using shovels). To locate the ground position of the interpreted anomaly coordinates, the navigational system “Waypoint Location” mode was used for the positioning systems. A nonmetallic pin flag, labeled with the unique anomaly identification, was placed in the ground at the interpreted location. 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.

Once found, the item was assessed to determine if it was MEC, MD, or other metallic material and was managed in accordance with the Work Plan (Shaw, 2011). Any items identified as MPPEH item were evaluated by the SUXOS as to whether an explosive hazard was present. If no explosive hazard was identified, the item was considered material documented as safe (MDAS) and was no longer considered MPPEH. If the SUXOS could not conclude that an item was free of explosives, the item was to be considered MPPEH that required destruction. The MPPEH item was then to be evaluated to determine whether it was safe to move or required blow-in-place). If an item was verified as MD by the UXO team, it was placed into 55-gallon drums for temporary on-site storage at Building 1501 at the Open Demolition Area #2 site as scrap steel.

If the item was determined not to be MEC, 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 MEC or MD was present, the item was replaced and the soil returned back into the investigation hole in reverse order from which it was excavated. The UXO-qualified personnel were conscious of encountering any cultural artifacts associated with historical cultural or archeological resources.

3.1.2.2 High-Density Anomalous Area Reacquisition and Investigation Procedures

Trenching was performed at locations identified as having a high density of buried anomalies. Locating the ground position for these areas was similar to the single-point anomalies except on a larger scale. The navigational system "Waypoint Location" mode was used for the positioning systems to locate the coordinates of the trench boundary. Nonmetallic pin flag, labeled with the unique anomaly identification, were placed in the ground at the interpreted location of the trench. As for the single-point anomaly locations, 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.

The trench locations were mechanically excavated using an excavator. Each trench was approximately 20 feet long and 3 feet wide and continued in depth until the target anomalies were identified; native material was identified and a clear, distinct boundary between the native and fill material was evident; a maximum depth of 10 feet was attained; bedrock was reached; or the water table was reached. Soil material in each trench was removed in layers at approximately 1-foot intervals.

At the areas identified as having subsurface anomalies, the UXO technicians worked directly with the excavation crew to identify the anomaly. One UXO technician stood in a safe area at the front of the operation and was responsible for examining the area to be advanced into and to visually observe for the presence of MEC or MD before the next layer of soil was disturbed. If no MEC or MD was identified, then the excavation continued in 1-foot lifts. Any MPPEH identified in the trench was required to be evaluated by the SUXOS prior to moving or continuing excavation activities.

Once the soils were excavated, they were spread on 6-mil polyethylene sheeting in an adjacent area where the UXO technicians were able to visually examine for MPPEH in accordance with the Work Plan (Shaw, 2011). For excavations less than 4 feet deep, a UXO technician was able to enter an excavation to confirm no additional ferrous items were located beneath the first item using a Schonstedt magnetometer. If an excavation was greater than 4 feet deep, the previously mentioned trenching criteria (i.e., native material was identified and a clear, distinct boundary between the native and fill material was evident; a maximum depth of 10 feet was attained; or the water table was reached) was used. If no explosive hazard was identified, the item was considered as MDAS and no longer considered MPPEH. If the SUXOS could not conclude that an item was free of explosives, the item was to be considered MPPEH that required destruction. The MPPEH item was then to be evaluated to determine whether it was safe to move or required blow-in-place. If an item was verified as MD by the UXO team, it was to be placed into 55-gallon drums for temporary on-site storage at Building 1501 at the Open Demolition Area #2 site as scrap steel.

Once confirmed that the source had been identified and no MEC or MD was present, the item was to be replaced and the soil returned back into the investigation hole in reverse order from which it was excavated. 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 4.0.

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 Site 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 Site Geophysicist and the UXOQCS.

3.1.3 UXO Estimator® Analysis

Following completion of the investigation activities, the UXO Estimator® module was then used to calculate if enough investigation had been performed to satisfy the performance criteria of 0.5 MEC per acre at a 95-percent confidence level based on the actual field data as well as calculate an average ordnance density. The data incorporated into the module for this exercise included the land-based acreage of the MRS (11.88 acres), the actual area investigated (4.19 acres), the number of MEC items identified during the investigation, and a 95-percent confidence level. The results of DGM investigation and the UXO Estimator® calculation to determine whether the performance criteria were achieved are discussed in Section 4.2.5, "UXO Estimator® Analysis Results."

3.1.4 Underwater Investigation Procedures

Underwater diving activities were performed by former U.S. Navy Explosive Ordnance Disposal (EOD) divers in accordance with the Dive Operations Plan in the *Final Accident Prevention Plan Addendum for Military Munitions Response Program Remedial Environmental Services* (Shaw, 2010). The dive team consisted of a four-man crew that included a SUXOS, a UXO Safety Officer, a UXO Technician, and a Standby Diver. The underwater investigation activities were completed over 100 percent of the quarry pond bottom, which comprised approximately 1 acre, and achieves the DQOs presented in the Work Plan (Shaw, 2011). The process consisted of placing “jackstay” lines across the length of the area of water to cover each transect. The former U.S. Navy EOD diver covered 5 feet at one side of the jackstay and then returned down the opposite side of the jackstay to cover an additional 5 feet. The dive support team would then move the jackstay line and the former U.S. Navy EOD diver would repeat the process.

The maximum depth of water at the ponds was approximately 8 feet at the northwest portion of the pond; however, the average depth in the saturated areas was generally less than 3 feet. Due to the silt makeup of the sediment, the clarity of the water at the quarry pond was very poor. These conditions limited the ability for the former U.S. Navy EOD divers to move or jar any MEC or MPPEH that had the potential of being buried in the sediment of the ponds. Therefore, no intrusive investigations using manual digging could be performed for underwater anomalies and instead the divers used the Navy tactile underwater-investigation techniques. The former U.S. Navy EOD divers were very familiar with the different ordnance categories/groups, and the arming and functioning of each item. The diver used a Diver Mag 1 underwater magnetometer to identify anomalies and after pinpointing the location of the object on the bottom (or in the sediment), the diver used his hands to gently assess the orientation of the item and from tactile exploration, determine the general group the ordnance item belongs to by its shape (i.e., bomb, projectile, grenade, rocket, etc.). Then, using general measurement tools (i.e., elbow to wrist = 1 foot, palm width = 4 inches, etc.) the approximate size of the item was determined. The item was then to be evaluated by feel to determine if a fuze was present or absent. If a MPPEH item was identified, the item was not to be moved or subjected to any sudden forces during the investigation.

3.2 MC Characterization

The MC characterization activities and decision making process at the Ramsdell Quarry Landfill MRS are summarized in this section. The determination as to whether MC characterization was required at the MRS was made based on the recommendations in the SI Report (e^2M, 2008), historical evidence associated with past activities conducted at the MRS, and the results of the intrusive investigations for MEC. It was specified in the Work Plan (Shaw, 2011) that incremental and/or discrete samples would be required in the surface soil and/or subsurface soil where concentrated areas of MEC and MD are encountered, if any. Based on this decision rule, two ISM surface soil samples, RQLss-075(I)-0001-SS and RQLss-076(I)-0001-SS, were collected from combined grid locations at Area 2 where concentrated MD was encountered during the intrusive investigation activities. No MEC or MD was found at Area 1 and no sampling for MC was required at this portion of the MRS.

The MC samples collected for the RI were collected in accordance with the *Final Sampling and Analysis Plan and Quality Assurance Project Plan*, hereafter referred to as the "Sampling and Analysis Plan (SAP)," which is included in Appendix D of the Work Plan (Shaw, 2011). The results of the RI sampling activities are presented in Section 4.4, "Nature and Extent of SRCs."

3.2.1 Sampling Approach and Rationale

Based on the distribution of the MD across the grid locations at Area 2, surface soil samples were collected using ISM to evaluate the nature and extent of contamination associated with historical activities at the MRS and to determine whether or not there is unacceptable risk associated with MC. Each of the ISM samples were collected over two 100- by 100-foot grids totaling 20,000 square feet or 0.46 acres per sample. Surface soil sample RQLss-075(I)-0001-SS was collected over grids D06 and D07 and surface soil sample RQLs-076(I)-0001-SS was collected over grids C08 and D08. The combined grids for each sample are considered the sampling units and were biased to locations where MD was well distributed across or just beneath the ground surface. The increments for the ISM soil samples were collected at depths of 0 to 0.5 feet (0 to 6 inches) bgs and the entire length of the soil collected at each of the increments within a sampling unit was used to make up each of the ISM samples. **Table 3-1** summarizes the media samples for the RI and the rationale for the sample strategy.

Table 3-1
Summary and Rationale for MC Sample Collection

Medium	Sample Type	Sample Unit Area (Acres)	Sample Depth (feet bgs)	Number of Samples[1]	Rationale
Surface Soil	ISM	0.46	0–0.5	2	To characterize the potential release of MC in surface soil at areas with concentrated MD.

[1] Number of samples does not include field duplicate or other quality control samples.
bgs denotes below ground surface.
ISM denotes incremental sampling methodology.
MC denotes munitions constituents.
MD denotes munitions debris.

3.2.2 Incremental Surface Soil Sample Collection

This section presents the sampling methods and detailed descriptions of the sampling activities performed for the ISM samples collected for the RI. The combined ISM sampling units for the RI are considered the surface soil decision unit at the MRS. The surface soil decision unit is based on locations where concentrated areas of MD were identified, where SRCs associated with historical activities are expected, and is the area at the MRS in which a decision regarding MC in surface soil will be made. Additionally, the sampling units that make up a decision unit should have the same potential receptor exposure scenario which is the case for the RI sampling locations at the MRS and is discussed further in Section 4.0.

The collection methodology for the ISM samples collected for the RI is presented in the SAP and is based upon the procedures presented in the *Interim Guidance 09-02, Implementation of Incremental Sampling (IS) of Soil for the Military Munitions Response Program* (USACE, 2009b). The ISM surface soil samples were collected on August 22, 2011, and each sample consisted of 30 increments collected from sampling units using a systematic random pattern. Each increment was collected at 0 to 0.5 feet bgs, and the entire 0.5-foot soil column for each increment in a sampling unit was used to make up each of the ISM samples.

The key steps for collection of a systematic random sample for the RI were the following: (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 (USACE, 2009b).

The sampling units were established by placing nonmetallic pin flags at the corners of each sampling unit. 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 and 2 kilograms (kg).

The QC samples included one field duplicate sample, one matrix spike (MS)/matrix spike duplicate sample (MSD), and an equipment rinsate sample. The field duplicate sample RQLss-077(I)-0001-SS was sent as a blind duplicate to the analytical laboratory. The collection of the field duplicate sample required similar increments of soil as the original sample. Therefore, at the ISM sampling unit where the field duplicate sample was required, an additional ISM sample was collected in a systematic random pattern from within the same sampling unit consisting of 30 increments of soil; the same number increments as the parent sample. The increments for the field duplicate were collected at different randomly selected locations from the original sample increments. The field duplicate was labeled with a different sample number than the original sample and was submitted to the laboratory for processing as a blind field duplicate. Sample RQLss-075(I)-0001-SS was designated as the MS/MSD on the chain-of-custody form prior to shipment.

The ISM surface soil samples were collected in accordance with the SAP (Shaw, 2011) and there were no deviations during the RI field activities. The sampling field logs where all data and observations at the sample locations were recorded, and the chain-of-custody form for the ISM surface soil samples submitted to the contracted laboratory are included in **Appendix C**. The surface soil ISM sampling units are presented on **Figure 3-2**.

3.2.3 Sample Analysis

Analytical services for chemical samples were provided by CT Laboratories, Inc. (CT Laboratories) of Baraboo, Wisconsin, which is accredited through the DoD Environmental Laboratory Accreditation Program (ELAP) and the National Environmental Laboratory Accreditation Conference. The EPA publication SW846 entitled, *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, Analytical Protocols* (EPA, 2007) provides test procedures and guidance that are recommended for use in conducting the evaluations and measurements needed to comply with the RCRA. These methods are accepted by EPA for obtaining data to satisfy the requirements of 40 Code of Federal Regulations (CFR), Parts 122 through 270, promulgated under RCRA, as amended, and are commonly used on CERCLA sites for contamination evaluation. Test methods are approved procedures for measuring the presence and concentration of physical and chemical pollutants, evaluating properties such as toxic properties of chemical substances, or measuring the effects of substances under various conditions. The selection of chemical analysis for the Ramsdell Quarry Landfill MRS was based on the historical use of the MRS (OB/OD and disposal activities), the types of munitions that may have been treated/disposed at the MRS, and the potential MC associated with those munitions. Any munitions items used or disposed at the facility may be present at Area 2. Based on this information, the proposed SW846 analytical suites and methods were presented in the MC Sampling Rationale in the SAP (Shaw, 2011) and included the following:

- Metals (aluminum, antimony, barium, cadmium, total chromium, hexavalent chromium [Cr^{+6}], copper, iron, lead, strontium, mercury, and zinc)—Method EPA SW846 6010C/7471A/7196A
- Explosives—Method EPA SW846 8330B
- Nitrocellulose—Method EPA SW846 9056
- Polychlorinated biphenyls (PCBs)—Method EPA SW846 8082A
- SVOCs—Method EPA SW846 8270C
- Total organic carbon (TOC)—Method EPA 9060A/Lloyd Kahn Method
- pH—Method EPA SW846 9045D

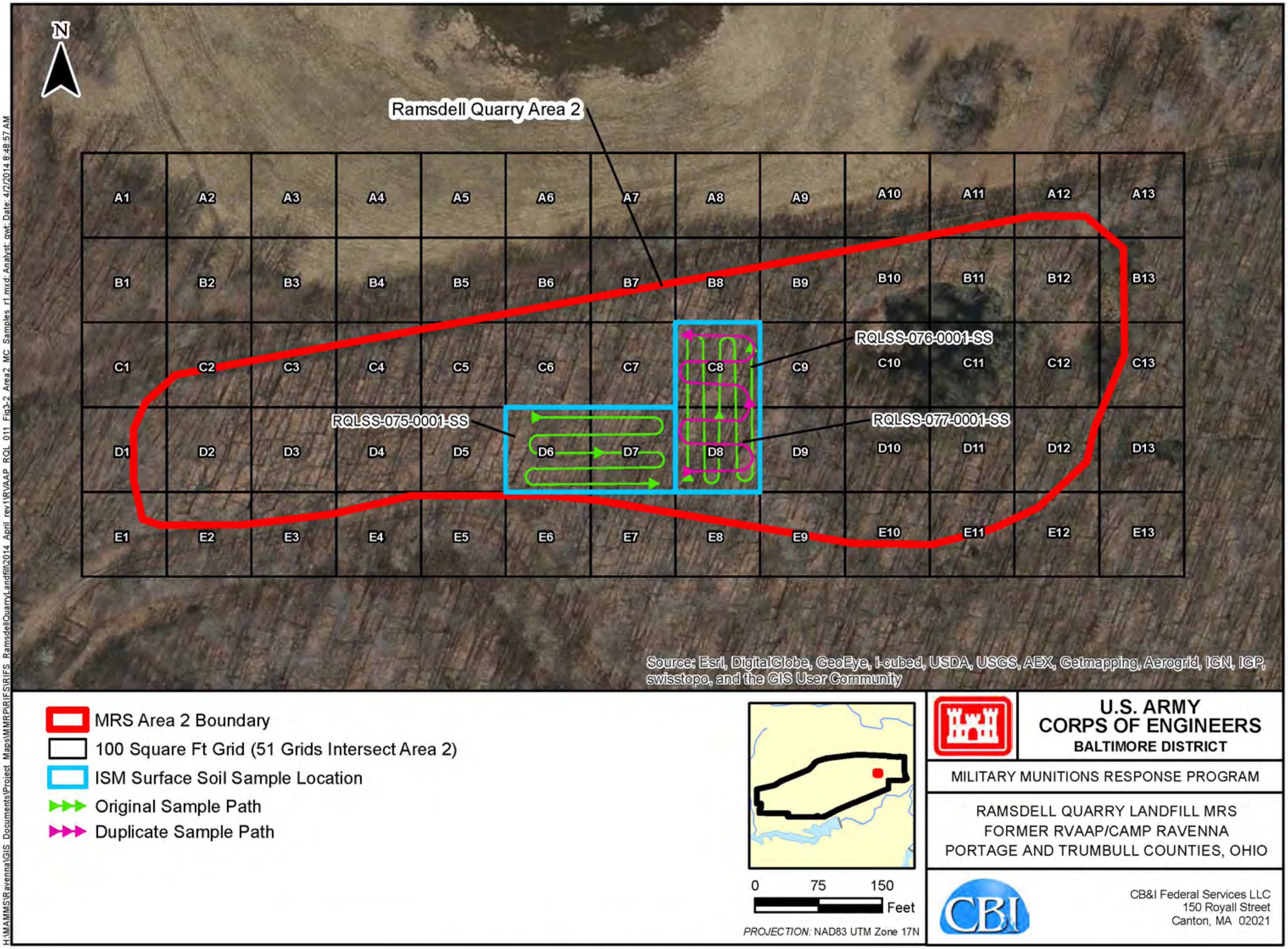


FIGURE 3-2 MC SAMPLE LOCATIONS

In addition to the above analyses, the samples were also analyzed for geochemical parameters via EPA Method 6010C in order to potentially evaluate naturally high inorganic concentrations and distinguish them from potential contamination. The geochemical parameters analyzed for the Ramsdell Quarry Landfill MRS include calcium, magnesium, and manganese.

For the ISM soil samples (including duplicates), the 1- to 2-kg samples were submitted to the contracted laboratory for processing and analysis. Processing consisted of drying out each of the samples and sieving them 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 were analyzed for metals, explosives, nitrocellulose, and SVOCs. The ISM field samples were analyzed for TOC and pH following processing of the sample and prior to grinding. A summary of the number and types of samples collected is presented in **Table 3-2**.

The collected samples were properly packaged for shipment and dispatched to the contracted analytical laboratory, CT Laboratories, in accordance with the SAP (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.

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

Sample Name	Sample Type	Sampling Unit Area (acres)	Depth (feet bgs)	Analytical Parameters	No. of Samples	Field Duplicate
Surface Soil						
RQLss-075(I)-0001-SS	ISM	0.46	0–0.5	Metals[1] Geochemical metals[2] Explosives Nitrocellulose SVOCs TOC pH PCBs	1	
RQLss-076(I)-0001-SS		0.46	0–0.5		1	1

[1] Metals includes analysis for aluminum, antimony, barium, cadmium, chromium (total and hexavalent), copper, iron, lead, mercury, strontium, and zinc.

[2] Geochemical metals include analysis for calcium, magnesium, and manganese.

bgs denotes below ground surface.
ISM denotes incremental sampling methodology.
PCB denotes polychlorinated biphenyl.
SVOC denotes semivolatile organic compound.
TOC denotes total organic carbon.

3.2.4 Laboratory Analysis

The samples were collected and analyzed according to the FWSAP (SAIC, 2011b) and the SAP (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 guidance contained in the DQO guidance (EPA, 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 (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 *DoD Quality Systems Manual for Environmental Laboratories*, Version 4.2, which is hereafter referred to as the "Quality Systems Manual (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 (SAIC, 2011b). EPA SW-846 chemical analytical procedures were followed for the analyses of metals, explosives, nitrocellulose, pH, SVOCs, PCBs, and TOC. TOC analysis was also performed via the 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, laboratory control samples (LCSs), surrogates (organic analysis), laboratory duplicates, and MS/MSD/post-digestion spike (PDS) as applicable to method and project requirements. An equipment rinsate sample was submitted for analysis, along with a field duplicate sample, to provide a means to assess the quality of the data resulting from the field sampling program. **Table 3-3** presents a summary of QA/QC samples utilized during the RI field activities for the Ramsdell Quarry Landfill MRS.

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

Table 3-3 (continued)
Summary of Quality Assurance/Quality Control Samples

Sample Type	Rationale
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 to provide information about the effect of the sample matrix on the measurement methodology
Matrix Spike Duplicate	
Matrix Spike Samples	Analyzed to assist in determining the analytical accuracy of the analysis for the samples of interest and to provide information about the effect of the sample matrix on the measurement methodology
Post-Digestion Spike	
Surrogates	

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 form. These files will remain in a secure area under the custody of CB&I until they are transferred to the USACE—Baltimore District and the ARNG. CT Laboratories retains 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 were 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 operating procedures (SOPs) in the SAP (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, method blanks, and LCS information

3.2.5 Data Validation

Following receipt of the analytical data packages, CB&I performed data validation on all surface soil samples collected from the Area 2 section of the Ramsdell Quarry Landfill MRS (including the field duplicate and QC samples) 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 sample and field duplicate sample. This validation also 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 chemicals of concern (COCs), chemicals of potential ecological concern (COPECs), and calculating risk.

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 (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 LOD.
- “J”—The reported result is an estimated value.
- “UJ”—Analyte was estimated and not detected or reported less than the LOD.
- “R”—Data was considered to be rejected and shall not be used.

In addition to assigning qualifiers, the validation process also selected the appropriate result to use when reanalyses or dilutions were performed. Where laboratory QC samples were outside of analytical method specifications, the validation chemist determined whether laboratory reanalysis 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 Evaluation 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 the 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 in the data were produced, reviewed, and reported by the laboratory in accordance with specifications outlined in the SAP (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 SAP (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 validity of assumptions inferred 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 and preservations
- QC results reported on summary forms as applicable to the analysis performed (i.e., initial and continuing calibrations; method, calibration, and equipment blanks; LCS/MS/MSD; field and laboratory duplicates; 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 method and work plan requirements. Further details and discussion are provided in the *Data Evaluation 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 the qualifications provided 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)* (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." In review of analytical information, the sample results qualified as "J" or "UJ" (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 RI 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., less than the method reporting limit and greater than the MDL) and MS/MSD/field duplicate values outside established criteria. For the spiked sample RQLss-075(I)-0001-SS, there were two data rejections (i.e., R-flagged results) for the SVOCs 3,3'-dichlorobenzidine and 4-chloroaniline that were resultant from a MS/MSD recoveries of less than 10 percent. Analysis for SVOCs was selected to evaluate for MC at the MRS on the basis that OB/OD activities may have generated combustion byproducts, in particular polycyclic aromatic hydrocarbon (PAHs). In addition, the filler material used in the types of incendiary bombs that were reported to have been destroyed at the Area 1 portion of the MRS consisted of the Oil Gel PT-1 mixture. This mixture contained rubber, fuel oil, and a small amount of gasoline (USACE, 2010a). Method 8270C includes analysis for 61 SVOC compounds, including both 3,3'-dichlorobenzidine and 4-chloroaniline that are not considered as constituents associated with the Oil Gel PT-1 filler, combustion byproducts, or PAHs. Therefore, these compounds are not considered to be MC associated with the munitions that were destroyed or the OB/OD activities that historically occurred at the MRS and the R-flagged determinations for these compounds do not impact the overall conclusions of the RI.

- **Precision—**Laboratory duplicate pairs and/or laboratory MSD 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 a 50-percent relative percent difference (RPD) for organic and inorganic parameters. Serial dilutions are evaluated at less than or equal to a 10 percent difference. Field duplicate pairs, laboratory duplicate pairs, laboratory MSDs, and/or serial dilutions were evaluated as applicable per method for the surface soil samples.

For sample RQLss-076(I)-0001-SS and the field duplicate sample RQLss-077(I)-0001-SS, cadmium and chromium were outside laboratory duplicate RPD criteria and were qualified estimated "J" based upon these outliers. For sample RQLss-075(I)-0001-SS, the serial dilution for antimony, barium, cadmium, calcium, magnesium, and zinc exceeded the percent difference criterion. No qualification was required based upon sample results for antimony and cadmium that were less than 50 times the limit of quantitation and the PDS recoveries for barium, cadmium, calcium, magnesium, and zinc were acceptable.

The MS/MSD pair was outside RPD criteria for target compounds antimony and chromium for the spiked sample RQLss-075(I)-0001-SS. The parent sample was qualified estimated "J" for antimony and no qualification (sample result greater than four times the spike added) for chromium based upon these outliers.

A blind surface soil field duplicate sample pair RQLss-076(I)-0001-SS and RQLss-077(I)-0001-SS was collected for all parameter groups. Bis(2-ethylhexyl)phthalate, cadmium, and chromium were outside criteria and qualified estimated "J" for the field duplicate pair based upon the high RPDs. For all other parameter groups, all criteria were met for the field duplicate pair.

Although these results have been qualified as estimated due to the outliers noted, the data are still considered useable (EPA, 1989). Further discussion regarding analytical precision is provided in the *Data Evaluation Report* in **Appendix D**.

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

For SVOC batch 86740, the LCS recovery for 3,3'-dichlorobenzidine was above the laboratory acceptance criteria; however, this analyte was not detected in any of the associated samples; therefore, there were no impacts to any of the reported samples. All other LCS recoveries were within criteria limits for all parameter groups; therefore, did not warrant qualification.

For SVOC batch 86740, the MS/MSD recoveries for spiked sample RQLss-075(I)-0001-SS were below recovery limits for 3,3'-dichlorobenzidine, 3-nitroaniline, 4-chloroaniline, and 4-nitroaniline. For compounds 3,3'-dichlorobenzidine and 4-chloroaniline, the MS/MSD recoveries were less than 10 percent; therefore, these compounds were rejected "R" in the parent sample. Target compounds 3-nitroaniline and 4-nitroaniline were qualified estimated "UJ" based upon the low MS/MSD recoveries.

For spiked sample RQLss-075(I)-0001-SS, the MS/MSD recoveries were outside criteria limits for Cr^{+6}, aluminum, antimony, barium, cadmium, calcium, total chromium, copper, iron, lead, magnesium, manganese, and zinc. Based upon these outliers, the parent sample was qualified estimated "J" for antimony and zinc (i.e., low recoveries); no qualification for aluminum, total chromium, iron, and manganese (i.e., sample result greater than four times the spike added); and no qualification for barium, cadmium, calcium, copper, lead, and magnesium (i.e., acceptable PDS recoveries). The PDS sample recoveries were outside criteria limits for Cr^{+6} and zinc; therefore, the parent sample was qualified estimated "UJ" for Cr^{+6} and "J" for zinc based upon these outliers.

All surrogates were within criteria for all applicable methods (i.e., SVOCs, PCBs, and explosives). No further actions were required.

Although some data results have been qualified as estimated due to the outliers noted, the data are still considered useable (EPA, 1989). Further discussion regarding analytical accuracy is presented in the *Data Evaluation 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.

The point-source anomaly investigation discovered MD to be well distributed at the grid locations investigated at the Area 2 portion of the MRS. The MD was found at a maximum depth of 24 inches, and approximately 88 percent of the MD was located in the top 6 inches of soil. The ISM samples that were collected at Area 2 were collected at the grid locations where the MD was found and at the 0-to-6–inch sample depth where the majority of the MD was discovered. Based on the amount and distribution of MD encountered during the point-source anomaly investigation at the 0-to-6–inch depth at Area 2, it would be expected that this depth interval would be the most impacted with MC and would have the greatest exposure risk for representative receptors. Based on the RI field records and the results of the *Data Evaluation Report* that are discussed in this section, the 0-to-6–inch sample depth and the sample units where the ISM samples were collected is considered representative of the media being sampled for MC. Sample collection was performed using CB&I SOPs and the analytical testing was performed using the EPA methodology with the ELAP-accredited laboratory. Sampling protocols were properly followed to assure 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. Surface soil field sample duplicate sample RQLSS-077(I)-0001-SS was also collected at the Ramsdell Quarry Landfill MRS and is considered to be representative of the original sample RQLSS-076(I)-0001-SS in accordance with the Work Plan (Shaw, 2011) and sample SOPs.

In review of the analytical data, data validation reports, and field records, compounds 3,3'-dichlorobenzidine and 4-chloroaniline were rejected for the spiked sample RQLss-075(I)-0001-SS due to MS/MSD recoveries of less than 10 percent. These compounds are not considered to be MC associated with the munitions that were destroyed or the OB/OD activities that historically occurred at the MRS, and the R-flagged determinations for these compounds do not impact the overall conclusions of the RI. No significant nonconformances were noted for holding times, QC blanks, precision, and completeness evaluations. All other analytical data were deemed representative in accordance with EPA guidance (EPA, 1989).

A QC field audit was conducted for field sampling activities at the facility in accordance with the Work Plan (Shaw, 2011). The audit was activity-based and covered ISM surface soil sample collection conducted at the Group 8 MRS in February 2012. Although the audit was not conducted at the Ramsdell Quarry Landfill MRS, the QC audit is directly applicable to the ISM surface soil samples collected at the MRS because the sampling conducted at both the Group 8 and the Ramsdell Quarry Landfill MRSs was performed using the same procedures as outlined in the Work Plan, and the samples were collected by many of the same individuals at both sites. The QC field audit is presented with the field documentation in **Appendix C**.

Several nonconformances were observed during the QA audit by the UXOQCS. 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. This incident was observed by the UXOQCS prior to actual sampling activities, and during the removal of the sampling equipment and materials from the vehicle. The step probes were properly protected at the time of the observance as noted in the audit and the lack of separate of the step probes from the other equipment did not affect the data. Results of the rinsate blank (GR8-RB-01) for the sampling equipment step probes as part of this sampling event provide supporting evidence that equipment was properly decontaminated during field activities.

An additional nonconformance was identified by the UXOQCS and is considered to be more of a recommendation. The recommendation was to ensure the separation of the step probes from other equipment in the vehicle. The step probes were properly protected at the time of the observance as noted in the audit and the lack of separation of the step probes from the other equipment 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 successful achievement of the objectives of the program and valid conclusions. Completeness is defined as the percentage of measurements which are judged to be usable. The percent completeness criterion is 95 percent. In this data validation review, three categories of completeness quotients are calculated: (1) the overall sampling completeness, (2) the overall analytical completeness, and (3) the analytical completeness by parameter group.

Three ISM surface soil samples, including a field duplicate sample, were proposed in the Work Plan (Shaw, 2011) for this sampling event. 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. Three ISM surface soil samples were collected and sent to the laboratory for analysis. The sample numbers include a field duplicate sample for each matrix. A rinsate blank was also collected for ISM surface soil samples. Therefore, the overall sampling completeness is 100 percent.

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 417 useable data points of possible 419 data points, resulting in an overall analytical completeness quotient of 99.5 percent for all parameter groups. The completeness statistics were computed as follows:

- 417 represents the number of accepted analytes as usable data points (2 analytes were rejected)

- 419 represents the number of analyzed inputs, which is equal to the number of analytes for all field samples

The SVOC compounds 3,3'-dichlorobenzidine and 4-chloroaniline were rejected for the spiked sample RQLss-075(I)-0001-SS due to MS/MSD recoveries of less than 10 percent. The SVOC parameter-specific completeness was 99.2 percent (i.e., 242 usable out of 244 total SVOC compounds). These compounds are not considered to be MC associated with the munitions that were destroyed or the OB/OD activities that historically occurred at the MRS, and the R-flagged determinations for these compounds do not impact the overall conclusions of the

RI. There were no rejected data points for any of the parameters explosives, metals, nitrocellulose, Cr^{+6}, PCBs, TOC, pH, or total solids 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 95 percent. Further discussion regarding data completeness is presented in the *Data Evaluation Report* in **Appendix D**.

- **Comparability—**Comparability is the confidence with which one data set can be compared to another. Comparability was controlled using SOPs that have been developed to standardize the collection of measurements, samples, and approved analytical techniques with defined QC criteria.

Established field SOPs that were preapproved in the SAP (Shaw, 2011) for the RI program were applied to work at the MRS during this sampling round. The field SOPs were followed, as established in the SAP (Shaw, 2011), to ensure that protocols meet project DQOs. The recorded field documentation provided verification 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.

The laboratory chemical analyses were performed by CT Laboratories, an ELAP-accredited laboratory, in accordance with the approved SAP (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.

- **Sensitivity—**The sensitivities are dependent on the analytical method, the sample volumes and dilutions, and percent moistures (solid matrix) used in laboratory determinative analysis. For each analyte, the method sensitivities (i.e., MDLs, method reporting limits, LODs, etc.) and analyte detections presented in the analytical data were compared to the screening criteria for each of the samples collected. The screening criteria are presented in Attachment F, *Table 12 Proposed*

Human Health and Ecological Screening Levels for Ravenna AAP MRSs, of the SAP (Shaw, 2011). Upon comparing the sample results to the minimum project screening criteria, the method sensitivity requirements were met. All MDLs, LODs, and reporting limits were less than the project screening criteria. Although high concentration results may require the analysis be performed at diluted concentrations, no samples in this data group needed to be analyzed at diluted concentrations. A complete summary of the project data against the minimum screening criteria is presented in the data summary tables in **Appendix E**.

- **QC Blanks—**Method blanks, calibration blanks, and rinsate 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."

Field equipment rinsate blank sample RQL-078-RB had concentrations of benzyl alcohol at 18 micrograms per liter (µg/L), pyrene at 0.40 µg/L, and antimony at 5.4 µg/L. All other parameters and target analytes were nondetect. Although benzyl alcohol, pyrene, and antimony were detected in the blank, no qualification of data was necessary as either the analyte was not detected in the associated sample or the analyte was detected in an associated sample but at a concentration greater than five times that of the blank sample concentration action level.

The QC batch method blanks for SVOCs, PCBs, and explosives were free of contamination. Laboratory method blank for metals QC batch 38346 contained trace levels of aluminum at 1.0 mg/kg, barium at 0.0096 mg/kg, calcium at 0.88 mg/kg, iron at 3.3 mg/kg, magnesium at 0.2 mg/kg, and manganese at 0.13 mg/kg. All of the associated environmental samples had concentrations of aluminum, barium, calcium, iron, magnesium, and manganese greater than five times the blank sample concentration action levels; therefore, no qualifiers were applied based upon these outliers.

Trace amounts of multiple metals were detected in the laboratory calibration blanks; however, these concentrations were well below detected sample concentrations and did not warrant further qualification. As a result, no further actions were required. Further discussion of the QC sample blanks is provided in the *Data Evaluation Report* in **Appendix D**.

The Ramsdell Quarry Landfill MRS data were determined to be of sufficient quality to make informed decisions for the surface soil samples that were collected during the RI field activities. Further discussions of data qualifications are provided in the *Data Evaluation Report* in **Appendix D**.

3.3 Decontamination Procedures

Decontamination of dedicated sampling equipment was performed in accordance with the procedures presented in the SAP (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 soil samples. Each step probe was decontaminated after the collection of each ISM soil sample that consisted of 30 increments that were combined to make each of the 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 ASTM International (ASTM) Type 1 water and phosphate-free detergent (Liquinox) solution to remove residual particulate matter and surface film from the equipment.
- Rinse the equipment with ASTM Type 1 water.
- Rinse the equipment with methanol.
- Rinse with ASTM Type 1 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, equipment rinsate samples (RQL-078-RB) were collected by running distilled water through the sampling equipment for the identical analytical parameters as the environmental samples. The purpose of the equipment rinsate samples was to assess the adequacy of the equipment decontamination process.

The results of the equipment blank analysis 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 laboratory data 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 sampling activities at the Ramsdell Quarry Landfill MRS 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 (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, which describes the waste characterization analyses performed, waste characterization screening, and IDW transport and disposal, is presented in **Appendix F**.

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 Ramsdell Quarry Landfill MRS 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 human and environmental receptors. Once the MEC hazards and MC risks are determined, they will then be integrated into the preliminary CSMs developed during the SI (e^2M, 2008) that were presented in Section 2.0, “Project Objectives.” Photographs of the RI activities performed at the MRS 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 Ramsdell Quarry Landfill MRS. These efforts included a combination of visual and DGM surveys and intrusive investigations that were conducted in accordance with the Work Plan (Shaw, 2011).

The UXO Estimator® program is a USACE software tool that is used to determine a field sampling plan for ordnance sites and analyze field data after it has been collected (USACE, 2003b). As discussed in Section 3.1.1, “Geophysical Survey Activities,” the UXO Estimator® module was used for the purposes of the RI field work at the Ramsdell Quarry Landfill MRS to provide performance criteria that were agreed upon among the stakeholders (0.5 MEC/acre at a 95-percent confidence level) and the confidence level of the actual field data after the field work was complete. Following evaluation of the field results, the UXO Estimator® module was then used to advise if enough intrusive investigation of anomalies had been performed to satisfy the performance criteria.

4.1.1 Visual Survey Results

While no visual surveys were proposed for the Ramsdell Quarry Landfill MRS, the potential presence of MEC and/or MD on the ground surface was investigated during the geophysical survey and intrusive investigation. Additional details on items found on the ground surface are presented in Section 4.2.

4.1.2 Geophysical Survey Results

Within Area 1, the DGM data were acquired over transects spaced approximately 3 meters (10 feet) apart across all accessible areas, which resulted in a spatial coverage of 2.05 acres. Within Area 2, approximately 2.14 acres of DGM data were acquired over six 100- by 100-foot grids and portions of thirteen 100- by 100-foot grids. The grids utilized for the DGM survey were adjusted in the field since existing features such as large immovable obstructions (trees and boulders), areas saturated with standing water, and the large open pit in the eastern section of the survey area, made some of the original proposed grids inaccessible for DGM. Between the 11.88 acres that made up the land-based portions of Area 1 and Area 2, the total spatial coverage was approximately 4.19 acres. This equates to an area of coverage that is slightly greater than the 35 percent DGM coverage that was proposed in the Work Plan (Shaw, 2011). **Figure 4-1** presents the actual locations where the DGM activities were performed at the MRS.

Interpretation of the geophysical data indicated that the highest areas of anomaly densities at Area 1 were along the west and east sides of Area 1 and at the center of Area 1 that was saturated with water. The area of highest anomaly densities was at the east side of Area 1. Regions that exhibited relatively low densities were also present within Area 1, particularly at the northern portion of Area 1. At Area 1, 595 anomalies with signal intensities greater than 4 mV on Channel 2 were identified for potential intrusive investigation. **Figures 4-2** and **4-3** present the results of the DGM survey completed at Area 1. **Figure 4-2** provides a sensitive color scale that highlights all anomalies above a signal threshold of 4 to 5 mV. **Figure 4-3** presents the Area 1 DGM data at a coarser scale in order to delineate the major aggregates of buried metal at the MRS with greater definition. In both figures, areas of anomaly saturation are clearly visible, as well as "clusters" or zones of relatively higher anomaly density within saturated areas.

The anomaly density at Area 2 was found to be relatively low and distributed throughout the this portion of the MRS, with the exception of the dense anomaly linear target features near the northwest corner and the southern portions of Area 2. These linear features were considered to be consistent with cultural features found during DGM surveys at other MRSs at the facility (i.e., utility lines). A total of 558 anomalies with signal intensities greater than 4 mV were identified for potential intrusive investigation at Area 2. **Figures 4-4a** and **4-4b** present the results of the DGM survey completed at Area 2.

4.1.3 Selection of Anomalies for Intrusive Investigation

This section presents a discussion of the target dig list development for the evaluation of MEC and MD at the MRS. The proposed intrusive investigation locations were submitted to the USACE and Ohio EPA for review and approval in the Area 1 and Area 2 technical memorandums that are included in DGM Report in **Appendix A**.

4.1.3.1 Selection of Individual Target Anomalies

In Area 2, 100 percent of the 558 individual target anomalies at signal intensities greater than the 4-mV threshold were selected for intrusive investigation since less than full DGM coverage was completed for this area. The anomaly selection criterion of 4 mV was in

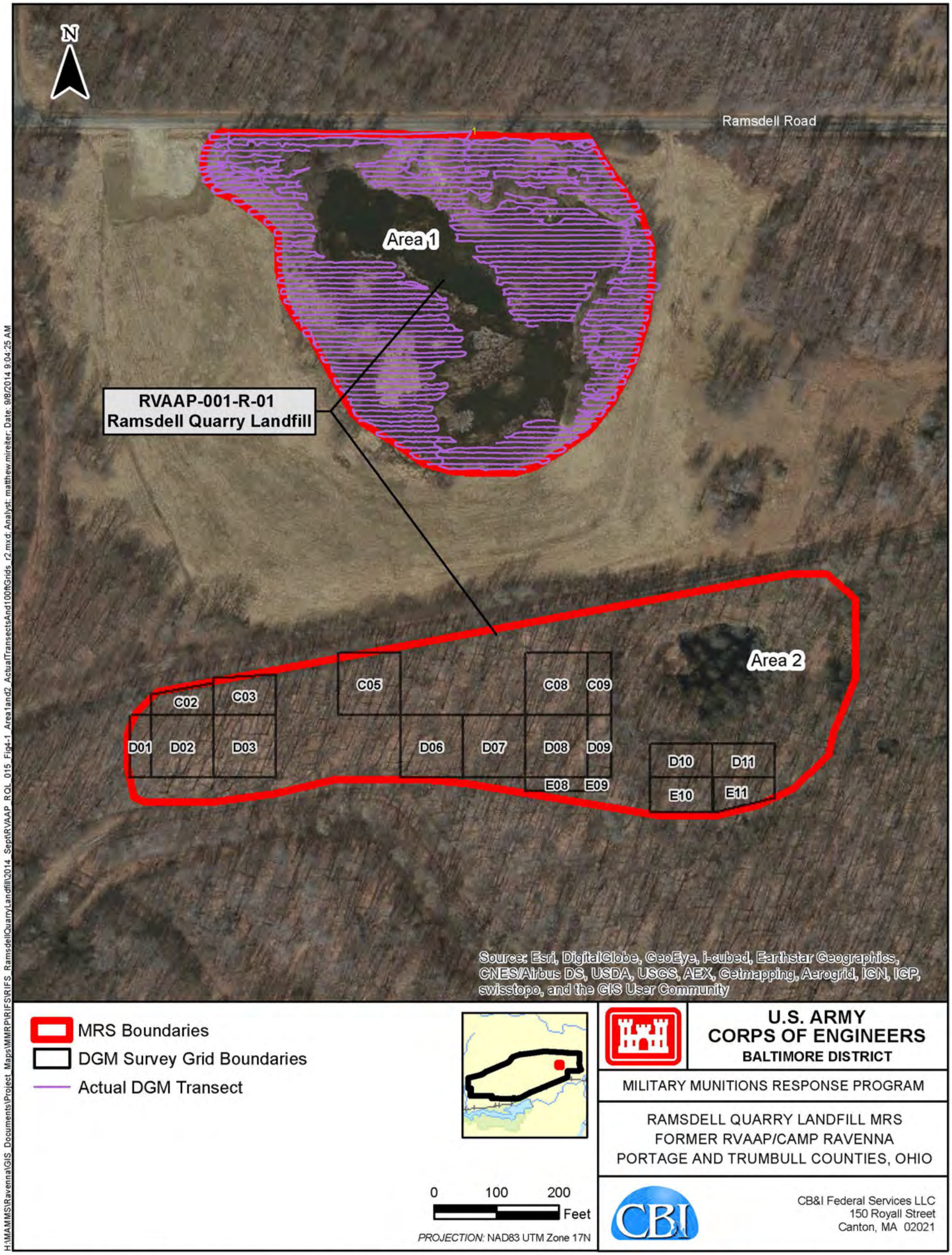


FIGURE 4-1 ACTUAL DGM TRANSECTS AND GRID LOCATIONS COVERAGE MAP

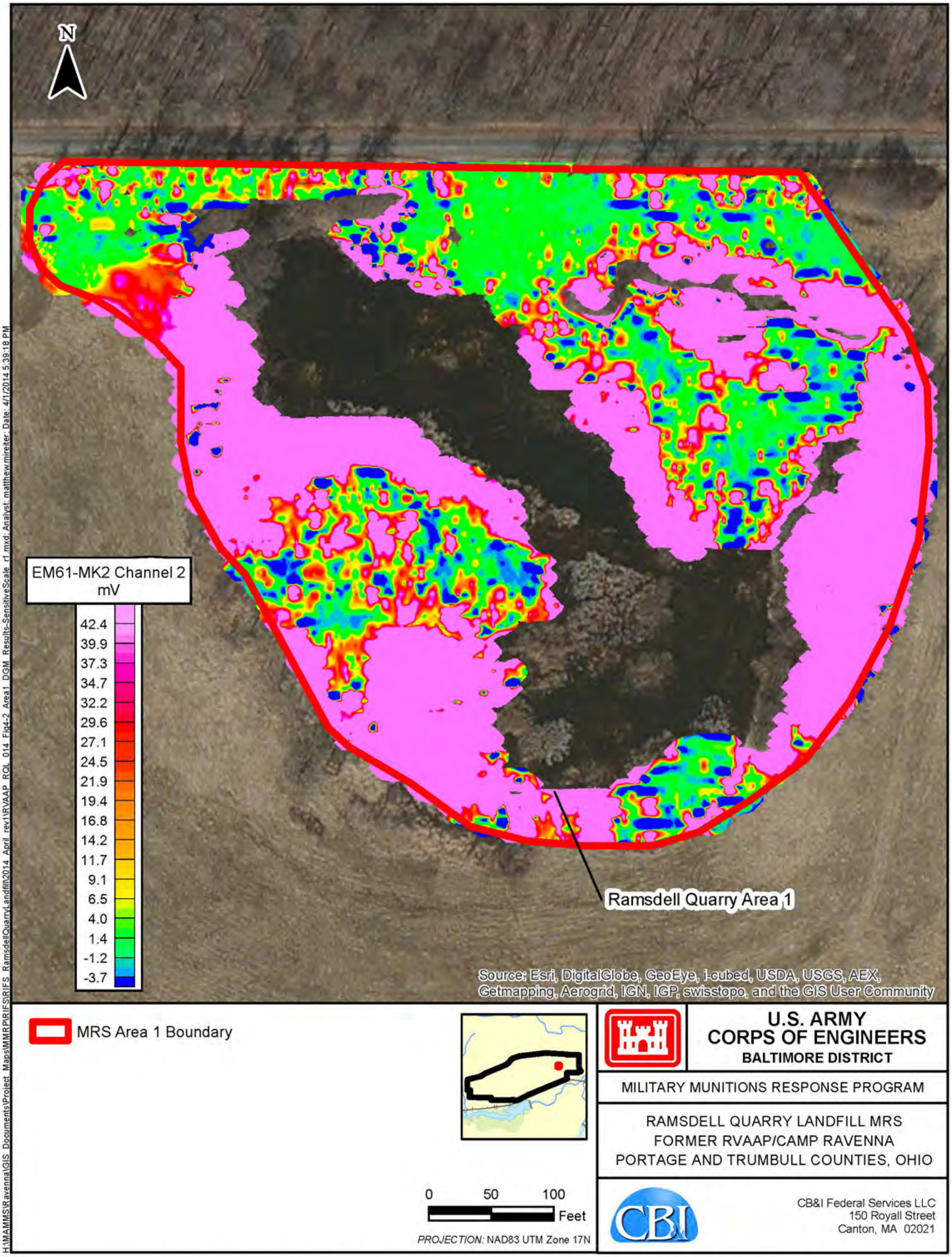
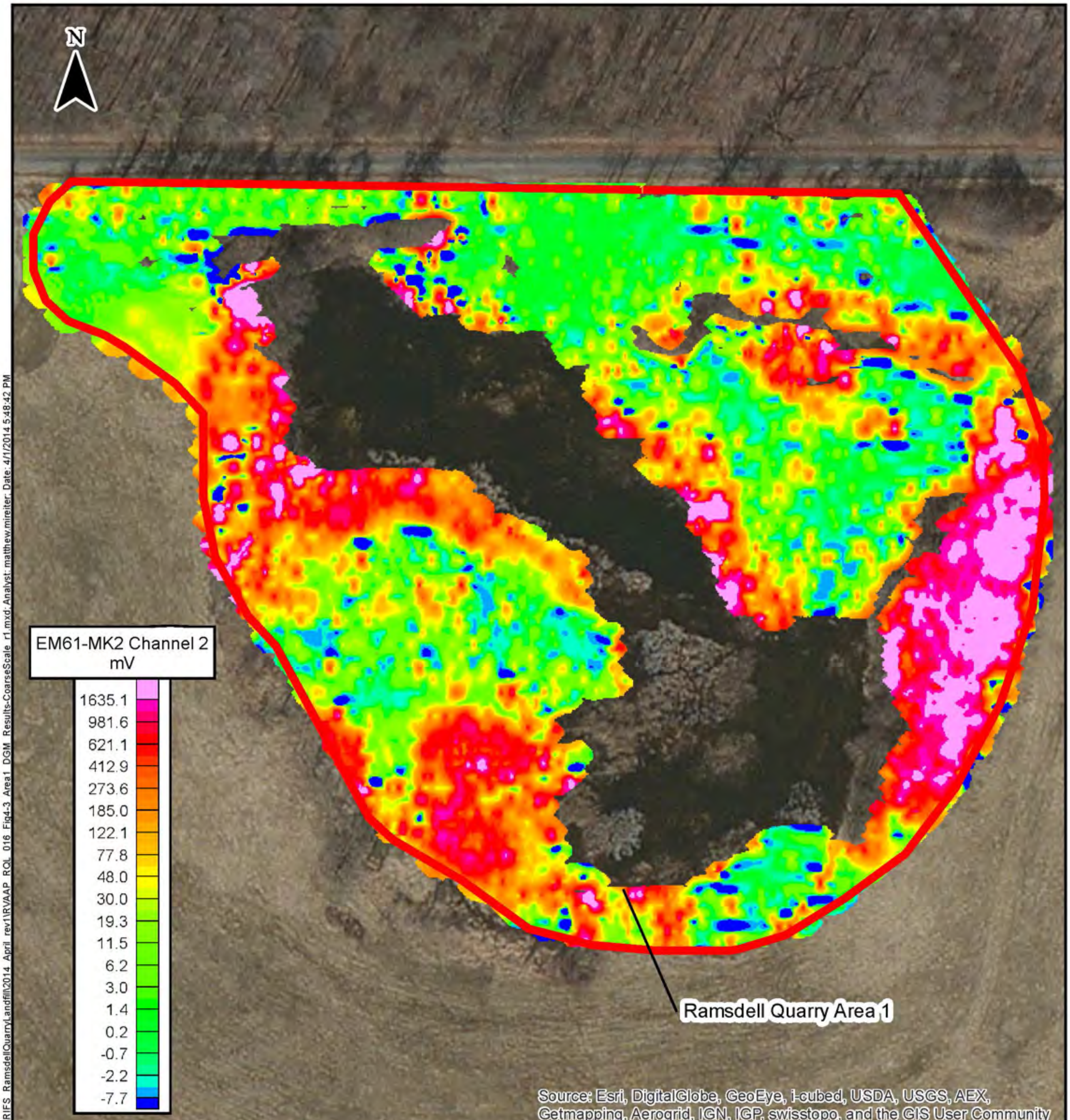


FIGURE 4-2 AREA 1 DGM SURVEY RESULTS – SENSITIVE SCALE



MRS Area 1 Boundary

0 50 100
Feet

PROJECTION: NAD83 UTM Zone 17N

U.S. ARMY CORPS OF ENGINEERS
BALTIMORE DISTRICT

MILITARY MUNITIONS RESPONSE PROGRAM

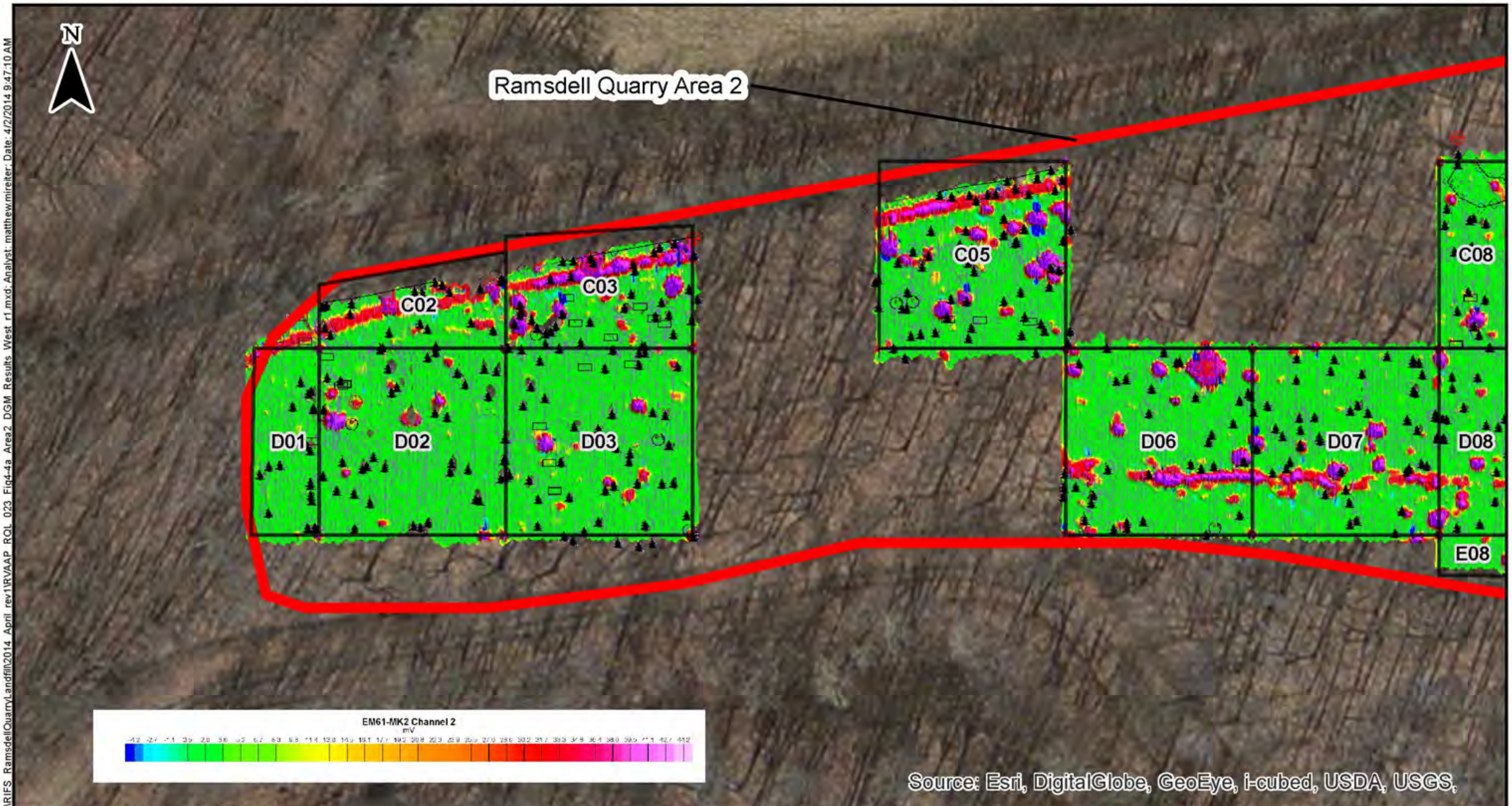
RAMSDELL QUARRY LANDFILL MRS
FORMER RVAAP/CAMP RAVENNA
PORTAGE AND TRUMBULL COUNTIES, OHIO

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

H:\MAMMS\Ravenna\GIS_Documents\Project_Maps\MMRP\RIFS\RIFS_RamsdellQuarryLandfill\2014_April_rev1\RVAAP_RQL_016_Fig4-3_Area1_DGM_Results-CoarseScale_r1.mxd; Analyst: matthew.mireiter; Date: 4/1/2014 5:48:42 PM

FIGURE 4-3 AREA 1 DGM SURVEY RESULTS – COARSE SCALE

H:\MAMMS\Ravenna\GIS_Documents\Project_Maps\MMRP\RIFS\RIFS_RamsdellQuarryLandfill\2014_April_rev1\RVAAP_RQL_023_Fig4-4a_Area2_DGM_Results_West_r1.mxd; Analyst: matthew.mireiter; Date: 4/2/2014 9:47:10 AM



MRS Area 2 Boundary
Intrusive Investigation Grids (100 sq ft each)
Survey Path
QC Point
Terrain Feature
Surface Metal
Logs
Stumps
Trees

0 40 80 Feet

PROJECTION: NAD83 UTM Zone 17N

U.S. ARMY CORPS OF ENGINEERS
BALTIMORE DISTRICT

MILITARY MUNITIONS RESPONSE PROGRAM

RAMSDELL QUARRY LANDFILL MRS
FORMER RVAAP/CAMP RAVENNA
PORTAGE AND TRUMBULL COUNTIES, OHIO

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

FIGURE 4-4A AREA 2 DGM SURVEY RESULTS - WEST SECTION

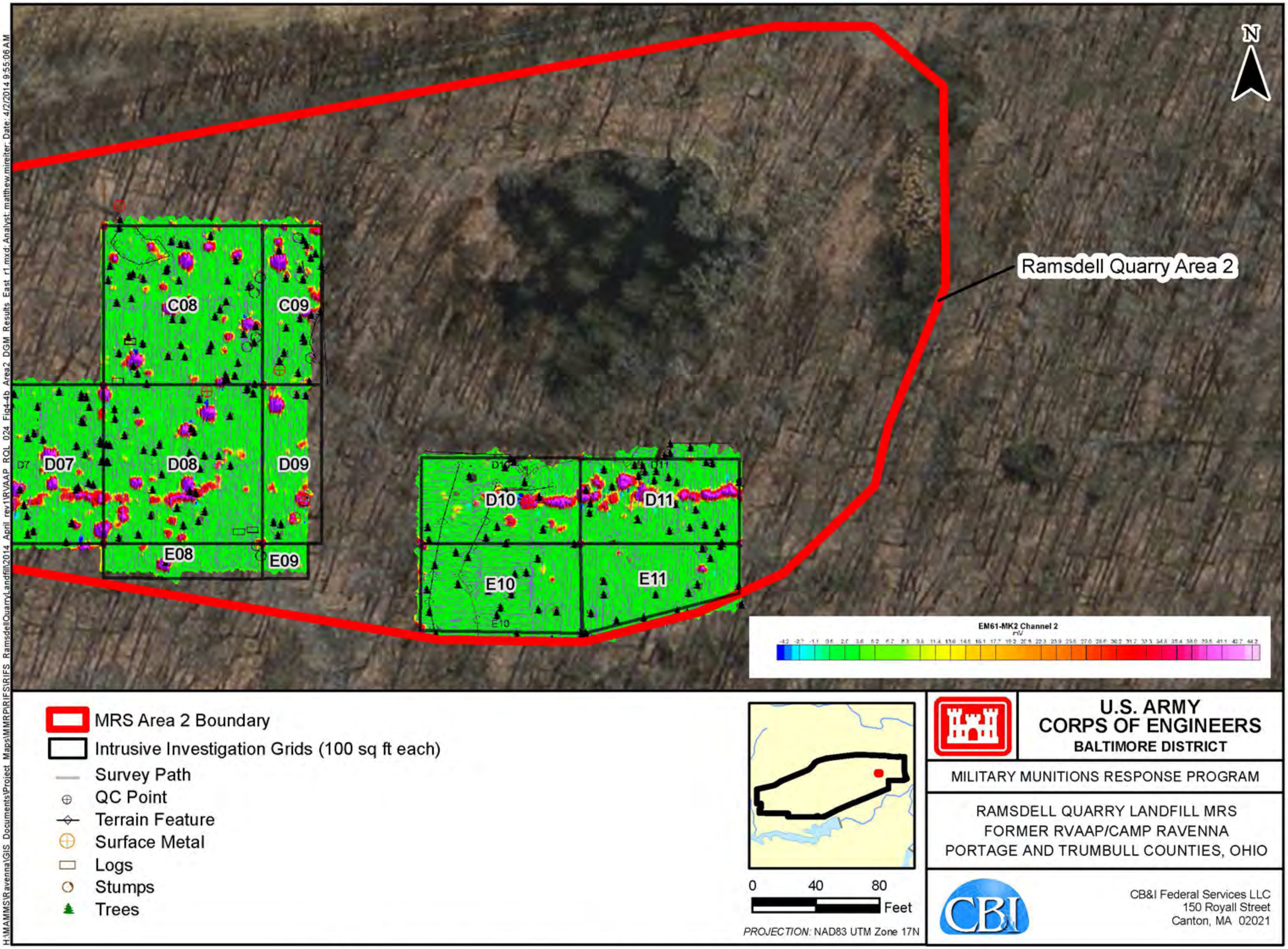


FIGURE 4-4B AREA 2 DGM SURVEY RESULTS - EAST SECTION

accordance with the Work Plan (Shaw, 2011). Additionally, the linear features along the north boundary and the south portions of Area 2 were selected for intrusive investigation based on recommendations made by the USACE during review of the Area 2 technical memorandum. Furthermore, the USACE indicated that additional investigation of anomalies along the linear features would be warranted if the features were not identified to be culturally related items (i.e., utility lines or other similar features).

In Area 1, 595 anomalies were identified as potential targets for intrusive investigation per the anomaly selection criteria presented in the Work Plan (Shaw, 2011). Intrusive activities at Area 2 were completed prior to the anomaly selection process for Area 1 and the results indicated that nearly 30 percent of the anomalies at signal intensities less than 5 mV were "no finds." Based on the results of the Area 2 intrusive investigation, as well as the results of the IVS installed at Load Line 7, where smaller MEC items in the near-surface produced responses exceeding 8 mV (Channel 2), CB&I proposed to investigate 100 percent of anomalies greater than or equal to 8 mV (491 anomalies) and to randomly select and investigate 50 percent of the anomalies between 4 and 8 mV (52 anomalies). It was also proposed that if any MEC/MD items were identified from the 52 randomly selected anomalies below 8 mV, then the remaining 50 percent of anomalies should be investigated. **Table 4-1** includes the rationale for individual point anomaly investigations within Area 1.

Table 4-1
Intrusive Investigation Rationale for Individual Target Anomalies

Area at MRS	Anomalies to be Investigated	Rationale
Area 1	100 percent of anomalies with intensities greater than or equal to 8 mV (491 point-source anomalies) and 50 percent of anomalies between 4 and 8 mV (52 point-source anomalies).	Intrusive results for Area 2 indicated 30 percent of anomalies with intensities less than 5 mV were "no finds" and results for the IVS indicated smaller MEC items in the near surface produced responses greater than or equal to 8 mV.
Area 2	100 percent of anomalies with intensities greater than 4 mV (558 point-source anomalies) and the linear features along the north boundary and the south portions of Area 2.	The 4-mV selection criteria was in accordance with the Work Plan (Shaw, 2011) and was the first area for intrusive investigation at the MRS

IVS denotes instrument verification strip.
MRS denotes Munitions Response Site.
mV denotes millivolt(s).

The individual target anomalies identified for intrusive investigation at Area 1 are presented on **Figure 4-5**. The individual targets anomalies for intrusive investigation at Area 2 are presented on **Figures 4-6a** and **4-6b**.

4.1.3.2 Selection of Anomalies at Areas of High Anomaly Density

Evaluation of the DGM data identified distinct zones of localized high anomaly density along the edges of Area 1, and eight trenches were proposed at these areas using mechanical excavation as the primary investigative technique. No areas of high anomaly density were identified at Area 2 that required investigation using the trenching methodology. The approach for the areas of high anomaly density using the trench investigation process was consistent with work performed in high anomaly density areas at other facility MRSs, including the Atlas Scrap Yard, Group 8, and Open Demolition Area #2 MRSs. A summary and rationale for the trench investigation locations are presented in **Table 4-2**.

Table 4-2
Intrusive Investigation Rationale for Target Anomalies in Areas of High Anomaly Density

Area at MRS	Anomalies to be Investigated	Rationale
Area 1	Eight trenches at distinct zones with high anomaly density along the edges of Area 1	Investigate the distinct zones with high anomaly density. Trenching will provide the most useful information in these areas and is consistent with previous investigations conducted at other MRSs with areas of high anomaly densities.
Area 2	No areas of high anomaly density identified.	No trenching required at Area 2.

MRS denotes Munitions Response Site.

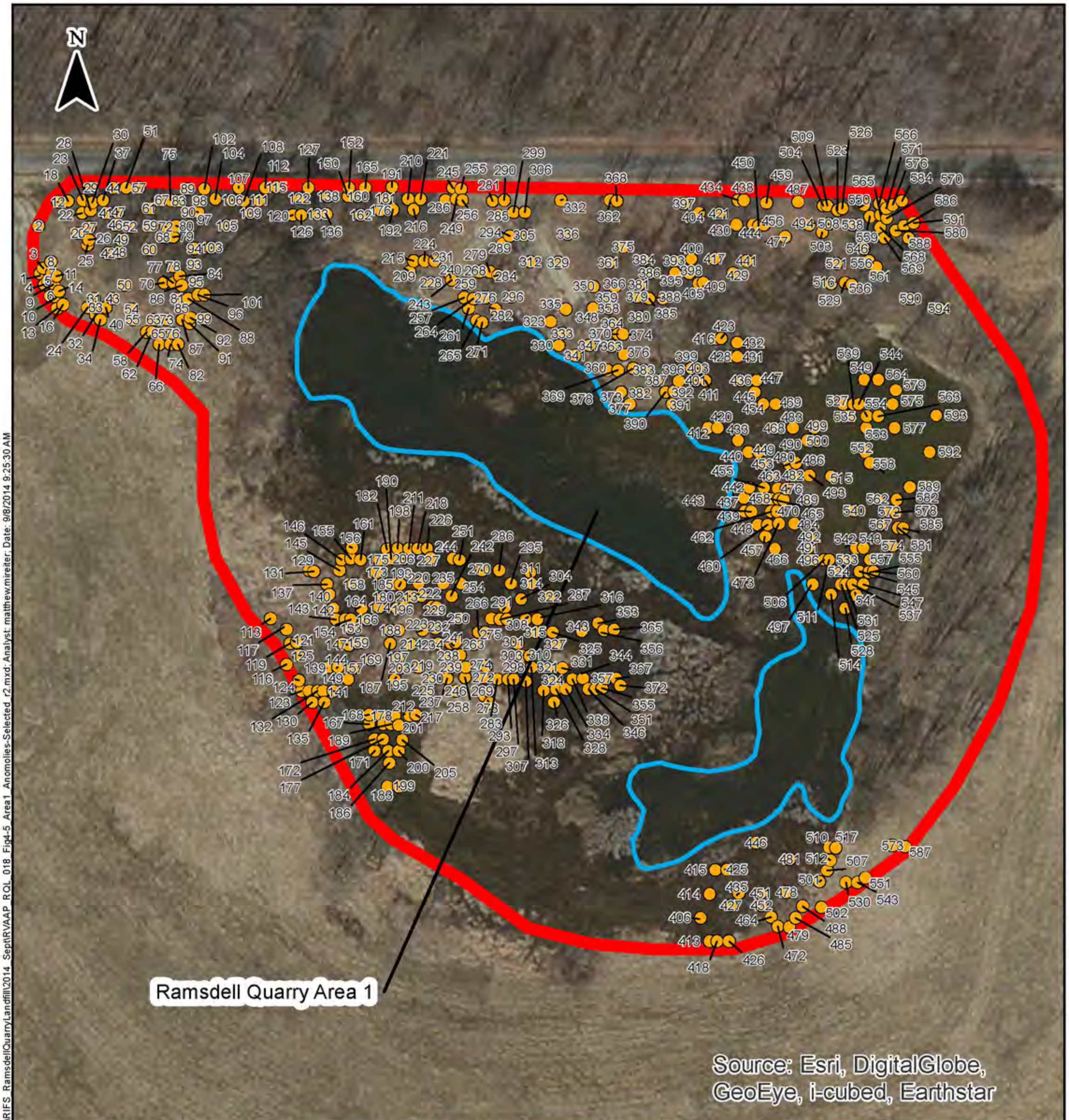
The areas of high anomaly density that were proposed for intrusive investigation at Area 1 are presented in **Figure 4-5**.

4.1.4 Geophysical Quality Control Results

The DGM data were processed and interpreted consistent with the Work Plan (Shaw, 2011). Data were acquired in all areas void of trees and thick vegetation. 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**.

4.2 Intrusive and Underwater Investigation Results

The section presents the results of the intrusive and underwater investigation activities performed at the Ramsdell Quarry Landfill MRS based on the DGM survey findings. A total of 543 point-source anomalies and 8 trenches were identified for intrusive investigation at Area 1. Within Area 2, 558 point-source anomalies were identified for intrusive investigation. The intrusive investigation at Area 2 and the underwater investigation at Area 1 were completed in August 2011. The intrusive investigation activities were delayed at



MRS Area 1 Boundary

Approximate Areas with Deep Water (> 2 Ft) at Time of DGM Survey (May-August 2011)

Anomaly Location Proposed for Investigation

0 50 100 Feet

PROJECTION: NAD83 UTM Zone 17N

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PORTAGE AND TRUMBULL COUNTIES, OHIO

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

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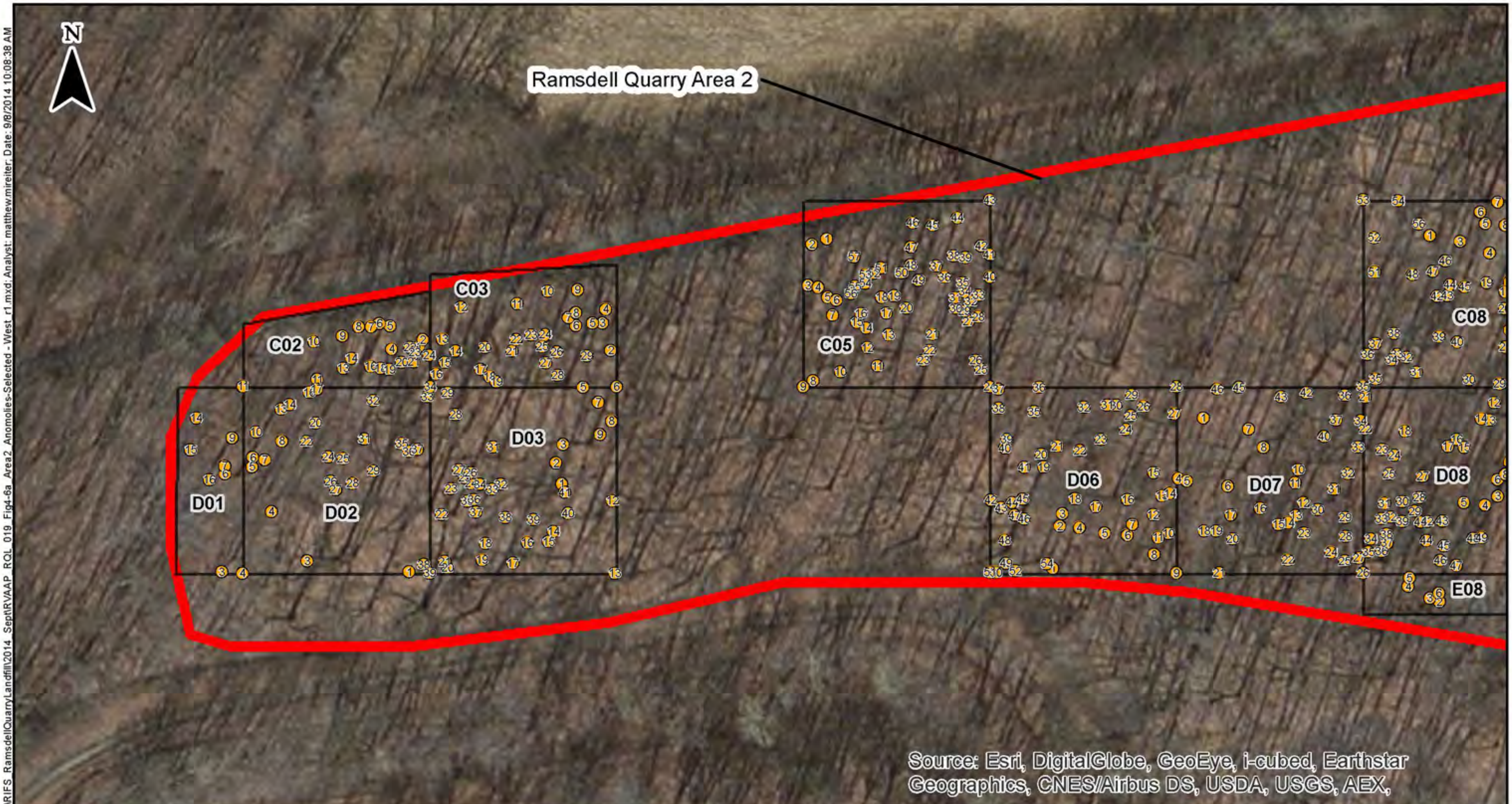
FIGURE 4-5 ANOMALIES SELECTED FOR INVESTIGATION AT AREA 1



MRS Area 2 Boundary

Intrusive Investigation Grids (100 sq ft each)

Anomaly Location Proposed for Investigation

0 40 80

Feet

PROJECTION: NAD83 UTM Zone 17N

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Canton, MA 02021

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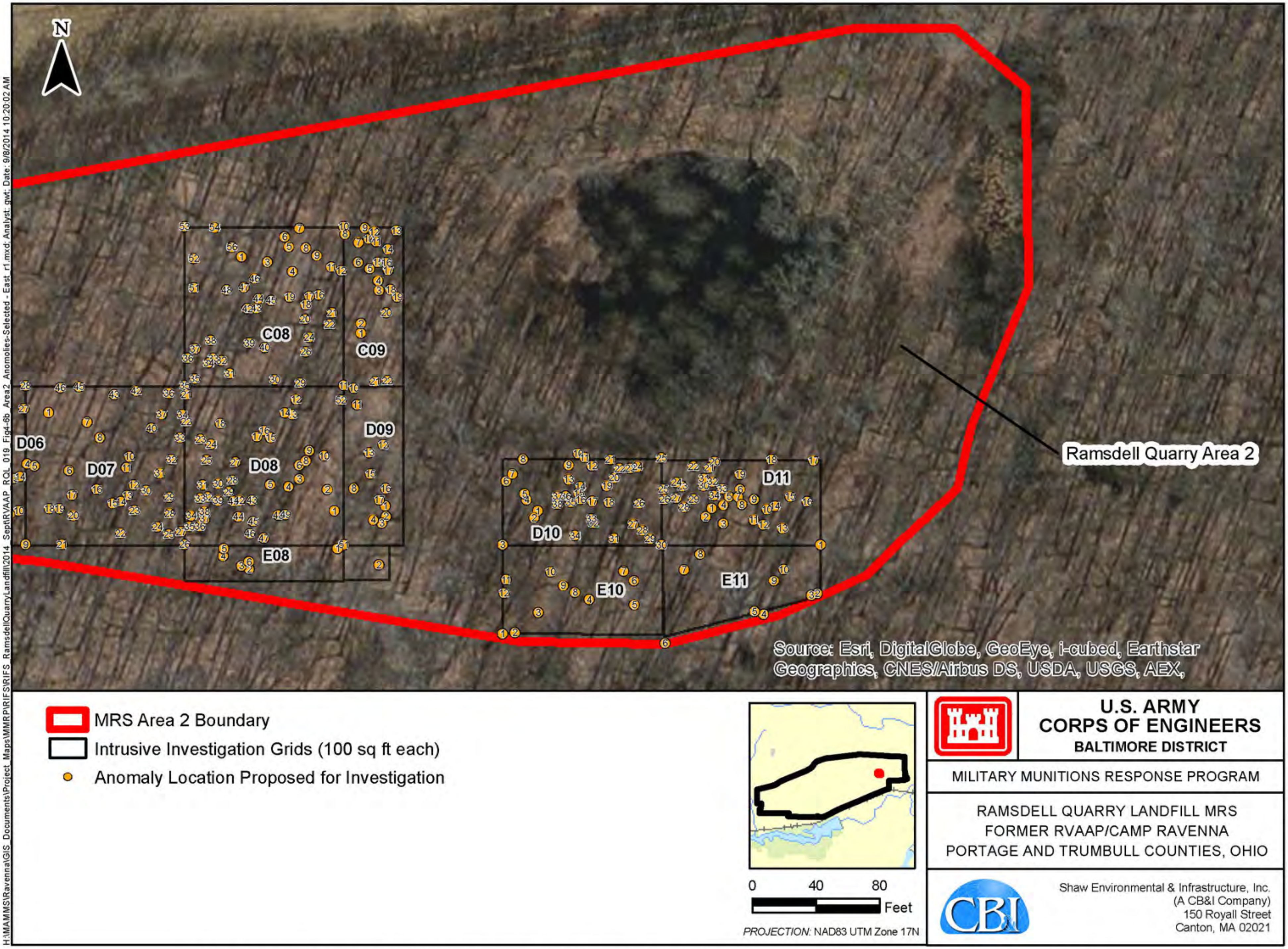
FIGURE 4-6A ANOMALIES SELECTED FOR INVESTIGATION AT AREA 2 - WEST SECTION



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Canton, MA 02021

FIGURE 4-6B ANOMALIES SELECTED FOR INVESTIGATION AT AREA 2 - EAST SECTION

Area 1 until August 2013 when adequate investigation controls and procedures associated with the potential for encountering buried ACM were approved by the Army. The results of the intrusive investigation at Area 1 are presented in **Figure 4-7**. The results for the intrusive investigation at Area 2 are presented in **Figures 4-8a** and **4-8b**. The results of the intrusive investigation at each of the areas are summarized in the data sheets that are presented in **Appendix H**.

4.2.1 Trench Investigation Results

In all, six of the eight trench locations at Area 1 with a high density of anomalies were successfully investigated during the RI field work and no MEC or MD was encountered. Between the time that the anomaly reacquisition activities were conducted at Area 1 in November 2011 and when the intrusive investigation activities actually took place in August 2013, the depth of water in the saturated areas of the quarry bottom had increased and trenches A1-04-1 and A1-08-1 were inaccessible.

The trenches were to be excavated until the target anomalies were identified; native material was identified and a clear, distinct boundary between the native and fill material was evident; a maximum depth of 10 feet was attained; or the water table was reached. Bedrock was encountered at shallow depths at several of the trench locations. The minimum depth that bedrock was encountered was at 30 inches at trench location A1-03-1. The maximum depth at any of the trenches was 48 inches at trench A1-05-1 where native soils were encountered.

A total of 1,655 pounds (lbs) of “Other Debris” items were encountered at four of the six trenches that were excavated at Area 1. The “Other Debris” was construction debris consisting of miscellaneous scrap metal and ACM roofing material. **Table 4-3** summarizes the trench results, the maximum depth attained if investigation was possible, a description of the items uncovered, and the estimated weight of the debris that was encountered.

Table 4-3
Trench Investigation Results

Trench Number	Maximum Depth (inches bgs)	Description of “Other Debris”	Approximate Weight (lbs)
A1-01-1	36	Scrap metal	500
A1-02-1	36	No debris encountered	0
A1-03-1	30	No debris encountered. Trench was excavated to bedrock.	0
A1-04-1	Underwater and inaccessible for intrusive investigation		
A1-05-1	48	Scrap metal	500
		Roofing material (ACM)	5

Table 4-3 (continued)
Trench Investigation Results

Trench Number	Maximum Depth (inches bgs)	Description of "Other Debris"	Approximate Weight (lbs)
A1-06-1	15	Scrap metal	500
A1-07-1	24	Scrap metal	150
A1-08-1	Underwater and inaccessible for intrusive investigation		
		Total:	**1,655**

ACM denotes asbestos-containing material.
bgs denotes below ground surface.
lb denotes pound.

The roofing material that was considered as ACM was removed in accordance with the approved *Accident Prevent Plan Addendum for Asbestos Abatement* (Shaw, 2013). In general, any ACM that impeded the advancement of intrusive activities was properly removed and disposed off site. The total amount of ACM roofing material encountered was 5 lbs, as determined by the Asbestos Hazard Evaluation Specialist in the field, and was removed from the trench A1-05-1 during the intrusive investigation activities at the MRS. With the exception for the ACM roofing material, all "Other Debris" items were left in place or returned back to the excavation from which it was removed and the trenches were backfilled with excavated material. Additional information and details regarding the ACM removal activities are presented in the *Asbestos Abatement Report for Military Munitions Response Program Remedial Investigation Environmental Services* in **Appendix I**.

4.2.2 Point-Source Anomaly Investigation Results

Anomaly reacquisition activities were conducted at Area 1 in November 2011 and 536 of the 543 point-source anomaly locations identified for intrusive investigation were successfully reacquired (98.7 percent). The anomalies that could not be reacquired consisted of 8 targets at the northwest quadrant of Area 1 (Targets 64, 110, 248, 267, 300, 309, 342, and 345) and one target at the northeast quadrant of Area 1 (Target 495). With the exception of Target 248, the remaining individual anomalies that could not be reacquired had low initial detection responses (less than 12 mV) which can often be difficult for reacquisition. Five of these targets had low initial detection responses less than 5 mV. Target 248 had a relatively high initial peak response of 149.7 mV and the proximity of the target location was near the edges of the water features at Area 1. The wet conditions and areas of standing water at Area 1 may have impacted the ability to reacquire Target 248 as well as the anomalies that could not be reacquired that had the initial peak readings above 5 mV.

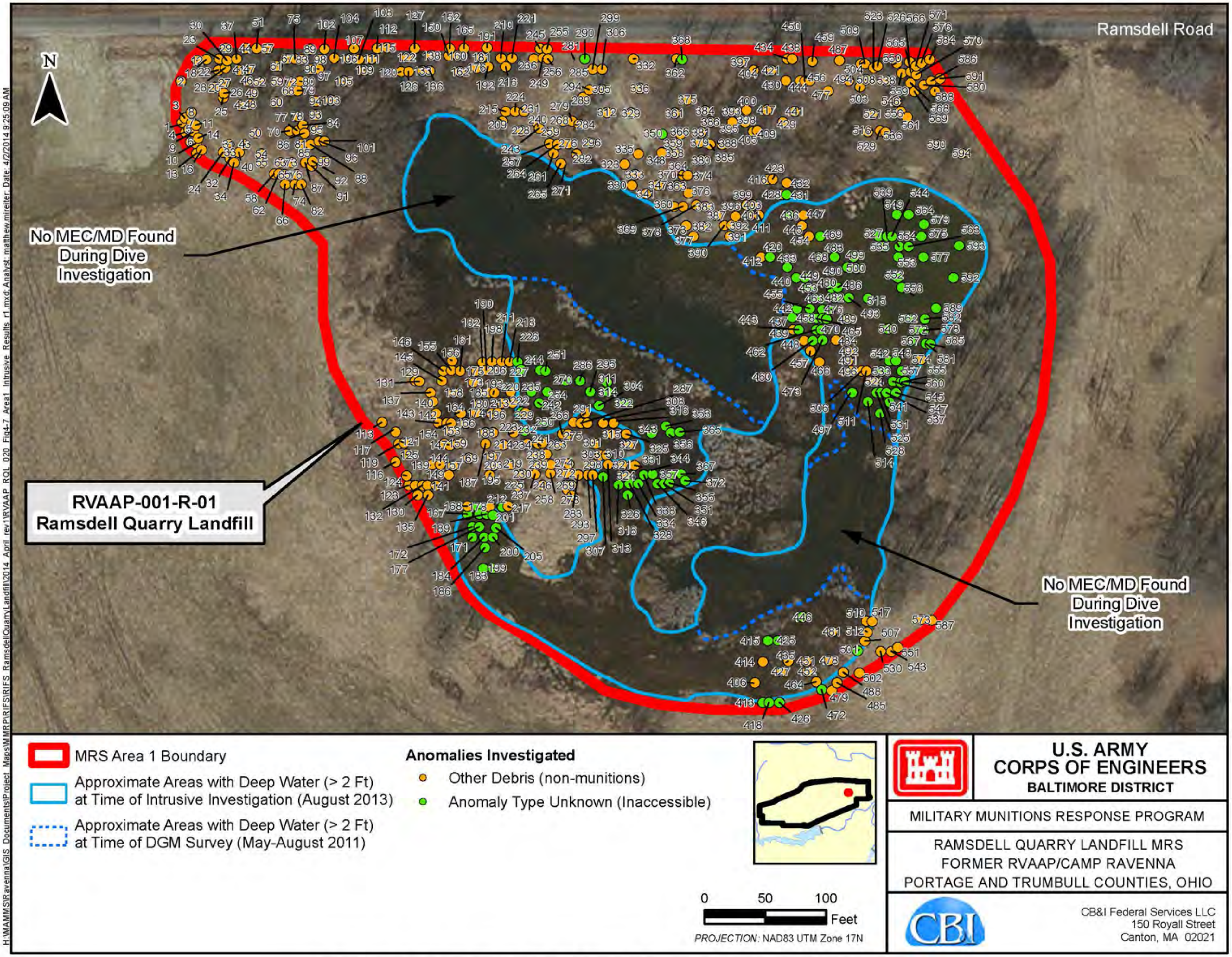

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FIGURE 4-7 INTRUSIVE INVESTIGATION RESULTS AT AREA 1

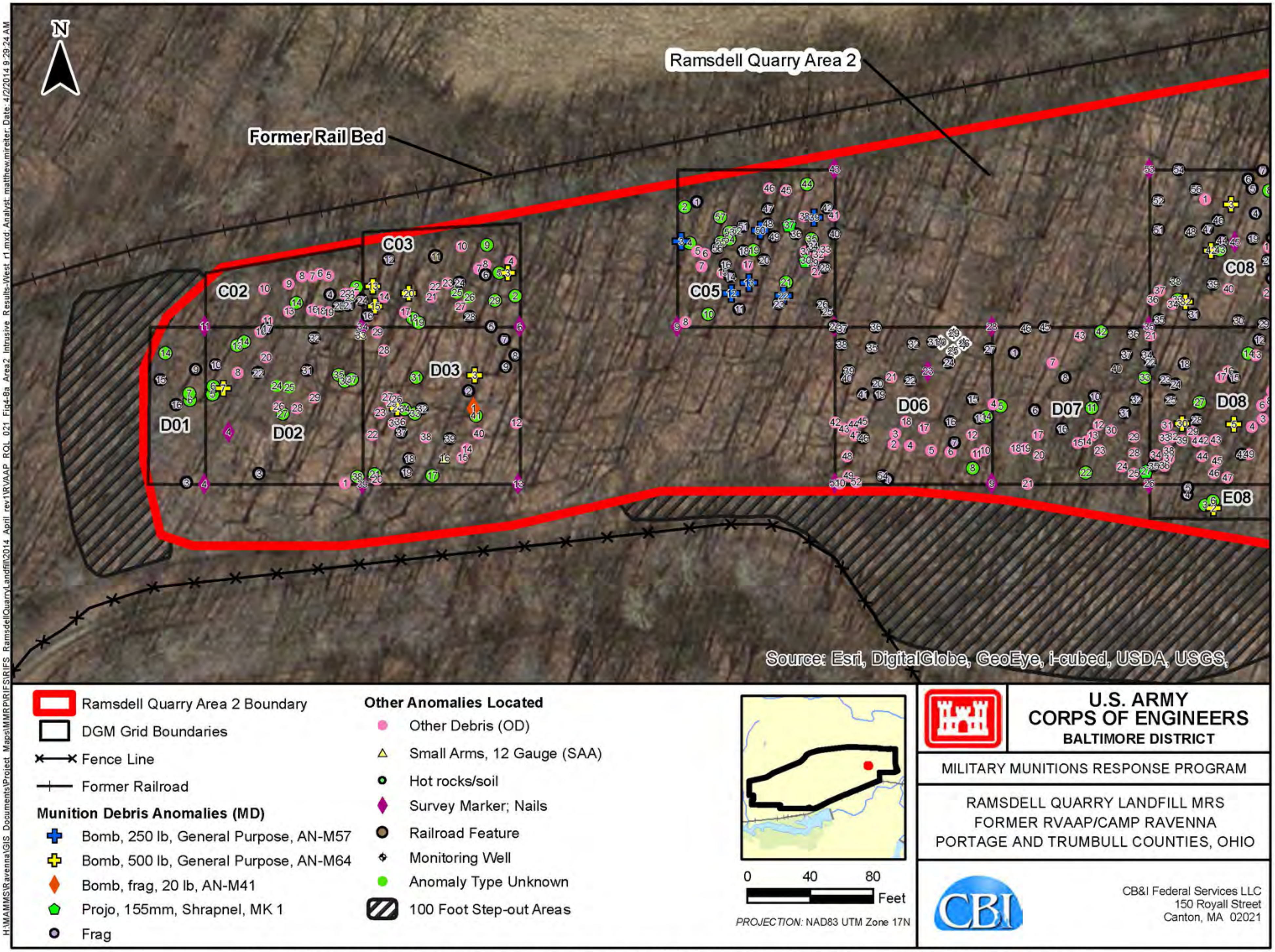

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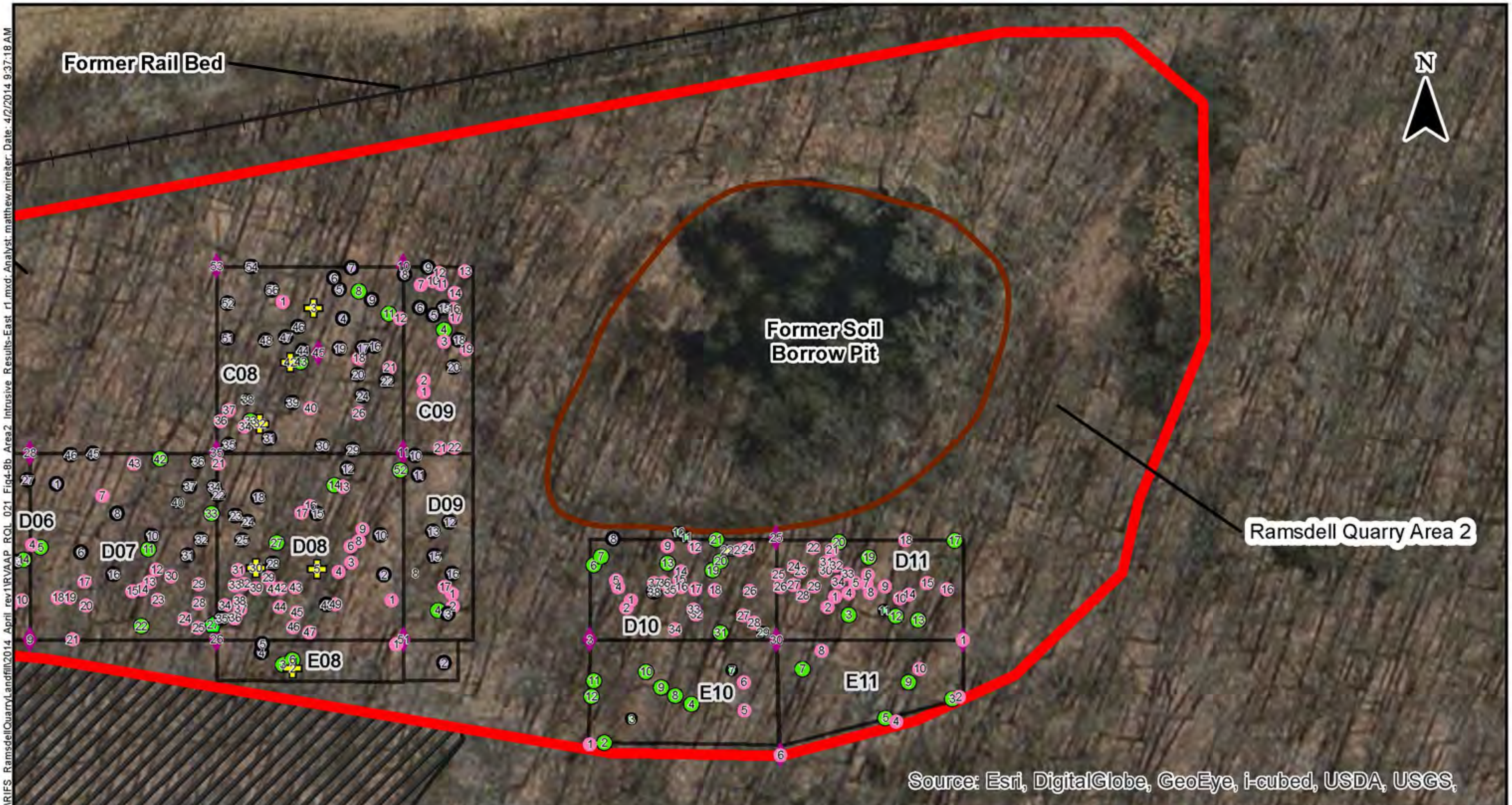
FIGURE 4-8A INTRUSIVE INVESTIGATION RESULTS AT AREA 2 - WEST SECTION



Ramsdell Quarry Area 2 Boundary
DGM Grid Boundaries
Former Soil Borrow Pit
Former Railroad

Munition Debris Anomalies (MD)
Bomb, 250 lb, General Purpose, AN-M57
Bomb, 500 lb, General Purpose, AN-M64
Bomb, frag, 20 lb, AN-M41
Projo, 155mm, Shrapnel, MK 1
Frag

Other Anomalies Located
Other Debris (OD)
Small Arms, 12 Gauge (SAA)
Hot rocks/soil
Survey Marker; Nails
Railroad Feature
Monitoring Well
Anomaly Type Unknown
100 Foot Step-out Areas

0 40 80
Feet

PROJECTION: NAD83 UTM Zone 17N

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FIGURE 4-8B INTRUSIVE INVESTIGATION RESULTS AT AREA 2 - EAST SECTION

Although 536 point-source anomaly locations were successfully reacquired in November 2011, the water levels at the saturated areas at Area 1 had significantly increased by the time the intrusive investigation activities were conducted in August 2013. As a result, 133 (25 percent) of the point-source anomalies were inaccessible and could not be investigated during the intrusive investigation activities. In all, 410 of the 536 reacquired anomalies (76 percent) were successfully investigated.

No MEC or MD was identified at any of the 410 individual target anomaly locations that were successfully investigated at Area 1. A total of 614 "Other Debris" items were identified at 401 of the individual target anomaly locations during the intrusive investigation activities. In all, approximately 1,844 lbs of "Other Debris," as determined by the UXO teams in the field, was encountered during the intrusive investigation activities at Area 1. The debris consisted mainly of scrap metal, nails, wire, bolts, fence posts, rebar, and pipes. The maximum depth investigated at any of the target anomaly locations was 60 inches (5 feet) at target location 230 where debris consisting of a metal cable was found; however, most of the "Other Debris" items were encountered in the top several inches of soil. All "Other Debris" items were either left in place or returned back to the excavation location from where they came.

Anomaly reacquisition and intrusive investigation activities for Area 2 were performed between July and August 2011. A total of 565 individual anomalies were selected for the intrusive investigation at Area 2, and 508 (90 percent) were successfully reacquired and investigated. The targets that could not be reacquired consisted of the following:

- Grid C2: Targets 14 and 15
- Grid C3: Targets 1, 2, and 29
- Grid C8: Targets 27 and 55
- Grid C9: Target 4
- Grid D1: Targets 1, 2, 5, 8, 10, 12, 13, 14, and 17
- Grid D2: Targets 9, 12, 14, 15, 18, 19, 21, 23, 30, 35, 36, 37, and 38
- Grid D3: Targets 4, 10, 11, and 16
- Grid D7: Targets 9, 11, and 38
- Grid D8: Target 7
- Grid D9: Target 4
- Grid D10: Targets 6, 7, 8, 20, and 22

- Grid D11: Targets 3, 13, 17, 20, and 22
- Grid E10: Targets 2, 4, 8, 9, 10, 11, and 12
- Grid E11: Target 5

With the exception of Target 11 within Grid D7 and Target 4 within Grid D9, the remaining individual anomalies that could not be reacquired had low initial detection responses (less than 12 mV) which can often be difficult for reacquisition. Target 11 within Grid D7 had a relatively high initial peak response of 181.87 mV. It is believed that the initial peak was due to a surface metal object that may have been moved during the DGM survey. During the post-excavation QC, the peak response at this target location was reduced to 0.2 mV.

The findings of the intrusive investigation at Area 2 resulted in no MEC; however, 187 MD items were found at 161 locations. The MD items found consisted of fragments and parts associated with the 20-lb AN-M41 series bomb, the 155mm MK-1 series projectile, the 250-lb AN-M57 series general purpose (GP) bomb, and the 500-lb AN-M64 series GP bomb. Although not considered as MD, small arms ammunition consisting of expended 12-gauge shells was found at three of the target locations (Target 33 in Grid D2, Target 18 in Grid D3, and Target 22 in Grid D10). The maximum depth that MD was found was 24 inches at Grids C3 and C5; however, most MD was encountered at depths less than 6 inches. In all, 670.4 lbs of MD was found during the intrusive investigation activities at Area 2. **Table 4-4** summarizes the MD findings per grid location at Area 2.

Table 4-4
Point-Source Anomaly Investigation Results at Area 2

Grid Locations	Quantity of MD	Maximum Depth of MD (inches bgs)	Description of MD	Approximate Weight (lbs)
C02	5	2	Fragments, unknown type	5.7
C03	9	24	Bomb, 500-lb, GP, AN-M64 series Fragments, unknown type	89.55
C05	38	24	Bomb, 250-lb, GP, AN-M57 series Projectile, 155mm, shrapnel, MK 1 series Fragments, unknown type	164.65
C08	31	6	Bomb, 500-lb, GP, AN-M64 series Fragments, unknown type	76.35
C09	9	8	Fragments, unknown type	21.6
D01	4	2	Fragments, unknown type	3
D02	7	6	Bomb, 500-lb, GP, AN-M64 series Fragments, unknown type	55.55

Table 4-4 (continued)
Point-Source Anomaly Investigation Results at Area 2

Grid Locations	Quantity of MD	Maximum Depth of MD (inches bgs)	Description of MD	Approximate Weight (lbs)
D03	13	4	Bomb, fragments, 20-lb, AN-M41 series Bomb, 500-lb, GP, AN-M64 series Fragments, unknown type	32.65
D06	21	18	Fragments, unknown type	78.2
D07	13	6	Projectile, 155mm, shrapnel, MK 1 series Fragments, unknown type	73.3
D08	14	6	Bomb, 500-lb, GP, AN-M64 series Fragments, unknown type	36.8
D09	17	10	Fragments, unknown type	20.2
D10	2	6	Fragments, unknown type	0.85
E08	3	6	Bomb, 500-lb, GP, AN-M64 series Fragments, unknown type	11.5
E09	1	8	Fragments, unknown type	0.5
			Total:	**670.4**

bgs denotes below ground surface.
GP denotes general purpose.
lb denotes pound.
MD denotes munitions debris.
mm denotes millimeter(s).

Step-out activities were performed outside the west and south boundaries of Area 2 from where MD was found in the intrusive investigation grid locations D01, D06, D07, D08, D09, E08, and E09. The step-out activities were only conducted outside these sections of Area 2 since the other grid locations along the Area 2 boundary where MD was found were either bound by the identified cultural features (i.e., the Load Line 1 fence to the south, the rail bed to the north, and the former soil borrow pit to the east) or no MD was found at the grid location (i.e., Grids E10 and E11 to the southeast). The step-out activities consisted of a meandering Schonstedt-assisted visual survey to a distance of approximately 100 feet from the MD items that were found near the Area 2 boundary. These activities were not tracked with the GPS since they were for verification purposes only. Some miscellaneous metal debris was found on or just below the ground surface during the step-out activities; however, no MEC or MD was found outside of the Area 2 boundary. The approximate locations where the step-outs were performed are presented in **Figures 4-8a** and **4-8b**.

In addition to the point-source anomalies that were selected for intrusive investigation, the linear features that were identified during the DGM survey along the northern boundary and southern portions of Area 2 were also investigated. The linear features were found to be primarily remnants of old barbed wire fencing. Some parts of the fences were found to still be standing in areas with thick brush that grew around it; however, much of the barbed wire that still remained was found buried in tree roots, detritus, or just below ground surface. In addition, a buried rail road signal cable was found along the northern portion of Area 2 in Grid C05. The signal cable was 1.5 inches in diameter and was found at approximately 3 feet bgs.

The remaining target locations consisted primarily of "Other Debris" at depths between the ground surface to a maximum depth of 48 inches. The average depth of the "Other Debris" items was approximately 6 inches. The "Other Debris" consisted of materials such as wire, pipes, nails, bolts, cables, remnants of rusted drums, slag (i.e., hot rocks), and miscellaneous scrap metal items. The combined total weight of the "Other Debris" at Area 2 was approximately 300 lbs. The quantities of MD and "Other Debris" at Area 2 were determined by the UXO teams in the field. All "Other Debris" items were either left in place or returned back to the excavation location from where they came.

4.2.3 Underwater Investigation Results

On August 6, 2011, former Navy EOD divers performed an underwater investigation for potential MEC over 100 percent of the quarry pond at Area 1 that covered approximately 1 acre. No intrusive investigation was performed for any anomalies discovered in the pond as the divers were unable to visually identify potentially hazardous ordnance that could not be moved or jarred for safety purposes. Instead, the divers had to utilize the tactile underwater investigation method that consisted of feeling the item and making a determination as to whether an item was potential MEC or MPPEH based on their expertise.

The underwater survey identified small quantities of metallic debris; however, no evidence of MEC or MD was found. The metal debris in the ponds consisted primarily of construction debris and miscellaneous scrap metal and iron. Most of the debris was encountered in the sediment along the southeast portion of the ponded area and is consistent with the high anomaly density areas at the land-based area at this portion of Area 1 that were intrusively investigated during the RI field activities. The findings of the underwater investigation are provided in **Figure 4-7**.

4.2.4 Post-Excavation Quality Control

Between Area 1 and Area 2, 325 anomaly locations (61 locations at Area 1 and 264 locations at Area 2) were randomly selected for post-excavation QC checks (i.e., intrusive anomaly verification) with the EM61-MK2 based on the USACE *Acceptance Sampling Table* (USACE, 2009a). At Area 1, four post-excavation QC locations (Targets 351, 413, 425, and 574) could not be investigated since they were at submerged areas. At one location

(Target 574), a steel fence post was left in place and the residual signal was greater than 4 mV (7,800 mV). At Area 2, the results of the post-excavation QC locations were considered acceptable even though the residual signal at 57 of the locations were greater than 4 mV (Channel 2). The results were attributed to either miscellaneous items such as wire or scrap metal that were embedded in the ground or tree roots that could not be moved (40 locations), QC nails (14 target locations), small scattered objects on the ground surface (1 location), or anomalies outside the radius of the target location (2 locations). At all of the remaining locations at both Area 1 and Area 2, the residual signals from the sensor were less than 4 mV (Channel 2) and no additional excavation locations were required to be checked.

4.2.5 UXO Estimator® Analysis Results

The UXO Estimator® module (USACE, 2003b) was used to analyze the data collected during the intrusive investigation activities to determine if the performance criteria target density of 0.5 MEC per acre at a 95-percent confidence level were met for the Ramsdell Quarry Landfill MRS. The actual investigation area of 4.19 acres exceeds the proposed investigation area of 4.16 acres, and since no MEC was found during the RI field activities, the UXO Estimator® module calculates the statistical upper bound density to be 0.5 MEC per acre at a 95-percent confidence level. Statistically, these results indicate there is a potential for remaining MEC since not all of the target anomalies were successfully investigated; however, the uncertainty is low since no MEC was found during the field work. The calculated density meets the target density of 0.5 MEC per acre and indicates that the performance criteria have been met.

4.2.6 Management and Disposal of MD

This section presents the management and disposal practices for the MD items that were encountered during the RI intrusive investigation activities at the Ramsdell Quarry MRS. In all, approximately 670 lbs of MD were generated during the intrusive investigation activities at the Area 2 portion of the MRS. No MD was found in Area 1. All MD items found were managed and disposed in accordance with the *Explosives Management Plan* in Section 5.0 of the Work Plan (Shaw, 2011).

Once an item was verified as MD, it was placed into a 55-gallon drum for disposal off of the facility. The drum was documented as MDAS and was transported for temporary storage at Building 1501 at the Open Demolition Area #2 site at the facility. The drum was labeled as "Scrap Steel," and on September 8, 2011, the drums that were inclusive of all MD that was generated by CB&I at the Ramsdell Quarry MRS and other facility MRSs investigated under the MMRP as of September 2011 were transported off site for demilitarization disposal at Demil Metals, Inc. in Glencoe, Illinois. The waste shipment documentation for the MD disposal is presented in **Appendix J**.

4.3 MC Data Evaluation

This section presents the results of the RI data screening process for MC that may be indicative of past activities that occurred at the Ramsdell Quarry Landfill MRS and to evaluate the occurrence and distribution of the SRCs in the media sampled. The data evaluated in this section is inclusive of the results of the RI sampling event only. Analytical data from previous samples collected during the SI and under the IRP were not included in this evaluation based on the rationale presented 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 that occurred at the MRS. The nature and extent of identified MC within the sampled environmental media (surface soil) established for this RI Report are also presented below. Data summary tables for the RI data collected at the Ramsdell Quarry Landfill MRS are presented in **Appendix E**.

4.3.1 Data Evaluation Method

The data evaluation methods discussed herein are consistent with those established in the *Final Facility-Wide Human Health Cleanup Goals* (SAIC, 2010), which is hereafter referred to as the "Final Facility-Wide Cleanup Goal (FWCUG) guidance." These methods consist of three general steps: (1) definition of data aggregates; (2) data verification, reduction, and screening; and (3) data presentation.

4.3.1.1 Definition of Aggregates

The data aggregate for this RI Report consists of the ISM surface soil samples that were collected at the two sampling units at the Area 2 section of the MRS and do not include the field duplicate or QC samples. The combined sampling units are considered as the surface soil decision unit for Area 2. The surface soil decision unit for Area 2 is based on locations where MD was 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 Area 2 will be made.

Each of the ISM surface soil samples were collected at similar depths (0 to 0.5 feet bgs) and at evenly sized sampling units (0.46 acres). The sampling units were biased towards locations at Area 2 where the majority (88 percent) of the MD items were found during the intrusive investigation. The 0- to 0.5-foot (6-inch) sample depth for the sampling units is considered the representative depth that MC associated with the MD encountered during the intrusive investigations would be expected since most of the MD was found just below ground surface to 6 inches bgs.

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 MRS and for MC exposure analysis for the evaluation of risks to human and ecological receptors. For consideration of the MC exposure analysis in the risk assessments, the defined exposure unit (EU) for surface soil is the entire Area 2 section of the MRS to the 0- to 0.5-foot sample depth.

4.3.1.2 Data Validation

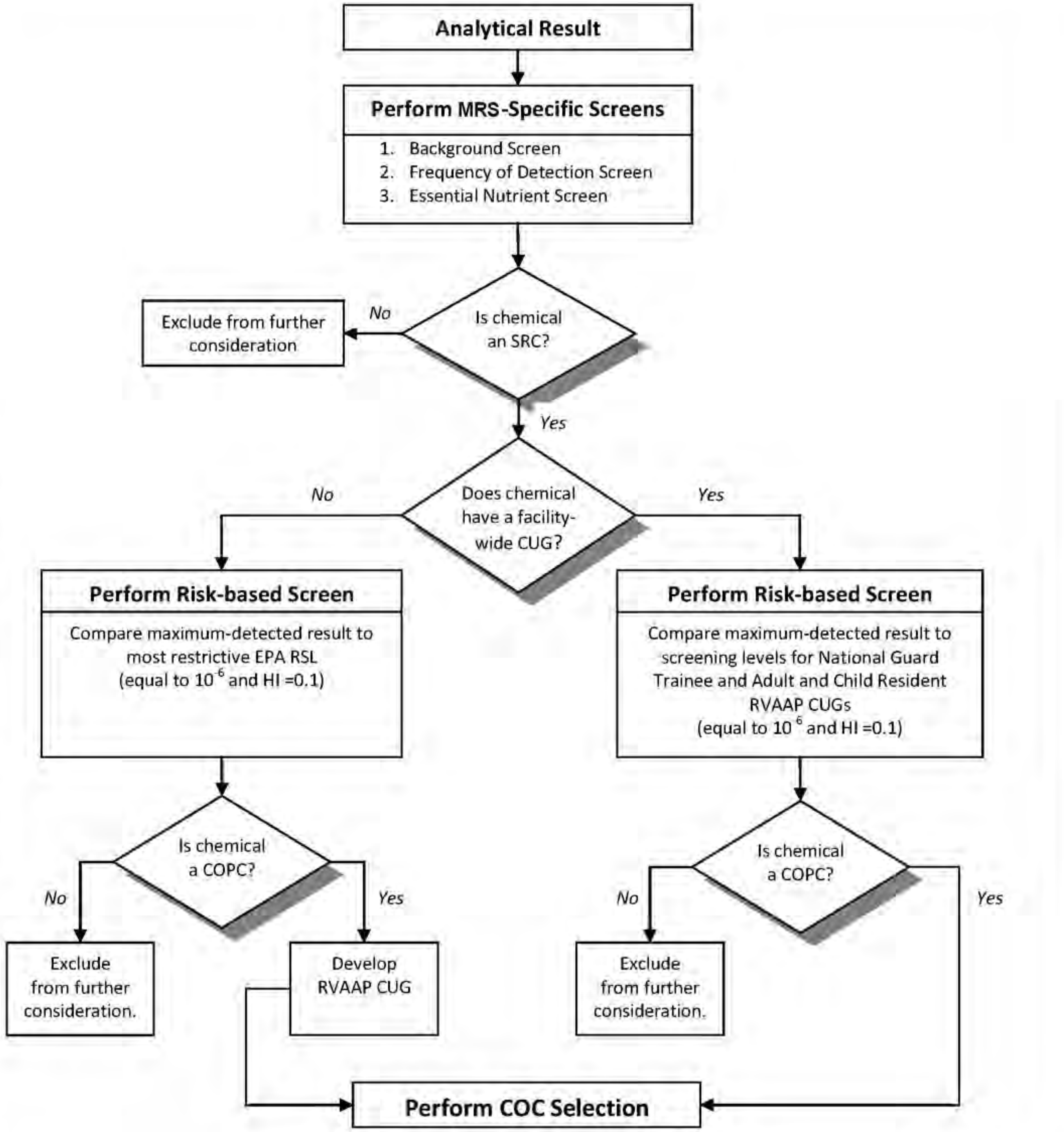
Data validation was performed on all samples collected from Area 2 (including field duplicates and QC samples) during the RI field activities. The review constituted comprehensive validation of 100 percent of the primary data set, as discussed in Section 3.2.5, "Data Validation." The results of the data validation were evaluated in Section 3.2.6, "Data Review and Quality Assessment," to determine if the valid data are sufficient for their intended end uses and suitable for making the environmental decisions established in the project DQOs.

4.3.1.3 Data Reduction and Screening

The data reduction process employed to identify SRCs involves identifying frequency of detection summary statistics, comparison to the 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 were 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 during calculation of the mean result for each compound. Following data reduction, the data were screened to identify SRCs using the processes outlined in the following sections. **Figure 4-9** shows the data screening process used to identify SRCs as chemicals of potential concern (COPCs) and perform selection for COCs as necessary. The determination of COPCs and COCs 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 munitions activities. 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



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

Note:
The determination of COCs and COPLs is for human health evaluation only.

U.S. ARMY
CORPS OF ENGINEERS
BALTIMORE DISTRICT

MILITARY MUNITIONS RESPONSE PROGRAM

RAMSDELL QUARRY LANDFILL MRS
FORMER RVAAP/CAMP RAVENNA
PORTAGE AND TRUMBULL COUNTIES, OHIO

Shaw Environmental & Infrastructure, Inc.
(A CB&I Company)
150 Royall Street
Canton, MA 02021

H:\MAMMS\Ravenna\GIS_Documents\Project_Maps\MMRP\RIFS\RIFS_RamsdellQuarryLandfill\2014_Sept\RVAAP_RQL_032_Fig4_9_Process_Chem_of_Concern.mxd; Analyst: gwt; Date: 9/8/2014 11:01:37 AM

FIGURE 4-9 RVAAP DATA SCREENING PROCESS

approach may be used to determine if the chemical is MRS-related (SAIC, 2011b). Since the total number of samples collected at the Area 2 section of the Ramsdell Quarry Landfill MRS was less than 20, frequency of detection was not utilized to support a weight of evidence approach for the data set.

Facility-Wide Background Screen

For each inorganic constituent, if the maximum detected concentration exceeded its BSV, it was considered to be an SRC. It should be noted that not all inorganic compounds analyzed as part of the RI sampling event have established screening levels or BSVs. Therefore, in the event an inorganic constituent 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 are not detected in the background data set. All detected organic compounds were considered to be above background because these classes of compounds do not occur naturally.

For the RI field efforts across the facility MRSs being investigated under the MMRP, analyses were conducted for calcium, magnesium, and manganese to be potentially used for geochemical analysis. Aluminum was analyzed for geochemical purposes at certain MRSs where it is not considered an MC related to munitions; however, aluminum is considered to be an MC associated with the Ramsdell Quarry Landfill MRS and was not analyzed as a geochemical metal for this MRS. 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 MEC metals are background related or actually elevated due to MRS history. Use of geochemical evaluation in this manner requires approval from USACE and the Ohio EPA prior to implementing the results as a comparison tool for background results. A geochemical evaluation was not required for the data collected at the Ramsdell Quarry Landfill MRS based on the evaluation of the metal results in Section 4.0 and the HHRA and ERA conclusions in Section 7.0 and Section 8.0, respectively.

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) (USACE, 2005). For the RI field effort, analyses were conducted for calcium, magnesium, and magnesium to be used for geochemical analysis should one be required. These three constituents were eliminated as SRCs in the environmental media, since they are not considered as an MC associated with the Ramsdell Quarry Landfill MRS.

4.3.1.4 Data Presentation

Data summary statistics for SRCs in surface soil collected at the Area 2 section of the Ramsdell Quarry Landfill MRS are presented in the following sections. The designated use and sample collection rationale for the surface soil samples collected at Area 2 is presented in **Table 4-5**. The summary of results for the surface soil samples is presented in **Table 4-6**. The SRCs identified in surface soil following the data evaluation process are presented in **Table 4-7**. The SRCs for surface soil are shown on **Figure 4-10**. The data summary tables for the samples collected at Area 2 for the RI, including field duplicate and QC samples, are presented in **Appendix E**.

4.3.1.5 Data Use Evaluation

During the RI field effort, the ISM surface soil samples were collected from established grids where numerous MD items were uncovered during the intrusive investigation. 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 precision, accuracy, representativeness, completeness, comparability, and sensitivity with respect to current MRS conditions and is discussed in Section 3.2.6.

The data collected for the RI were incorporated into the nature and extent of contamination evaluation. These samples are considered to be representative of current MRS conditions, were screened for SRCs, and carried forward for fate and transport evaluation and the risk assessment for human and ecological receptors. The designated use and sample collection rationale for the Ramsdell Quarry Landfill MRS samples are presented in **Table 4-5**.

4.4 Nature and Extent of SRCs

Data from the RI surface soil samples were screened to identify SRCs representing current conditions at the Area 2 section of the Ramsdell Quarry Landfill MRS. The SRC screening data for surface soil (not including field duplicate or QC samples) included samples RQLss-075(I)-0001-SS and RQLss-076(I)-0001-SS. This section presents a summary of the nature and extent of the SRCs identified in surface soil at Area 2 following the data evaluation process.

Table 4-5
Data Use Summary and Sample Collection Rationale

Sample Location ID	Sample Date	Depth (feet bgs)	Sampling Unit Area (acres)	Sample Type	Data Use Type	Sample Collection Rationale
RQLss-075(I)-0001-SS	8/22/2011	0 to 0.5	0.46	ISM	N&E, F&T, RA	Collected to characterize for MC associated with MD identified during the intrusive investigation at Grids D06 and D07.
RQLss-076(I)-0001-SS	8/22/2011	0 to 0.5	0.46	ISM		Collected to characterize for MC associated with MD identified during the intrusive investigation at Grids C08 and D08.

bgs denotes below ground surface.
F&T denotes fate and transport evaluation.
ID denotes identification.
ISM denotes incremental sampling methodology.
MC denotes munitions constituents.
MD denotes munitions debris.
N&E denotes nature and extent evaluation.
RA denotes risk assessment evaluation.

Table 4-6
Summary of Surface Soil Results

	Location ID:	**RQLss-075(I)**		**RQLss-076(I)**	
	Sample ID:	**RQLss-075(I)-0001-SS**		**RQLss-076(I)-0001-SS**	
	Sample Date:	**8/22/2011**		**8/22/2011**	
	Depth (feet bgs):	**0–0.5**		**0–0.5**	
Analyte	**BSV[1] (mg/kg)**	**Result (mg/kg)**	**VQ**	**Result (mg/kg)**	**VQ**
Metals					
Aluminum	*17,700*	10,500		12,200	
Antimony	*0.36*	**1.8**	**J**	**1.3**	
Barium	*88.4*	66.8		74.5	
Cadmium	*0*	**0.55**		**0.65**	**J**
Chromium (as Cr^{+3})	*17.4*	**165**		**117**	**J**
Copper	*17.7*	**23.3**		10.5	
Iron	*23,100*	15,800		16,700	
Lead	*26.1*	**30.5**		18.4	
Mercury	*0.036*	**0.056**		**0.063**	
Strontium	*0*	**3.5**		**3.6**	
Zinc	*61.8*	47.7	J	50.9	
Geochemical Metals					
Calcium	*15,800*	157		115	
Magnesium	*3,030*	1,240		1,600	
Manganese	*1,450*	1,160		1,270	
Explosives and Propellants					
1,3,5-Trinitrobenzene	*NA*	<0.25	U	<0.25	U
1,3-Dinitrobenzene	*NA*	<0.2	U	<0.2	U
2,4,6-Trinitrotoluene	*NA*	<0.2	U	<0.2	U
2,4-Dinitrotoluene	*NA*	<0.25	U	<0.25	U
2,6-Dinitrotoluene	*NA*	<0.25	U	<0.25	U
2-Amino-4,6-Dinitrotoluene	*NA*	<0.2	U	<0.2	U
3,5-Dinitroaniline	*NA*	<0.2	U	<0.2	U
4-Amino-2,6-Dinitrotoluene	*NA*	<0.2	U	<0.2	U
HMX	*NA*	<0.2	U	<0.2	U
m-Nitrotoluene	*NA*	<0.2	U	<0.2	U

Table 4-6 (continued)
Summary of Surface Soil Results

	Location ID:	**RQLss-075(I)**		**RQLss-076(I)**	
	Sample ID:	**RQLss-075(I)-0001-SS**		**RQLss-076(I)-0001-SS**	
	Sample Date:	**8/22/2011**		**8/22/2011**	
	Depth (feet bgs):	**0–0.5**		**0–0.5**	
Analyte	**BSV[1] (mg/kg)**	**Result (mg/kg)**	**VQ**	**Result (mg/kg)**	**VQ**
Nitrobenzene	*NA*	<0.2	U	<0.2	U
Nitroglycerin	*NA*	<1	U	<1	U
Nitroguanidine	*NA*	**0.18**	**J**	**0.28**	**J**
o-Nitrotoluene	*NA*	<0.25	U	<0.25	U
PETN	*NA*	<1	U	<1	U
p-Nitrotoluene	*NA*	<0.2	U	<0.2	U
RDX	*NA*	<0.25	U	<0.25	U
Tetryl	*NA*	<0.2	U	<0.2	U
Semivolatile Organic Compounds					
1,2,4-Trichlorobenzene	*NA*	<0.06	U	<0.06	U
1,2-Dichlorobenzene	*NA*	<0.06	U	<0.06	U
1,3-Dichlorobenzene	*NA*	<0.06	U	<0.06	U
1,4-Dichlorobenzene	*NA*	<0.06	U	<0.06	U
2,4,5-Trichlorophenol	*NA*	<0.305	U	<0.305	U
2,4,6-Trichlorophenol	*NA*	<0.305	U	<0.305	U
2,4-Dichlorophenol	*NA*	<0.305	U	<0.305	U
2,4-Dimethylphenol	*NA*	<0.305	U	<0.305	U
2,4-Dinitrophenol	*NA*	<1	U	<1	U
2-Chloronaphthalene	*NA*	<0.06	U	<0.06	U
2-Chlorophenol	*NA*	<1	U	<1	U
2-Methylnaphthalene	*NA*	<0.06	U	<0.06	U
2-Nitroaniline	*NA*	<0.06	U	<0.06	U
2-Nitrophenol	*NA*	<0.5	U	<0.5	U
3,3'-Dichlorobenzidine	*NA*	0.15	R	<0.255	U
3-Nitroaniline	*NA*	<0.06	UJ	<0.06	U
4,6-Dinitro-2-Methylphenol	*NA*	<0.05	U	<0.5	U

Table 4-6 (continued)
Summary of Surface Soil Results

	Location ID:	**RQLss-075(I)**		**RQLss-076(I)**	
	Sample ID:	**RQLss-075(I)-0001-SS**		**RQLss-076(I)-0001-SS**	
	Sample Date:	**8/22/2011**		**8/22/2011**	
	Depth (feet bgs):	**0–0.5**		**0–0.5**	
Analyte	**BSV[1] (mg/kg)**	**Result (mg/kg)**	**VQ**	**Result (mg/kg)**	**VQ**
4-Bromophenyl Phenyl Ether	*NA*	<0.06	U	<0.06	U
4-Chloro-3-Methylphenol	*NA*	<1	U	<1	U
4-Chloroaniline	*NA*	0.040	R	<0.1	U
4-Chlorophenyl Phenyl Ether	*NA*	<0.1	U	<0.1	U
4-Nitrobenzenamine	*NA*	<0.06	UJ	<0.06	U
4-Nitrophenol	*NA*	<1	U	<1	U
Acenaphthene	*NA*	<0.06	U	<0.06	U
Acenaphthylene	*NA*	<0.06	U	<0.06	U
Anthracene	*NA*	<0.06	U	<0.06	U
Benzo(a)anthracene	*NA*	<0.06	U	<0.06	U
Benzo(a)pyrene	*NA*	<0.06	U	<0.06	U
Benzo(b)fluoranthene	*NA*	<0.06	U	<0.06	U
Benzo(ghi)perylene	*NA*	<0.06	U	<0.06	U
Benzo(k)fluoranthene	*NA*	<0.06	U	<0.06	U
Benzoic Acid	*NA*	<1.5	U	<1.55	U
Benzyl Alcohol	NA	<0.205	UJ	<0.205	U
Bis(2-Chloroethoxy)methane	*NA*	<0.06	U	<0.06	U
Bis(2-Chloroethyl)ether	*NA*	<0.06	U	<0.06	U
Bis(2-Chloroisopropyl)ether	*NA*	<0.06	U	<0.06	U
Bis(2-Ethylhexyl)phthalate	*NA*	**0.81**		**0.25**	**J**
Butyl Benzyl Phthalate	*NA*	<0.205	U	<0.205	U
Carbazole	*NA*	<0.06	U	<0.06	U
Chrysene	*NA*	<0.06	U	<0.06	U
Cresols (Total)	*NA*	<1.85	U	<1.85	U
Dibenzo(a,h)anthracene	*NA*	<0.06	U	<0.06	U
Dibenzofuran	*NA*	<0.06	U	<0.06	U

Table 4-6 (continued)
Summary of Surface Soil Results

	Location ID:	RQLss-075(I)		RQLss-076(I)	
	Sample ID:	RQLss-075(I)-0001-SS		RQLss-076(I)-0001-SS	
	Sample Date:	8/22/2011		8/22/2011	
	Depth (feet bgs):	0–0.5		0–0.5	
Analyte	**BSV[1] (mg/kg)**	**Result (mg/kg)**	**VQ**	**Result (mg/kg)**	**VQ**
Diethyl Phthalate	*NA*	<0.205	U	<0.205	U
Dimethyl Phthalate	*NA*	<0.205	U	<0.205	U
Di-n-Butyl Phthalate	*NA*	<0.205	U	**0.11**	**J**
Di-n-Octyl Phthalate	*NA*	<0.1	U	<0.1	U
Fluoranthene	*NA*	**0.032**	**J**	<0.06	U
Fluorene	*NA*	<0.06	U	<0.06	U
Hexachlorobenzene	*NA*	<0.06	U	<0.06	U
Hexachlorobutadiene	*NA*	<0.205	U	<0.205	U
Hexachlorocyclopentadiene	*NA*	<0.1	U	<0.1	U
Hexachloroethane	*NA*	<0.06	U	<0.06	U
Indeno(1,2,3-cd)pyrene	*NA*	<0.06	U	<0.06	U
Isophorone	*NA*	<0.1	U	<0.1	U
Naphthalene	*NA*	<0.06	U	<0.06	U
N-Nitroso-di-n-Propylamine	*NA*	<0.205	U	<0.205	U
N-Nitrosodiphenylamine	*NA*	<0.205	U	<0.205	U
o-Cresol	*NA*	<1	U	<1	U
Phenanthrene	*NA*	<0.06	U	<0.06	U
Pyrene	*NA*	<0.06	U	<0.06	U
Polychlorinated Biphenyls					
Aroclor-1016	*NA*	<0.05	U	<0.05	U
Aroclor-1221	*NA*	<0.05	U	<0.05	U
Aroclor-1232	*NA*	<0.05	U	<0.05	U
Aroclor-1242	*NA*	<0.05	U	<0.05	U
Aroclor-1248	*NA*	<0.05	U	<0.05	U
Aroclor-1254	*NA*	<0.05	U	<0.05	U
Aroclor-1260	*NA*	<0.05	U	<0.05	U

Table 4-6 (continued)
Summary of Surface Soil Results

	Location ID:	**RQLss-075(I)**		**RQLss-076(I)**	
	Sample ID:	**RQLss-075(I)-0001-SS**		**RQLss-076(I)-0001-SS**	
	Sample Date:	**8/22/2011**		**8/22/2011**	
	Depth (feet bgs):	**0–0.5**		**0–0.5**	
Analyte	**BSV[1] (mg/kg)**	**Result (mg/kg)**	**VQ**	**Result (mg/kg)**	**VQ**
General Chemistry					
Hexavalent Chromium	*0*	<5	UJ	<5	U
Nitrocellulose	*NA*	<50	U	<50	U
pH (SU)	*NA*	5.05		5.03	
Total organic carbon	*NA*	27,000		26,000	
Total solids	*NA*	98.3		98.4	

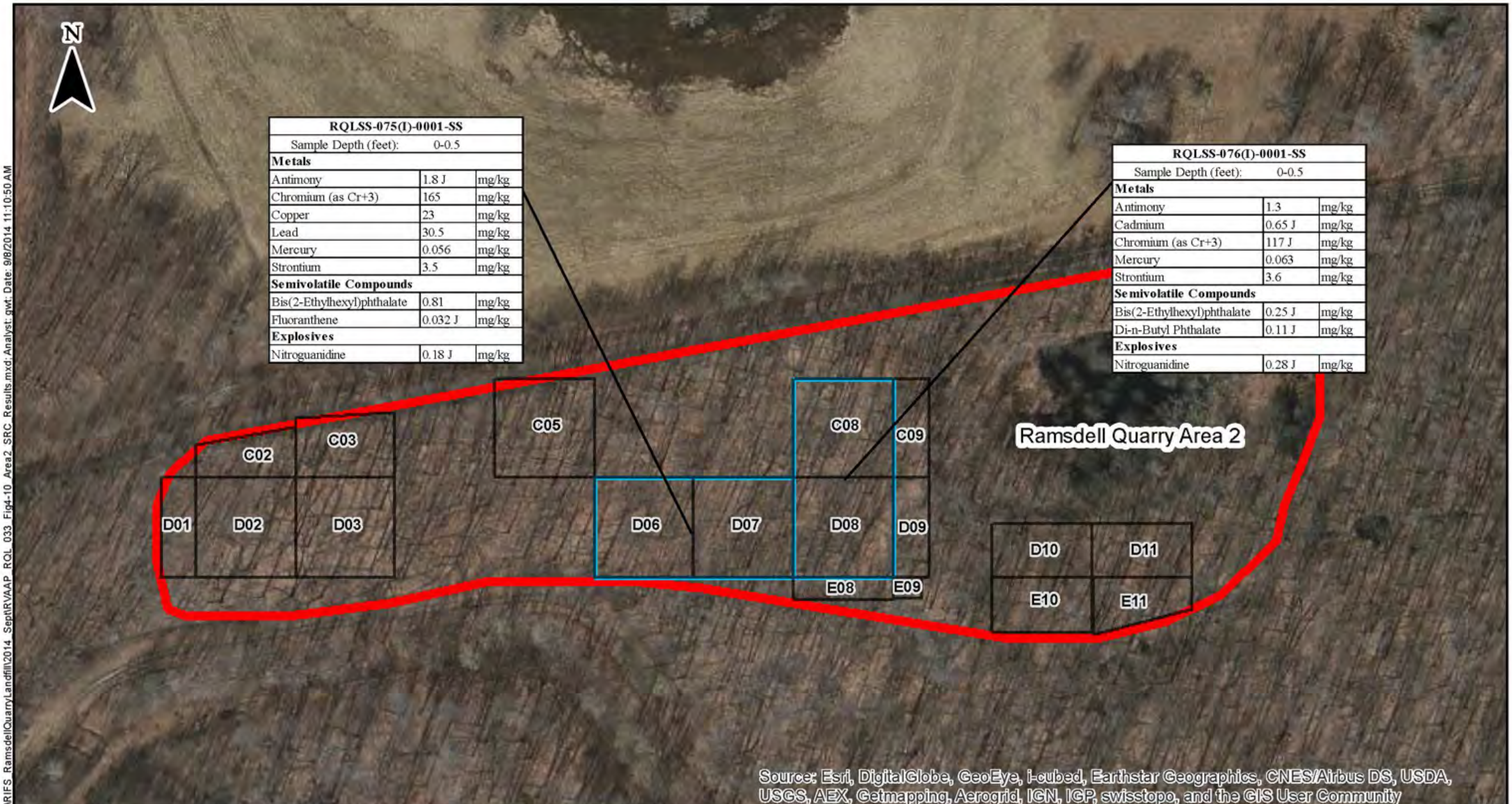
[1] Background values as presented in the Final Facility-Wide Human Health Cleanup Goals (SAIC, 2010).
[2] Geochemical parameters are not considered MC and are not evaluated further in the data evaluation process.
For metals, bold numbering indicates concentration is greater than the facility background value. For organics, bold numbering indicates a detected value.
< denotes less than.
bgs denotes below ground surface.
BSV denotes background screening value.
Cr^{+3} denotes trivalent chromium.
ID denotes identification.
J denotes the result is an estimated value.
MC denotes munitions constituents.
mg/kg denotes milligrams per kilogram.
NA denotes not applicable/available.
R denotes the data is rejected.
RVAAP denotes former Ravenna Army Ammunition Plant.
SU denotes standard unit.
U denotes result is not detected or the concentration is below the limit of detection.
UJ denotes the analyte was estimated and not detected or reported less than the limit of detection.
VQ denotes validation qualifier.

Table 4-7
SRC Screening Summary for Surface Soil

Analyte	CAS Number	Frequency of Detection	Minimum Detect		Maximum Detect		Mean Result (mg/kg)	BSV (mg/kg)	SRC?	SRC Justification
			Result (mg/kg)	VQ	Result (mg/kg)	VQ				
Explosives and Propellants										
Nitroguanidine	556-88-7	2/2	0.18	J	0.28	J	0.23	0	Yes	No BSV
Metals										
Aluminum	7429-90-5	2/2	10,500		12,200		11,350	17,700	No	Below BSV
Antimony	7440-36-0	2/2	1.3		1.8	J	1.55	0.96	Yes	Above BSV
Barium	7440-39-3	2/2	66.8		74.5		70.65	88.4	No	Below BSV
Cadmium	7440-43-9	2/2	0.55		0.65	J	0.6	0	Yes	No BSV
Chromium (as Cr^{+3})	7440-47-3	2/2	117	J	165		141	17.4	Yes	Above BSV
Copper	7440-50-8	2/2	10.5		23.3		16.9	17.7	Yes	Above BSV
Iron	7439-89-6	2/2	15,800		16,700		16,250	23,100	No	Below BSV
Lead	7439-92-1	2/2	18.4		30.5		24.45	26.1	Yes	Above BSV
Mercury	7439-97-6	2/2	0.056		0.063		0.0595	0.036	Yes	Above BSV
Strontium	7440-24-6	2/2	3.5		3.6		3.55	0	Yes	No BSV
Zinc	7440-66-6	2/2	47.7		50.9		49.3	61.8	No	Below BSV
Semivolatile Organic Compounds										
Bis(2-Ethylhexyl)phthalate	117-81-7	2/2	0.25	J	0.82		0.53	0	Yes	No BSV
Di-n-Butyl Phthalate	84-74-2	1/2	0.11	J	0.11	J		0	Yes	No BSV
Fluoranthene	206-44-0	1/2	0.032	J	0.032	J		0	Yes	No BSV

Table 4-7 (continued)
SRC Screening Summary for Surface Soil

[1] Background values as presented in the Final Facility-Wide Human Health Cleanup Goals (SAIC, 2010).
BSV denotes background screening value.
CAS denotes Chemical Abstracts Service.
Cr^{+3} denotes trivalent chromium.
J denotes that the reported result is an estimated value.
mg/kg denotes milligrams per kilogram.
RVAAP denotes Ravenna Army Ammunition Plant.
SRC denotes site-related chemical.
VQ denotes validation qualifier.



RQLSS-075(I)-0001-SS		
Sample Depth (feet):	0-0.5	
Metals		
Antimony	1.8 J	mg/kg
Chromium (as Cr+3)	165	mg/kg
Copper	23	mg/kg
Lead	30.5	mg/kg
Mercury	0.056	mg/kg
Strontium	3.5	mg/kg
Semivolatile Compounds		
Bis(2-Ethylhexyl)phthalate	0.81	mg/kg
Fluoranthene	0.032 J	mg/kg
Explosives		
Nitroguanidine	0.18 J	mg/kg

RQLSS-076(I)-0001-SS		
Sample Depth (feet):	0-0.5	
Metals		
Antimony	1.3	mg/kg
Cadmium	0.65 J	mg/kg
Chromium (as Cr+3)	117 J	mg/kg
Mercury	0.063	mg/kg
Strontium	3.6	mg/kg
Semivolatile Compounds		
Bis(2-Ethylhexyl)phthalate	0.25 J	mg/kg
Di-n-Butyl Phthalate	0.11 J	mg/kg
Explosives		
Nitroguanidine	0.28 J	mg/kg

MRS Area 2 Boundary
Intrusive Investigation Grids (100 sq ft each)
ISM Sample Unit (0.46 Acres Each)

Notes:
1) mg/kg denotes milligrams per kilogram.
2) "J" denotes the reported result is estimated.
3) Cr $^{+3}$ denotes trivalent Chromium

0 75 150 Feet

PROJECTION: NAD83 UTM Zone 17N

U.S. ARMY CORPS OF ENGINEERS
BALTIMORE DISTRICT

MILITARY MUNITIONS RESPONSE PROGRAM

RAMSDELL QUARRY LANDFILL 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 4-10 SRCS IN SURFACE SOIL

The surface soil samples were collected from grids where numerous MD items were observed. These samples were submitted for laboratory analysis for metals, explosives and propellants, SVOCs, and PCBs. The metals selected for analysis were inorganic MCs that were attributed to munitions historically used or disposed at the MRS and included aluminum, cadmium, copper, trivalent chromium (Cr^{+3}), Cr^{+6}, iron, lead, zinc, antimony, barium, and mercury. While not typically considered as MC, analysis for PCBs and SVOCs, including PAHs, were recommended in the Work Plan (Shaw, 2011) for the Ramsdell Quarry Landfill MRS since these chemicals may be attributed to the following: munitions treated/disposed at the MRS, waste oils that may have been used as accelerants for burning, or byproducts resulting from the OB/OD operations.

The samples were also submitted for geochemical parameters that included calcium, magnesium, and manganese for the rationale discussed in Section 4.3.1.3, “Data Reduction and Screening.” However, since a geochemical analysis was not performed for the data collected at the Ramsdell Quarry Landfill MRS, geochemical parameters are not evaluated further in this RI Report.

4.4.1 Metals

All 11 metals that are considered as MC associated with historical OB/OD activities at the MRS were detected in the ISM surface soil samples. Antimony, chromium, and mercury were detected at concentrations that exceeded the BSVs in both surface soil samples and were metals that were retained as SRCs for further evaluation. Copper and lead were detected at concentrations that exceeded the BSVs in surface soil sample RQLss-075(I)-0001-SS and were retained as SRCs. Concentrations of cadmium and strontium were detected in both surface soil samples; however, the facility does not have established BSVs for either metal; therefore, these metals were automatically retained as SRCs for further evaluation. Aluminum, barium, iron, and zinc were detected in both surface soil samples at concentrations less than the BSV and were not considered as SRCs.

4.4.2 Explosives and Propellants

Low concentrations of nitroguanidine were detected in the ISM surface soil samples. The maximum concentration was estimated (i.e., J-flagged) at 0.28 mg/kg in surface soil sample RQLss-076(I)-0001-SS. The facility does not have established BSVs for explosives or propellants; therefore, nitroguanidine was retained as a SRC in surface soil for the MRS. No other explosives or propellants were detected at the in the surface soil samples.

4.4.3 SVOCs

Three SVOCs were identified as SRCs in the ISM surface soil samples. Bis(2-ethylhexyl)phthalate was detected in both surface soil samples and the maximum detected concentration was 0.81 mg/kg in surface soil sample RQLss-075(I)-0001-SS. Di-n-butyl phthalate was detected in surface soil sample RQLss-076(I)-0001-SS only at an estimated concentration of 0.11 J mg/kg. Fluoranthene was detected in sample RQLss-075(I)-0001-SS only at an estimated concentration of 0.032 J mg/kg. The facility does not have established BSVs for SVOCs; therefore, all three analytes were retained as SRCs in surface soil for the MRS. No other SVOCs were detected in the surface soil samples.

4.4.4 Summary of Nature and Extent

In summary, 11 SRCs were identified between the 2 ISM surface soil samples: 7 metals, 1 explosive, and 3 SVOCs. The most SRCs (10) were detected in surface soil sample RQLss-075(I)-0001-SS that was collected over Grids D06 and D07. Eight SRCs were detected in surface soil sample RQLss-076(I)-0001-SS that was collected over Grids C08 and D08.

Of the seven metals identified as SRCs, cadmium and strontium were retained for further evaluation only due to a lack of a facility-wide BSV for each metal. The maximum detected concentrations for both metals were found in sample RQLss-076(I)-000-SS. For metals with BSVs, the maximum detected concentrations of antimony, chromium (as Cr^{+3}), copper, and lead were in surface soil sample RQLss-075(I)-0001-SS and the maximum detected concentrations for cadmium, mercury, and strontium were in sample RQLss-076(I)-0001-SS. With the exception for copper, the maximum detected concentrations for the metals were less than two times the minimum detected concentrations. The maximum detected concentration for copper was 2.3 times the minimum detected concentration.

The only explosive or propellant that was identified as an SRC in the ISM surface soil samples was nitroguanidine that was detected in both samples. The maximum concentration was detected in surface soil sample RQLss-076(I)-0001-SS and was less than two times the minimum detected concentration in surface soil sample RQLss-075(I)-0001-SS.

Bis(2-ethylhexyl)phthalate was the only SVOC that was detected in both ISM surface soil samples. The maximum concentration was detected in sample RQLss-075(I)-0001-SS and was just over three times the minimum detected concentration that was estimated (J-flagged) in surface soil RQLss-076(I)-0001-SS. Isolated detects for fluoranthene and di-n-butyl phthalate were found at low (estimated) concentrations in samples RQLss-075(I)-0001-SS and RQLss-076(I)-0001-SS, respectively.

Overall, comparison between the two ISM surface soil samples indicates similar results. The concentrations of the SRCs with relation to the same depth were consistent between the sampling units that make up the decision unit for surface soil with no obvious exceedances at either sampling unit.

Samples are collected using ISM to ensure that representative samples are collected. The ISM sample locations were selected based on locations and depths where concentrated areas of MD were identified, where SRCs associated with historical activities were expected, and at locations with similar exposure to receptors. The combined ISM sample units are the decision unit at the MRS in which a determination regarding MC in surface soil will be made. The ISM samples were collected in accordance with the Work Plan (Shaw, 2011) and it is determined that the DQOs were met for the evaluation for the nature and extent for SRCs in surface soil at Area 2.

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5.0 FATE AND TRANSPORT OF MEC AND MC

This section describes the fate of chemicals in the environment and potential transport mechanisms. Chemical fate refers to the expected final state that an element, compound, or group of compounds will achieve following release to the environment. Chemical transport refers to migration mechanisms away from the source area. Sections 5.1 and 5.2 discuss the fate and transport associated with MEC and MC at the MRS, respectively.

5.1 Fate and Transport of MEC

Transport of MEC at a MRS is dependent on many factors, including natural processes and human activities that may result in some movement of MEC, if present at the MRS. Natural processes or “weathering” are primarily characterized as mechanical and biological. Mechanical processes include expansion and contraction caused by sudden changes in temperature, the expansive force of water freezing in cracks, the splitting caused by plant roots, and the impact of running water. Biological processes include oxidation, hydration, carbonization, and loss of chemical elements by solution in water. 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.

The erosion potential is moderate at Area 1 due to the saturated areas and seasonal fluctuations in water levels. At Area 2, the erosion potential is slight due to the presence of woods and overgrown vegetation. The types of plants and trees at the MRS vary between Area 1 and Area 2. The vegetation at Area 2 includes primarily red maple with deeper root systems that aid in preventing or limiting significant erosion whereas the vegetation at Area 1 consists primarily of wetland vegetation with shallow root zones that are more susceptible to erosion. Any natural soil types that remain at the MRS would be expected to have low to moderate water capacity and moderate permeability. January is the coldest month of the year with a normal minimal temperature of 17.4 °F. The maximum frost depth in northern Ohio is approximately 36 inches bgs. Based on the climate conditions and frost depth at the MRS, any MEC or MD within 3 feet of ground surface is considered as being susceptible to freeze-thaw cycling, albeit primarily vertical movement, which may expose any potentially remaining and buried MEC. Overland migration of any exposed MEC is expected be minimal at Area 1, since this portion of the MRS is the bottom of a former quarry that is predominantly surrounded by the closed landfill to the east, west, and south. Elevated Ramsdell Road runs adjacent to Area 1 to the north. With the exception for the former soil borrow pit at the east portion of Area 2, the topography at Area 2 is subdued and would limit the potential for overland migration of any exposed MEC.

Any MEC or MD items may corrode or degrade based on weather and climate conditions and thereby release MC into the environment; however, it would be expected that potential impacts to the environment from MC would more likely occur at locations with concentrated MEC and/or MD items. No MEC was found at the Ramsdell Quarry Landfill MRS during the RI field activities; however, numerous MD items were encountered on the ground surface and at various depths to a maximum depth of 2 feet bgs at the Area 2 portion of the MRS. It was apparent from the corroded conditions of the MD items encountered during the RI field activities, that many of the MD items appeared to have succumbed to oxidation caused by exposure to water and air, which may have released MC to the environment. The evaluation of the fate and transport of potential MC is presented in Section 5.2.

The areas where any MEC is encountered become the points of potential direct contact exposure to the personnel engaged in the various activities. The future land use at Area 2 is military training under which intrusive activities may occur. As a result, there is a potential for human activities to expose receptors to subsurface MEC that may remain at the MRS. Due to residual asbestos and contamination under the IRP, which will require land-use controls/restrictions on the AOC that is collocated with Area 1, future use at Area 1 is anticipated to remain the same as current use (restricted access). No MD and MEC were encountered during the RI field activities at this portion of the MRS and the likelihood of encountering MEC under the future land use at Area 1 is considered to be low.

5.2 Fate and Transport of MC

This section describes the fate and transport of the MC identified as SRCs in the environment at the Area 2 section of the Ramsdell Quarry Landfill MRS and potential transport mechanisms. The release of MC is a process unique to the military. The sources and magnitude are distinctly different from the release of chemicals from industrial processes typically investigated under the IRP (Strategic Environmental Research and Development Program and Environmental Security Technology Certification Program, 2012). Once an MC released from MEC enters an environmental medium, the fate and transport of MC are dependent on a wide variety of factors. Migration pathways often include air, water, soil, and the interfaces between the phases of the chemical (i.e., solid, liquid, or gas). The fate and transport of MC occurs in all three environments: (1) terrestrial, (2) aquatic, and (3) atmospheric. Terrestrial environments are comprised of soil and groundwater, aquatic environments are comprised of surface water and sediment, and air is the only component of the atmospheric environment.

Several important physical and chemical properties of the impacted media affect the fate and persistence of chemicals, which governs their distribution and behavior in environmental media. Depending upon the specific chemical and soil conditions, chemicals may be transferred from surface soil to subsurface soil, to stream/wetland sediments or surface water, and from all media to the air. The propensity for a chemical to react to equilibrium conditions in the environment and transfer between media is an important factor determining the mobility of a chemical.

In the terrestrial environment, if the chemical is released to soil, it may volatilize, adhere to the soil by sorption, leach into the surface water bodies or groundwater, or degrade because of chemical (abiotic) or biological (biotic) processes. If the chemical is volatilized, then it may be released to the atmosphere. Chemicals that are dissolved eventually may be transported to an aquatic environment.

Once a chemical is released to the aquatic environment, it can either volatilize or remain in the aquatic environment. In the aquatic environment, chemicals may be dissolved in the surface water or sorbed to the sediment. Chemicals may move between dissolved and sorbed states depending on a variety of physical and chemical factors.

In the atmospheric environment, chemicals may exist as vapors or as particulate matter. The transport of chemicals relies mostly on wind currents and continues until the chemicals are returned to the earth by wet or dry deposition. Degradation of organic compounds in the atmosphere can occur due to direct photolysis, reaction with other chemicals, or reaction with photochemically generated hydroxyl radicals.

5.2.1 Sources of SRCs

This section presents a discussion of each of the SRCs that may result from potential contaminant sources in the environmental media at the Area 2 section of the Ramsdell Quarry MRS. A summary of the SRCs identified in the surface soil is as follows:

- *Explosives and Propellants*: nitroguanidine
- *Metals*: antimony, cadmium, chromium, chromium (as Cr^{+3}), copper, lead, mercury, and strontium
- *SVOCs*: bis(2-ethylhexyl)phthalate, di-n-butyl phthalate, and fluoranthene

The chemicals analyzed for the MRS were agreed upon in the Work Plan (Shaw, 2011) and were considered as MC associated with the previous activities at the MRS. The physical and chemical properties and potential release mechanisms and routes of migration for each of the SRCs are discussed in the following sections.

5.2.1.1 Explosives and Propellants

An explosive compound degradation rate is a function of low-temperature kinetics as well as the influence of visible light, infrared, ultraviolet radiation, and microbial action.

Degradation products such as nitric oxide, nitrogen dioxide, water, nitrogen, acids, aldehydes, ketones, and large fragments of the parent explosive molecule may be formed. Abiotic and microbial degradation rates are a function of temperature, which varies throughout the year. The fate and transport of the explosives identified at Area 2 are as follows.

- **Nitroguanidine—**Nitroguanidine (also called 1-nitroguanidine) is used as an explosive propellant in munitions. The nitroguanidine reduces the propellant's flash and flame temperature without sacrificing chamber pressure. Nitroguanidine is manufactured from guanine, a naturally occurring substance typically found in the excrement of bats and birds (guano). It is not flammable and is an extremely low sensitivity explosive; however, its detonation velocity is high. Nitroguanidine is expected to have high mobility in soil, and volatilization from soils is not anticipated to be a primary fate process given an estimated Henry's Law constant of 4.45×10^{-16} atmospheric cubic meters per mole based upon its vapor pressure and water solubility (Gorontzy et al., 1994). In aquatic environments, nitroguanidine is not expected to adsorb to suspended solids or sediment, and volatilization is also not anticipated (Gorontzy et al., 1994). The aquatic fate of nitroguanidine is dominated by photolysis and is not anticipated to bioconcentrate (Haag et al., 1990). In the atmosphere, nitroguanidine is expected to exist solely in the particulate phase and to be removed from the atmosphere through either wet or dry deposition. As it absorbs light at approximately 260 nanometers and above, nitroguanidine is susceptible to direct photolysis (National Institute of Standards and Technology Chemistry, 2010).

5.2.1.2 Metals

Since most metals are indigenous to the earth, they are usually found at varying concentration levels in most environmental media. Some metals build up in animal tissue (example, zinc accumulation in fish) while some metals accumulate in plants (example, vanadium). In soil, metal contaminants are dissolved in the soil solution, adsorbed or ion-exchanged in inorganic constituents, complexed with soluble organic matter, and precipitated as pure or mixed solids. Metals in the soil solution are subject to movement with water particles and may be transported through the vadose zone to groundwater, and then either volatilized or consumed by plants and aquatic organisms. Unlike organic constituents, metals cannot be degraded; however, the mobility and toxicity of some metals (i.e., arsenic, chromium and mercury) can be altered due to changes in oxidation states. The fate and transport of the metals identified in surface soil above background concentrations at Area 2 are as follows:

- **Antimony—**Antimony is naturally occurring in the earth's crust. Antimony is sensitive to oxidation/reduction (redox) conditions, and its ability to bind to soil depends on the nature of the soil and the form of antimony. Some studies suggest that antimony is fairly mobile under diverse environmental conditions (Rai et al., 1984), while others suggest that it is strongly adsorbed to soil (Ainsworth, 1988; Foster, 1989; King, 1988). In water, antimony has the capability to undergo photochemical reactions. However, these reactions do not appear to have a significant effect on its aquatic fate (Callahan et al., 1979).

- **Cadmium—**Cadmium is naturally occurring in the earth's crust. Cadmium may travel through soil. However, the mobility of cadmium is strongly influenced by the soil pH and amount of organic matter. In general, cadmium tends to bind strongly to organic matter and clay minerals and can be taken up by plants. However, cadmium may leach into water under acidic conditions where adsorption is minimized (Elinder, 1985; EPA, 1979). Cadmium is considered more mobile than other heavy metals in aquatic environments. Under varying ambient conditions of pH, salinity, and redox potential, cadmium may redissolve from sediments (U.S. Department of the Interior, 1985; EPA, 1979; Feijtel et al., 1988; Muntau and Baudo, 1992). The element does not form volatile compounds in the aquatic environment; therefore, partitioning from water into the atmosphere doesn't occur (EPA, 1979).

- **Chromium—**Chromium exists in two valence states in the environment: trivalent (Cr^{+3}) or hexavalent (Cr^{+6}). Typically, Cr^{+3} in an aqueous environment is associated with particles, while Cr^{+6} remains in solution. Cr^{+3} is the most thermodynamically stable form of chromium under common environmental conditions. Cr^{+3} has a low solubility and a strong tendency to adsorb to negatively charged soil clay particles. As a result, Cr^{+3} is generally immobile and remains close to the origin of deposition. Cr^{+6} occurs in the environment as the negatively charged species chromate (CrO_4^{-2}) or dichromate ($Cr_2O_7^{-2}$), which are highly soluble and have a low affinity to adsorb on mineral surfaces. As a result, Cr^{+6} tends to be mobile in the environment. Cr^{+6} will reduce to the trivalent state if it encounters strongly reducing conditions. This process will immobilize the chromium (EPA, 1998).

- **Copper—**Copper is strongly sorbed by soil particles (i.e., clays, metal oxides, and organic matter). Copper binds to soil much more strongly than other divalent cations, and the distribution of copper in the soil solution is less affected by pH than other metals (Gerritse and Van Driel, 1984). The adsorption of copper generally increases with increasing pH. Like other heavy metals, the movement of copper in soil is also influenced by the permeability of the soil and the amount of clay and iron oxides that are present. These factors tend to attenuate the mobility of copper through adsorption and cation exchange. Volatilization of copper happens to a slight degree, but is insignificant relative to other processes that aid in the reduction of copper concentrations. It sorbs significantly to suspended organic materials and bed sediments, thus reducing its mobility. Much of copper discharged to waterways is in particulate matter and settles out; precipitates out; or adsorbs to organic matter, hydrous iron, and manganese oxides, and clay in sediment or in the water column. A significant fraction of the copper is adsorbed within the first hour, and in most cases, equilibrium is obtained with 24 hours (Harrison and Bishop, 1984).

- **Lead—**Lead is a naturally occurring metal found in small amounts in the earth's crust. The most common form of lead found in nature is Pb^{+2}, although lead also exists to a lesser extent as Pb^{+4} and in the organic form with up to four lead-carbon bonds. Most lead deposited on surface soil is retained and eventually becomes mixed into the surface layer. However, lead can migrate into subsurface environments. The migration of lead in the subsurface environment is controlled by the solubility of lead complexes and adsorption to aquifer materials. Adsorption to soil and aquifer material greatly limits the mobility of lead in the subsurface environment. The capacity of soil to adsorb lead increases with pH, cation exchange capacity, organic carbon content, redox potential, and phosphate levels. At pH values above 6, lead is either adsorbed on clay surfaces or forms lead carbonate. Lead exhibits a high degree of adsorption in clay-rich soil (Kabata-Pendias, 2001).

- **Mercury—**Mercury is a naturally occurring metal that can exist in several valence states, including +1, +2, and the elemental form. Mercury has a strong tendency to sorb to the organic fractions of soils, which is influenced by the organic matter content of the soils or sediment. In addition, mercury is strongly sorbed to sesquioxides in soil at a pH higher than 4 (Blume and Brummer, 1991) and to the surface layer of peat (Lodenius and Autio, 1989). The transport and partitioning of mercury in surface waters and soils is influenced by the particular form of the compound. It can be microbally transformed to organic forms such as methyl mercury, which is mobile and volatile. Volatile forms of mercury are anticipated to evaporate to the atmosphere, whereas dissolved solid forms partition to particulates in the soil or water column and are transported downward in the water column to the sediments (Hurley et al., 1991). Vaporization of methylated and elemental forms of mercury from soil and surface water is controlled by temperature, with emissions from contaminated soils being greater in warmer weather (Lindberg et al., 1991). Mercury has been shown to volatilize from the surface of more acidic soils (Warren and Dudas, 1992). It should be noted that mercury does not have a tendency to leach into water. However, surface water may cause mercury in particulate form to move from soil to water, especially in soils with high humic content (Meili, 1991).

- **Strontium—**Strontium is a naturally occurring element with typical soil concentrations around 0.2 mg/kg. It is an alkaline earth element with chemical properties similar to calcium and barium. Elevated concentrations of strontium can be attributed to the disposal of coal ash, incinerator ash, and industrial wastes (Agency for Toxic Substances and Disease Registry, 2004). In addition, strontium nitrate is a component of munitions used/produced at the facility. In soils and sediments, strontium has moderate mobility and sorbs moderately to metal oxides and clays (Hayes and Traina, 1998). It will also precipitate as carbonate or sulfate minerals in higher total dissolved solids groundwater. Strontium can be transported through dry or wet deposition (National Council on Radiation Protection & Measurements, 1984). There is limited information about the bioavailability of strontium from environmental media.

5.2.1.3 SVOCs

Three SVOCs (one PAH and two phthalates) were identified as SRCs at the Area 2 section of the MRS. The fate and transport of the SVOCs identified as SRCs at Area 2 is as follows:

- **PAHs—**One PAH, fluoranthene, was identified as an SRC in the surface soils at Area 2. PAHs are a group of more than 100 organic compounds consisting of two or more fused aromatic rings. As a general rule, when PAH compounds grow in molecular weight, their solubility in water decreases, solubility in fat tissues increases, their melting and boiling points increase, and their volatilities decrease. The vapor pressure ranges of the PAHs present indicates that these compounds do not readily volatilize into the atmosphere and is further supported by the Henry's law constant values. The organic carbon/water partition coefficient (K_{oc}) is a measure of the tendency of a chemical to be sorbed to the organic fraction of soil. The K_{oc} values for the PAHs detected indicate these PAHs have high sorption potentials and will not tend to leach into surface water runoff. This is further supported by the octanol/water partition coefficient (K_{ow}) which is an indication of whether a compound will dissolve in a solvent (i.e., n-octanol) or water. The PAHs detected are nonpolar and hydrophobic, and, as mentioned above, will tend to sorb to surface soil rather than partition into the polar water phase (Environment Canada, 1998).

- **Phthalates—**Phthalates are a family of SVOCs that are various esters of phthalic acid. The compounds bis(2-ethylhexyl)phthalate and di-n-butyl phthalate were identified as SRCs at Area 2. The most common uses for these compounds are as plasticizers, which are added to plastic formulations such as polyvinyl chloride to make them more flexible and increase their durability (Montgomery and Welcom, 1989). They are also added to "plastic explosives" such as C-4 at concentrations up to several weight percent, which allows the explosive to be molded into any desired shape. These compounds have fairly low solubilities so they are slowly leached from their source material. Their high K_{oc} values indicate that they will adsorb on soil particles, which will limit their mobility in the soil column. Their volatilities are low; therefore, vapor inhalation is not a key exposure pathway (Group, 1986). The aerobic microbial degradation rates in oxic soil and aquatic environments are high, but they may persist under anaerobic conditions as found in organic-rich soil or wetland sediments (Stales, et al., 1997).

5.2.2 Summary of Fate and Transport

This section presents a summary of the fate and transport of MC based upon the descriptions of the chemicals identified as SRCs in the environment and the potential transport mechanisms for MC identified for the Area 2 section at the Ramsdell Quarry Landfill MRS.

With the exception for the soil borrow pit at the eastern portion of Area 2, the extent of ground disturbance where the concentrated areas of MD were found during the RI field activities is not known. The depth of soil disturbance was at least to 4 feet bgs at several locations at Area 2, based on the depths that debris was found during the RI field work. The native soils at Area 2 consist primarily of the Mitiwanga silt loam that has moderately slow permeability and slow runoff (USDA et al., 1978). Bedrock is typically found at depths less than 5 feet in this soil type and evidence of exposed bedrock is present in Area 2 at the former soil borrow pit. Based on the local topography, some of the precipitation falling as rainfall and snow likely leaves Area 2 as surface runoff or drains to the former soil borrow pit or the small wetland area at the eastern portion of Area 2. The precipitation that does not leave Area 2 as surface runoff infiltrates into the subsurface. Some of the infiltrating water is lost to the atmosphere as evapotranspiration. The remainder of the infiltrating water recharges the groundwater. The rate of infiltration and eventual recharge of the groundwater is controlled by soil cover, ground slope, saturated hydraulic conductivity of the soil, and meteorological conditions throughout Area 2.

Of the SRCs detected in soils at Area 2, nitroguanidine is generally considered have the highest mobility in soil. Nitroguanidine was retained as a SRC since it was a detected explosive analyte; however, the detected concentrations were low and estimated (J-flagged) values. The organic matter in the existing soil at Area 2 is approximately 4.7 percent (Edwards et al., 1999) and the detected SVOCs are anticipated to sorb to soils based on the K_{oc} values. Therefore, the SVOCs are not expected to leach into surface water runoff or migrate through the soil column. Based on the detected results, significant sources of explosives and SVOCs were most likely not released during previous activities at Area 2.

The inorganic SRCs have a tendency to sorb to soil at a pH of 4 or greater depending on the specific analyte. Although the inorganics were detected, the site-specific pH for Area 2 is greater than 5, which indicates that these inorganic SRCs would be expected to be found in the general location where they were released, with only limited downward or overland migration.

The depth to groundwater across the MRS ranges from 0 to 39.5 feet bgs, and typically surface water and groundwater interact at the saturated portions of Area 1, which is significantly lower than the surrounding landfill area. Depth to groundwater is consistently deeper at approximately 30 feet bgs at Area 2. Evaluation of the groundwater beneath the Ramsdell Quarry Landfill MRS is included as part of the facility-wide groundwater monitoring program, and three well locations (RQLmw-007, RQLmw-008, and RQL-009) are wells that are required to be monitored under the RCRA due to the presence of the landfill. The *Facility-Wide Groundwater Monitoring Program RVAAP-66 Facility-Wide Groundwater Report on the October 2012 Sampling Event* (EQM, 2012) summarizes samples collected throughout the facility, including at the MRS, during two sampling events that occurred between October 2011 and July 2012. Between these times, groundwater samples were collected at 10 monitoring well locations that were installed in shallow bedrock within the MRS. Seven of the wells are monitored annually and the three RCRA wells are monitored biannually to fulfill the RCRA monitoring requirements associated with the regulated closed landfill. Most of the wells are generally situated hydraulically downgradient of Area 2 and many of these wells were hydraulically upgradient and downgradient of Area 1. The RCRA wells are situated in the closed landfill that is between Area 1 and Area 2. Detected analytes considered as MC that exceeded either the Maximum Contaminant Levels or the Regional Screening Levels (RSLs) (EPA, 2013) consisted of aluminum, iron, bis(2-ethylhexyl)phthalate, dibenzo(ah)anthracene, and indeno(123-cd)pyrene. Out of these detected constituents in groundwater, only bis(2-ethylhexyl)phthalate was identified as a SRC in surface soil as part of the RI. Bis(2-ethylhexyl)phthalate was detected at six well locations and only two of the six detected concentrations exceeded the Maximum Contaminant Level of 6.0 μg/L. The mobility capabilities of bis(2-ethylhexyl)phthalate is low since it is slow to leach and tends to sorb to soil particles. Additionally, the bis(2-ethylhexyl)phthalate concentrations may be associated with other sources such as the polyvinyl chloride used in the construction of the monitoring wells

(Wisconsin Department of Natural Resources, 2002). Based on the evaluation of the most recent groundwater sampling events at the MRS, it appears that SRCs identified in surface soil have not migrated to shallow groundwater in bedrock.

In summary, the soil conditions and shallow bedrock at Area 2 limit downward or overland migration of inorganics and SVOCs. The dense vegetation conditions and subdued topography at Area 2 are also a limiting factor for overland migration of both MEC and MC. Detected metals and SVOCs are expected to remain in the top several inches of soil on the ground surface or in subsurface soils beneath concentrated areas of buried MEC or MD where they were released. Nitroguanidine is an explosive that is considered relatively mobile in soil; however, the concentrations are either naturally occurring from the excrement of bat and bird guano or significant concentrations were not released in surface soils as a result of historical activities at Area 2. Evaluation of available information for groundwater indicates that groundwater has not been impacted from the historical munitions-related activities that occurred at the MRS. Groundwater at the MRS will continue to be monitored under the RCRA requirements for the closed landfill and the facility-wide groundwater monitoring program.

6.0 MEC HAZARD ASSESSMENT

This section presents an evaluation of the MEC hazards that may be associated with the Ramsdell Quarry Landfill MRS in accordance with the *Interim Munitions and Explosives of Concern Hazard Assessment Methodology* (EPA, 2008), hereafter referred to as the "MEC hazard assessment (HA) guidance." 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; however, cleanup scenarios and land-use control alternatives are not typically evaluated in an RI. 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.

No MEC was observed at the MRS during the field activities; however, MD items were confirmed to be present within Area 2 during the RI. The MD items were solid and/or inert, and posed no explosives safety hazard. Based on the findings of the RI field work, the calculation of a MEC HA score was not warranted for the Ramsdell Quarry Landfill MRS.

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7.0 HUMAN HEALTH RISK ASSESSMENT

The purpose of the HHRA is to document whether SRCs present at the Area 2 section of the Ramsdell Quarry Landfill MRS pose a risk to current or future human receptors, and to identify which, if any MRS conditions need to be addressed further under the CERCLA process. This HHRA has been prepared in accordance with the Work Plan (Shaw, 2011) using the streamlined approach to risk decision making, as described in the FWCUG guidance (SAIC, 2010). In particular, the *Ravenna Army Ammunition Plant Position Paper for the Application and Use of Facility-Wide Cleanup Goals* (USACE, 2012), hereafter referred to as the “Position Paper,” describes the applicability and use of the FWCUGs in the following steps:

- Identify COPCs at the 1×10^{-6} (one in a million) excess cancer risk level or noncarcinogenic hazard quotient (HQ) value of 0.1 for Area 2 by comparing concentrations of SRCs to the FWCUGs.
- Identify COCs at the 1×10^{-5} (one in one hundred thousand) excess cancer risk level or noncarcinogenic HQ risk value of 1 by comparing concentrations to specific FWCUGs and using a “Sum of Ratios” approach to account for cumulative effects. This method sums the ratios of the SRC concentrations to the FWCUG for all COPCs. A Sum of Ratios greater than 1 represents an unacceptable risk, and cancer and noncancer effects are considered separately.

This HHRA 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); therefore, evaluation for the Commercial Industrial Land Use using the RSLs for industrial exposure (EPA, 2013) was not included. The following sections discuss the HHRA approach, the data used in the HHRA, and the COPC and COC evaluation for the samples collected at Area 2 during the RI field activities.

7.1 Data Used in the HHRA

The MC investigation for the RI was based on the results of the MEC evaluation, focusing on Area 2 of the Ramsdell Quarry Landfill MRS since no MEC or MD were found in Area 1. The MC investigation consisted of the collection of two ISM surface soil samples at sampling units that covered selected investigation grids where concentrated areas of MD were found during the intrusive investigation. The increments for the ISM surface soils samples were collected at depths of 0 to 0.5 feet (0 to 6 inches) bgs. The MRS is considered the EU based on the anticipated future land use. The available data used in this HHRA are presented in **Table 7-1**.

Table 7-1
Summary of Data Used in the Human Health Risk Assessment

Sample Number	Sample Date	Sample Unit Area (acres)	Depth (feet bgs)	Sample Type	Analysis
Surface Soil					
RQLss-075(I)-0001-SS	8/22/2011	0.46	0–0.5	ISM	Metals[1] Explosives Nitrocellulose SVOCs PCBs TOC pH
RQLss-076(I)-0001-SS	8/22/2011	0.46	0–0.5	ISM	

[1] Metals analysis for surface soil and sediment includes aluminum, antimony, barium, cadmium, chromium (total and hexavalent), copper, iron, lead, mercury, strontium, and zinc.
bgs denotes below ground surface.
ISM denotes incremental sampling methodology.
SVOC denotes semivolatile organic compound.
PCB denotes polychlorinated biphenyl.
TOC denotes total organic carbon.

7.2 Human Receptors

The future land use at the Area 2 portion of the Ramsdell Quarry Landfill MRS is military training and the Representative Receptor is the National Guard Trainee. The evaluation of the receptor for military training, in conjunction with the evaluation of the Resident Receptor (Adult and Child) for Unrestricted Land Use, form the basis for identifying COCs in the RI. Evaluation for Unrestricted Land Use is performed to assess for baseline conditions and the no action alternative under CERCLA, and as outlined in the HHRAM (USACE, 2005).

The facility has defined exposure scenarios for receptors in surface soil, and they are presented in the HHRAM (USACE, 2005). Sampling for MC under the MMRP is selective in general to evaluate identified munitions-related source areas and the potential that MC may have been released from the source areas. The data used in the HHRA is used to evaluate for the receptors at the depths that the samples were collected; however, the data is not intended to evaluate for predefined exposure scenarios as is typically performed under the IRP. The standard approach for investigating sites under the MMRP, to a certain degree, is adapted to address MEC; however, the HHRA is valuable in identifying potential releases of MC from the source areas and if the MC poses risks to the human receptors (U.S. Army, 2009). A discussion of the medium sampled during the RI field activities and how the actual sample depths relate to the defined exposure scenarios for the human receptors is presented below.

The ISM surface soil sample intervals were 0 to 0.5 feet bgs and are considered to be representative of the surface soil conditions within the combined sampling units at Area 2 that is the EU for surface soil. The 0- to 0.5-foot sample depth is considered the representative depth for the evaluation of MC for the identified human receptors at Area 2 since the MD found during the intrusive investigation activities was predominantly found at this depth interval. This sampling methodology is consistent with the sample depth intervals recommended in the *Military Munitions Response Program Munitions Response Remedial Investigation/Feasibility Study Guidance* (U.S. Army, 2009).

Surface soil at the facility is defined as 0 to 1 foot bgs for the Resident Receptor (Adult and Child) and 0 to 4 feet bgs for the National Guard Trainee. Based on these exposure scenarios, the soil data collected at 0 to 0.5 feet is used to evaluate surface soil for all receptors. The sample data for the surface soil EU is considered suitable for comparison against the established facility HHRA screening criteria for the National Guard Trainee and the Resident Receptor (Adult and Child).

7.3 COPC Identification

The section presents the evaluation of the MRS data and the identification of COPCs for the intended receptors based on the current and future land use. The data for this RI Report was evaluated in accordance with the initial evaluation step presented in the Position Paper (USACE, 2012) to identify SRCs, as presented in Section 4.3, “MC Data Evaluation.” The evaluation incorporates the criteria specified in the Position Paper to eliminate chemicals that are not SRCs (i.e., infrequently detected chemicals, chemicals at similar concentrations to background, and essential nutrients). Some chemicals were analyzed for a specific purpose other than for identifying MC (i.e., the collection of calcium, manganese, and magnesium concentrations for the purposes of performing a geochemical analysis on chemical concentration ratio data), and are not known or suspected MC at the MRS. The basis for the selection of SRCs is provided in Section 4.3.1.3. The SRCs identified for surface soil included the following:

- *Explosives and Propellants*: nitroguanidine
- *Metals*: antimony, cadmium, chromium (as Cr^{+3}), copper, lead, mercury, and strontium
- *SVOCs*: bis-2(ethylhexyl) phthalate, di-n-butyl phthalate, and fluoranthene

Soil samples were analyzed for total chromium and Cr^{+6}. Since Cr^{+6} was not detected in either soil sample, the detected chromium concentrations are assumed to be in the trivalent form.

To establish COPCs, all chemicals that had not been eliminated to this point were evaluated using the following steps:

- The FWCUGs developed for the Resident Receptor (Adult and Child) and the National Guard Trainee for each chemical were used. If there were no FWCUGs developed for a particular chemical, then the RSLs (EPA, 2013) based on residential exposure were used. If neither a FWCUG nor a RSL was available, then a cleanup goal was developed or another approach was developed in concurrence with USACE and the Ohio EPA. FWCUGs or RSLs were available for all chemicals not previously eliminated or values for a closely related compound were used; therefore, development of a FWCUG was not needed.
- The FWCUGs at the 1×10^{-6} (one in a million) excess cancer risk level and noncarcinogenic risk (HQ) using the 0.1 risk value for each of the receptors was selected.
- A comparison of the selected FWCUG to the exposure point concentration (EPC) was completed. The EPCs for the Ramsdell Quarry Landfill MRS are the maximum detected concentrations.
- The chemical was retained as a COPC if the EPC exceeded the most stringent FWCUG for the Resident Receptor (Adult and Child) or the National Guard Trainee for either one of the 1×10^{-6} excess cancer risk values and the noncarcinogenic HQ using the 0.1 risk value. The EPC was compared to the RSL if no FWCUG was available.

The Work Plan (Shaw, 2011) specifies that in addition to screening the FWCUGs for the Resident Receptor (Adult and Child) and the National Guard Trainee, evaluation of the remaining OHARNG receptors will be conducted in order to ensure that the most stringent receptor is identified. For the chemicals detected at the Ramsdell Quarry Landfill MRS, the FWCUGs for the Resident Receptor (Adult and Child) or National Guard Trainee were less than those for any other OHARNG receptor. As a result, the National Guard Trainee, the most stringent OHARNG receptor, and the Resident Receptor (Adult and Child) were considered for COPC evaluation. The most stringent screening values used to evaluate for the identified human receptors are presented in the data summary tables in **Appendix E**.

Table 7-2 presents the screening results for COPCs for the Resident Receptor (Adult and Child) and the National Guard Trainee in accordance with the FWCUG guidance (SAIC, 2010). These tables include the FWCUGs that are the lower of the values for the 1×10^{-6} (one in a million) excess cancer risk level and an HQ of 0.1 for noncancer effects. As previously mentioned, if a chemical was detected for which there was no FWCUG, the RSLs (EPA, 2013) based on residential soil exposure were used. The RSLs were based on

Table 7-2
Summary of Screening Results for COPCs in Surface Soil for the Resident Receptor and the National Guard Trainee

	Range of Values (mg/kg)												
	Detected Concentrations				Reporting Limits								
Site-Related Chemical	**Minimum**	**VQ**	**Maximum**	**VQ**	**Minimum**	**Maximum**	**Location of MDC**	**R(A) FWCUG[1,2] (mg/kg)**	**R(C) FWCUG[1,2] (mg/kg)**	**NGT FWCUG[1,2] (mg/kg)**	**RSL[3,4] (mg/kg)**	**COPC?**	**COPC Justification**
Explosives and Propellants													
Nitroguanidine	0.18	J	0.28	J	0.25	0.25	RQLss-076(I)	NA	NA	NA	610	No	Below risk screening criteria
Metals													
Antimony	1.3		1.8	J	0.81	0.81	RQLss-075(I)	13.6	2.82	175		No	Below risk screening criteria
Cadmium	0.55		0.65	J	0.041	0.041	RQLss-076(I)	22.3	6.41	10.9		No	Below risk screening criteria
Chromium (as Cr^{+3})	117	J	165		0.14	0.14	RQLss-075(I)	19,694	8,147	329,763		No	Below risk screening criteria
Copper	10.5		23.3		0.41	0.41	RQLss-075(I)	2,714	311	25,368		No	Below risk screening criteria
Lead	18.4		30.5		0.25	0.25	RQLss-075(I)	NA	NA	NA	400	No	Below risk screening criteria
Mercury	0.056		0.063		0.0084	0.0085	RQLss-076(I)	16.5	2.27	172		No	Below risk screening criteria
Strontium	3.5		3.6		0.081	0.081	RQLss-076(I)	NA	NA	NA	4,700	No	Below risk screening criteria
Semivolatile Organic Compounds													
Bis(2-Ethylhexyl)phthalate	0.25	J	0.81		0.41	0.41	RQLss-075(I)	NA	NA	NA	35	No	Below risk screening criteria
Di-n-Butyl Phthalate	0.11	J	0.11	J	0.41	0.41	RQLss-076(I)	NA	NA	NA	610	No	Below risk screening criteria
Fluoranthene	0.032	J	0.032	J	0.12	0.12	RQLss-076(I)	276	163	5,087		No	Below risk screening criteria

[1] FWCUG is lower noncarcinogenic FWCUG at a HQ of 0.1 and excess carcinogenic FWCUG risk of 10^{-6}.
[2] RSL denotes Regional Screening Level for residential soil (November 2013). The lower of values based on an HQ of 0.1 and a cancer risk of 10^{-6}.
Chromium denotes total chromium; the cleanup goals shown are for the trivalent form, as hexavalent was not detected.
COPC denotes chemical of potential concern.
FWCUG denotes Facility-Wide Cleanup Goal per the Final Facility-Wide Human Health Cleanup Goals (SAIC, 2010).
HQ denotes hazard quotient.
J denotes an estimated concentration.
MDC denotes maximum detected concentration.
mg/kg denotes milligrams per kilogram.
NA denotes not applicable/available.
NGT denotes National Guard Trainee.
R(A) denotes Resident Receptor (Adult).
R(C) denotes Resident Receptor (Child).
RVAAP denotes former Ravenna Army Ammunition Plant.
VQ denotes validation qualifier.

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the lower of values derived considering an excess cancer risk of 10^{-6} and noncancer hazard considering an HQ of 1. However, the RSLs included in these tables were derived based on noncancer risk that were adjusted to a HQ of 0.1 in order to be consistent with the noncancinogenic FWCUGs. The RSL for lead was not adjusted in this manner, since it was not derived using the HQ approach. In some cases, FWCUGs or RSLs were not available for the detected chemical, and values for a closely related compound were used. All such substitutions are noted in the tables.

The COPCs are identified by comparing the maximum detected concentration to the applicable screening criteria. Substances that are considered SRCs as identified in Section 4.0, and for which the maximum detected concentration is greater than the lowest FWCUG, or the RSL if no FWCUGs are available, are considered COPCs. As shown in **Table 7-2**, no SRCs were identified as COPCs for any of the human receptors.

7.4 COC Evaluation

This section typically describes the COC evaluation process for the human receptors, which are identified through additional screening of the COPCs. Since no COPCs were identified for the Area 2 section of the Ramsdell Quarry Landfill MRS, no identification or evaluation of COCs was necessary.

7.5 HHRA Summary

The SRCs in surface soil at the Area 2 section of the Ramsdell Quarry Landfill MRS were evaluated through the screening of the maximum detected concentrations against the FWCUGs for the Resident Receptor (Adult and Child) and the National Guard Trainee. No COPCs were identified through this process; therefore, no further evaluation of COCs was conducted.

7.6 Uncertainty Assessment

There are various sources of uncertainty in the assessment of exposure and risk that are common to all risk assessments. These general sources of uncertainty are not described here, however, those specific to this assessment are discussed. These uncertainties generally relate to sampling considerations, the determination of EPCs, and the selection of appropriate receptors. There are numerous uncertainties related to the FWCUGs, including exposure assumptions and toxicity values. These uncertainties are inherent to the use of these values, and will be similar for all assessments using them. Therefore, these uncertainties are not discussed here unless there is a particular issue relevant to this evaluation.

Uncertainty can arise from sampling techniques or approaches. The surface soil samples collected for the RI were sampled using the ISM technique. This technique provides a good representation of average concentrations over the area sampled. While it may not identify small areas of greater concentrations, this approach is useful for estimating exposure which is expected to occur over an area and not discrete locations.

The identification of COPCs and COCs is based on the identification of SRCs. The SRC identification process is largely based on comparison of MRS-specific concentrations to facility background concentrations, in particular for inorganics. The identification of these inorganics as SRCs in some cases is based on small differences in maximum concentrations compared to background. This comparison is subject to uncertainties in both the MRS data and the facility background data sets.

The evaluation of total chromium in this assessment is based on the FWCUGs for Cr^{+3}. Samples were also analyzed for Cr^{+6}, which was not detected in soil. The assumption that total chromium is present in the trivalent form represents a minor uncertainty to the risk assessment, in particular since it was not identified as a COPC.

A number of substances detected at the MRS have no FWCUGs for surface soil. In these cases, the RSLs (EPA, 2013) for soil were used as the screening values for COPCs for all receptors. This provides a conservative evaluation, since the RSLs used are based on residential exposure. In addition, the chemicals for which there was a FWCUG available were likely ones of concern that had been detected in previously completed investigations on the facility. This means that if a chemical lacks a FWCUG, it is likely not an SRC from a facility-wide perspective.

The selection of the maximum detected concentration as the EPC provides a conservative evaluation of potential exposures at the Ramsdell Quarry Landfill MRS, and may overestimate exposure and risk for the entire MRS. The selection of receptors also represents an uncertainty to the risk assessment. The evaluation of COPCs and COCs for Unrestricted Land Use to assess baseline conditions is required in accordance with CERCLA, and represents a conservative evaluation of possible future exposures. The future land use at the Area 2 portion of the MRS is military training, and the Representative Receptor is the National Guard Trainee. This receptor has the greatest potential for exposure to any remaining MEC or MC at the MRS. Furthermore, evaluation of the FWCUGs against the SRCs that were detected at the MRS for other OHARNG receptors showed that none were lower than those for the Resident Receptor (Adult and Child) or the National Guard Trainee. Therefore, risks are not expected to be underestimated for other future land-use receptors.

8.0 ECOLOGICAL RISK ASSESSMENT

The ERA evaluated the potential for adverse effects posed to ecological receptors from potential releases at the Area 2 section of the Ramsdell Quarry Landfill MRS and was prepared in accordance with the Unified Approach to performing ERAs (USACE, 2011) that was established at sites under environmental investigation at the facility. This ERA was consistent with the process described in the *RVAAP Facility-Wide Ecological Risk Assessment Work Plan* (USACE, 2003c) and the *Risk Assessment Handbook Volume II: Environmental Evaluation* (USACE, 2010c). Other supporting documents used in the preparation of the ERA include the EPA *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments* (1997) and the Ohio EPA *Ecological Risk Assessment Guidance Document* (2008), hereafter referred to as the "EPA guidance" and "Ohio EPA guidance," respectively; the *Tri-Service Procedural Guidelines for Ecological Risk Assessments* (Wentsel, et al., 1996); and the *Region 5 Biological Technical Assistance Group (BTAG) Ecological Risk Assessment Guidance Bulletin No. 1* (EPA, 1996).

Consistent with the Unified Approach for performing ERAs (USACE, 2011) at the facility, a screening-level ecological risk assessment (SLERA) was performed on the surface soil samples collected at the Area 2 section of the Ramsdell Quarry Landfill MRS. The SLERA is an initial screening step in the ERA eight-step approach as described in EPA guidance (1997). The SLERA comprises Steps 1, 2, and the first part of Step 3 (often referred to as Step 3a), in which a refinement of the chemicals initially selected as COPECs is performed prior to determining whether additional investigation is necessary. If the SLERA indicates that additional investigation is warranted, it is followed by a more comprehensive baseline ecological risk assessment (BERA) by completing the second part of Step 3 (i.e., "Step 3b") through Step 7. Step 8 is a risk management step that occurs after information presented in the previous steps of the ERA has been fully considered. The Ohio EPA guidance (2008) presents a similar "tiered" approach that allows for a progression through four levels of the ERA as required by the findings and conclusions of each level: Level I Scoping, Level II Screening, Level III Baseline, and Level IV Field Baseline. Levels I and II are approximately equivalent to Steps 1 and 2 of a SLERA. Level III includes food chain modeling using exposure dose and toxicity estimates for generic receptors using conservative assumptions, and is incorporated as part of Step 3a in the SLERA if it is considered necessary to refine COPECs. The Level IV Field Baseline is equivalent to the BERA (Steps 3b through 7), where conservative assumptions used in the Level III Baseline is modified using MRS-specific information.

As stated previously, the SLERA under the facility-wide Unified Approach includes Steps 1 through 3a of the eight-step process for ERAs (EPA, 1997). This is equivalent to a Level I and II evaluation according to the Ohio EPA process and is also consistent with the ERA approach described in USACE guidance (2003c and 2010b) and the Unified Approach to performing ERAs (USACE, 2011) at the facility. A BERA is not considered necessary for this MRS, and the ERA process is terminated following the completion of the SLERA.

8.1 Scope and Objectives

The goal of the ERA was to evaluate the potential for adverse ecological effects to ecological receptors from MC at the Area 2 section of the Ramsdell Quarry Landfill MRS. This objective was met by characterizing the ecological communities in the vicinity of the MRS, determining the particular chemicals present, identifying pathways for receptor exposure, and estimating the magnitude of the likelihood of potential adverse effects to identified receptors. The ERA addressed the potential for adverse effects to the vegetation, wildlife, threatened and endangered species, and wetlands or other sensitive habitats associated with the MRS.

The objective of this ERA was to provide an estimate of the potential for adverse ecological effects associated with contamination resulting from former activities at Area 2. The results of the ERA would contribute to the overall characterization of the surface soil conditions at Area 2 and were used to determine the need for additional investigations or to develop, evaluate, and select appropriate remedial alternatives.

The ERA used MRS-specific analyte concentration data for surface soil taken from Area 2. Risks to ecological receptors were evaluated by performing a multistep screening process in which, after each step, the detected analytes in the media were either deemed to pose negligible risk and eliminated from further consideration or carried forward to the next step in the screening process to a final conclusion of being a COPEC. COPECs are analytes whose concentrations are great enough to pose potential adverse effects to ecological receptors. Following the determination of COPECs, an ecological CSM was developed that described the selection of receptors, exposure pathways, assessment and measurement endpoints, and accounts for accumulative effects.

8.2 Level I Scoping

The scoping step of the ERA included descriptions of habitats, biota, and threatened and endangered and other rare species, selection of an EU, and the identification of COPECs at Area 2. If a potential threat to ecological receptors was suspected, the ERA proceeded to a Level II Screening.

8.2.1 Site Description and Land Use

The Ramsdell Quarry Landfill MRS is an approximate 13.43-acre area located in the central portion of the facility. The Ramsdell Quarry Landfill MRS is comprised of two areas: a northern section (Area 1) where OB/OD operations took place in an old quarry, and a southern area (Area 2) that contains a small inactive soil borrow pit and wooded area where installation personnel had historically found MD (e^2M, 2008). Concentrated areas of MD were found during the RI field activities at Area 2 which is the focus of this ERA. Area 2 is primarily wooded with overgrown ground vegetation. Current activities at the Area 2 include military training and natural resource management activities. The future land use at Area 2 is military training.

8.2.2 Ecological Significance

The ecological features of the Area 2 section of the MRS are presented in this section. The protection of these features from chemical releases, as assessed by the ERA, is articulated by the facility management goals in Section 8.2.3.

The topography at the Area 2 portion of the MRS is relatively flat with ground surface elevation gradually ranging upgradient to the west from approximately 975 to 990 feet amsl. A topographical low of 970 feet amsl is presented in the former soil borrow pit at the eastern portion of Area 2. Natural drainage at Area 2 appears to follow the local topography from west to east. A former rail bed bisects Area 2 and the southern portion of the closed landfill that is between Area 1 and Area 2. The elevation of the former rail bed is approximately 10 feet lower than the surrounding topography and presents a definitive separation between the two areas.

Portions of the Red Maple Woods and Submergent Marsh plant communities are found along the eastern edge of Area 2. Red maple, green ash, and pin oak are common in the Red Maple Woods community, and cattails, spatterdock, and white water lily are dominant species in the submergent marsh association (AMEC, 2008). Approximately 0.5 acres of wetland were identified in the former soil borrow pit located at the eastern portion of Area 2 and along the eastern Area 2 boundary during a planning-level survey (AMEC, 2008). Additional details pertaining to the ecological setting are provided in the following sections.

8.2.3 Facility Management Goals

The INRMP (AMEC, 2008) was developed for the OHARNG as the primary guidance document and tool for managing natural resources at the facility. Several of these management goals have relevance to maintaining the ecological resources at the MRS. Therefore, they are pertinent to the ERA because they articulate overarching objectives regarding ecological resources that should be considered when identifying whether adverse impacts associated with a release have occurred. Specifically, the following goals listed in the INRMP are pertinent to the ERA for the Area 2 section of the Ramsdell Quarry Landfill MRS:

- Manage wildlife resources in a manner compatible with the military mission and within the limits of the natural habitat (Goal 1).
- Protect and maintain populations of rare plant and animal species on the facility in compliance with federal and state laws and regulations (Goal 4).
- Manage wetlands and other surface waters in accordance with applicable federal, state, and local regulations, and to protect water quality and ecological function while facilitating the military mission (Goal 9).
- Manage soil to maintain productivity and prevent and repair erosion in accordance with state and federal laws and regulations (Goal 10).

8.2.4 Terrestrial and Aquatic Resources

This section summarizes the terrestrial resources identified for Area 2 that are evaluated in the ERA. The Area 2 portion of the MRS is comprised mostly of terrestrial habitat and is the area where soil samples were collected during the RI field work. Therefore, the focus of this ERA is on terrestrial resources, rather than aquatic and semi-aquatic resources.

8.2.4.1 Special Interest Areas

Special interest areas are ecosystems that are not federally protected and have no legal standing, but are areas that host state-listed species, are representative of historic ecosystems, or are otherwise noteworthy. No special interest areas have been identified at the Ramsdell Quarry Landfill MRS from the natural heritage data searches.

8.2.4.2 Wetlands

A planning-level survey for wetlands was conducted at the facility and included both Area 1 and Area 2 at the MRS (AMEC, 2008). In addition to the wetlands and open water identified in Area 1, approximately 0.5 acres of wetland were identified at the eastern portion of Area 2 as is discussed in Section 8.2.2.

8.2.4.3 Animal Populations

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 (AMEC, 2008).

Vegetation at the facility can be grouped into three categories: (1) herb dominated, (2) shrub dominated, and (3) tree dominated. Approximately 60 percent of the facility is covered by forest or tree-dominated vegetation. The facility has seven forest formations, four shrub formations, eight herbaceous formations, and one nonvegetated formation (AMEC, 2008).

Surface water features within the facility include a variety of streams, ponds, floodplains, and wetlands. Numerous streams drain the facility, including 19 miles of perennial streams. The total combined stream length of streams at the facility is 212 linear miles. Approximately 153 acres of ponds are found on the facility. These ponds generally provide valuable wildlife habitat. The ponds generally support wood ducks, hooded mergansers, mallards, Canada goose, and many other birds and wildlife species. Some ponds have been stocked with fish and are used for fishing and hunting (AMEC, 2008). Wetlands are abundant and prevalent throughout the facility. These wetland areas include seasonal wetlands, wet fields, and forested wetlands. Most of the wetland areas on the facility are the result of natural drainage and beaver activity; however, some wetland areas are associated with anthropogenic settling ponds and drainage areas.

An abundance of wildlife is present on the facility. A total of 35 species of land mammals, 214 species of birds, 41 species of fish, and 34 species of amphibians and reptiles have been identified on the facility (AMEC, 2008). Available habitat at the Ramsdell Quarry Landfill MRS consists primarily of mesic woods and wetlands. Common bird species that could be expected to use the wooded areas include the Acadian flycatcher (*Empidonax virescens*), black-capped chickadee (*Poecile atricapillus*) and red-eyed vireo (*Vireo olivaceus*). Common large mammals such as white-tailed deer (*Odocoileus virginianus*), raccoon (*Procyon lotor*), and woodchuck (*Marmota monax*), and several small mammals such as the eastern cottontail (*Sylvilagus floridanus*), white-footed mouse (*Peromyscus leucopus*), and short-tailed shrew (*Blarina brevicauda*) are present at the facility (ODNR, 1997) and may use the upland habitat present at the Area 2 section of the Ramsdell Quarry Landfill MRS.

8.2.4.4 Threatened, Endangered, and Other Rare Species Information

The relative isolation and protection of habitat at the facility has created an important area of refuge for a number of plant and animal species considered rare by the State of Ohio. No federally listed species are known to reside at the facility. To date, a combined 91 state- and federal-listed species are confirmed to be on the facility property as are listed in **Table 1-3** (Camp Ravenna, 2013).

Biological inventories have been performed across the facility. No confirmed sightings of state-listed species on the MRS have been reported (AMEC, 2008). There is the potential for state-listed or rare species to be within the MRS boundary. Although there are no documented state-listed or rare species at the MRS, a state-listed threatened species, the barn owl (*Tyto alba*), has been historically identified to live approximately 0.5 miles to the west of the MRS (AMEC, 2008).

8.2.5 Level I Conclusions and Recommendations

Based on the presence of ecological resources at the facility, and the potential presence of detected SRCs associated with historical MRS processes that could adversely affect these resources, proceeding to the Level II Screening step was recommended for this ERA. This Level II Screening is presented in Section 8.3.

8.3 Level II Screening

A Level II Screening was performed for the soil sample data collected at Area 2 to compare MRS-specific data to appropriate ecological screening values (ESVs) and other criteria to determine the need for further evaluation. An ecological CSM was developed to identify the potential ecological receptors at risk and the exposure pathways by which these receptors could be exposed to contamination in the Area 2 media. Specific assessment and measurement endpoints are identified based on the CSM to describe ecological features targeted for protection. Then, a COPEC identification step was performed to determine what SRCs, if any, potentially represent a threat to the ecological receptors present at Area 2.

8.3.1 Ecological CSM

The ecological CSM depicts and describes the known and expected relationships among the stressors, pathways, and assessment endpoints that are considered in the ERA, along with a rationale for their inclusion. Two ecological CSMs are presented for this Level II Screening. One ecological CSM is associated with the media screening conducted during the Level II Screening (**Figure 8-1**). The other ecological CSM (**Figure 8-2**) represents a preliminary CSM for a Level III Baseline, should one be considered necessary. The ecological CSMs for Area 2 were developed using the available site-specific information and professional judgment. The chemical source, source media, transport mechanisms, exposure media, exposure routes, and ecological receptors for the ecological CSMs are described below.

8.3.1.1 Contamination Source

The contamination source consists of MC that may have potentially been released to the surrounding environment from MD found on and beneath the ground surface in Area 2 of the MRS.

8.3.1.2 Source Media

The source media at Area 2 is surface soil where MC may have potentially released due to the disposal of MD at that portion of the MRS. Although surface soil at the facility is defined as 0 to 1 foot bgs, the ISM surface soil samples used in the SLERA and collected under the

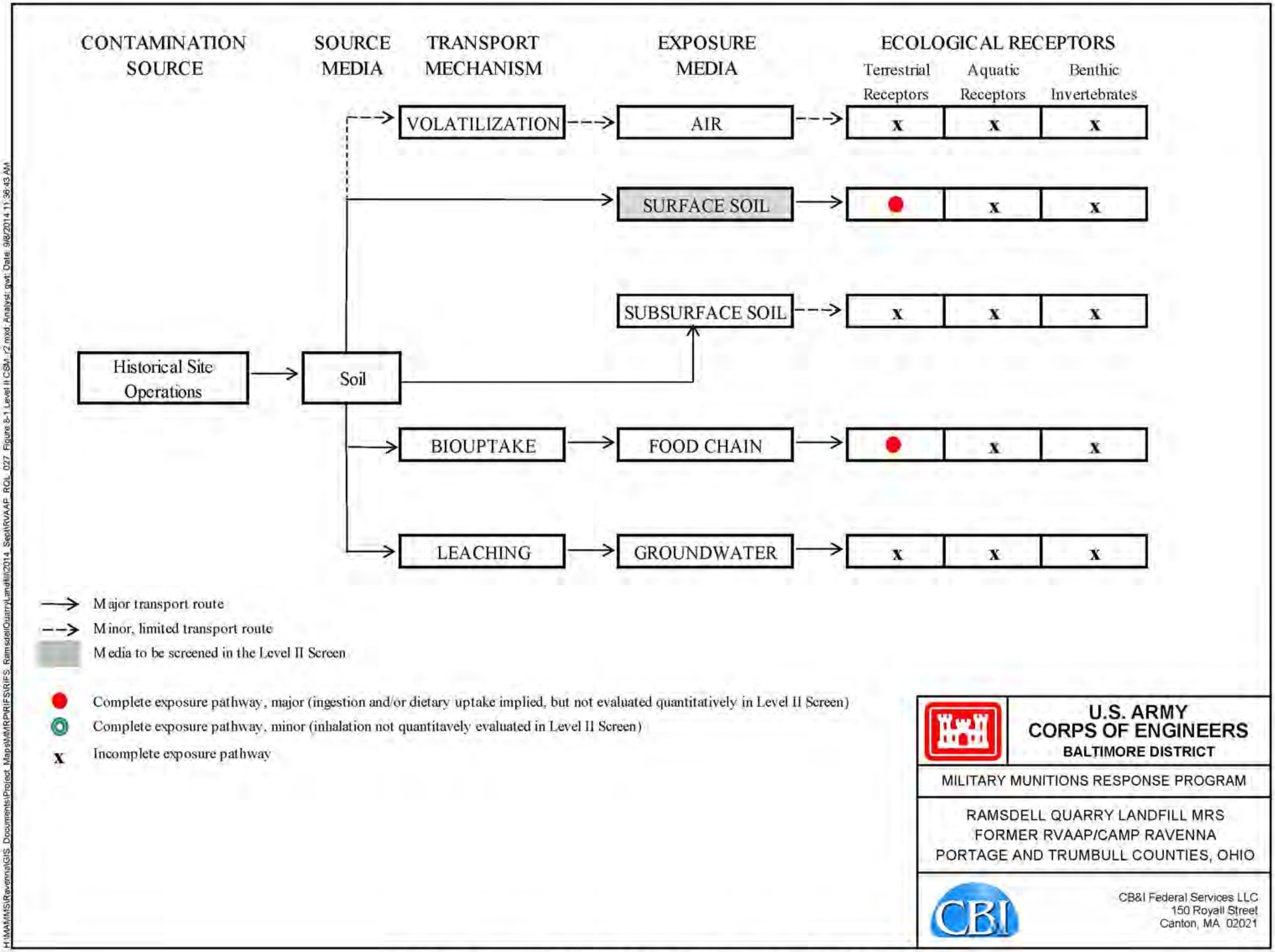
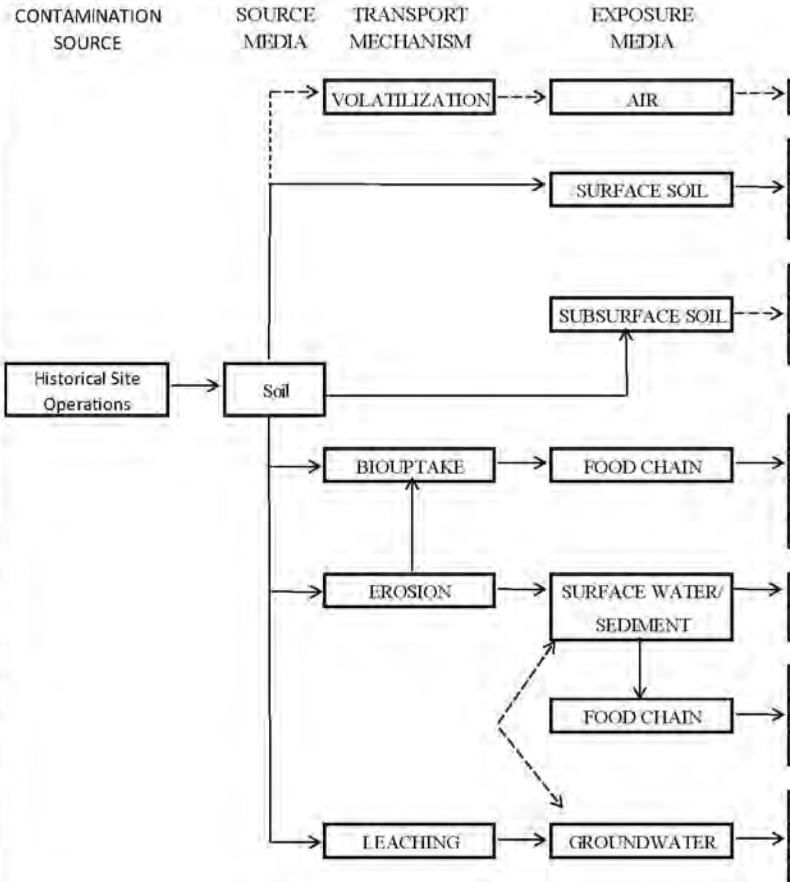


FIGURE 8-1 LEVEL II CONCEPTUAL SITE MODEL



EXPOSURE MEDIA	EXPOSURE ROUTES	Terrestrial Plants	Terrestrial Inverts	Rabbit Vole	Shrew Robin	Fox Hawk	Aquatic biota	Muskrat Duck	Mink Heron	Benthic Inverts
AIR	INHALATION (VAPORS)	X	X	X	X	X	X	X	X	X
SURFACE SOIL	INGESTION	X	●	●	●	●	X	X	X	X
SURFACE SOIL	DIRECT/DERMAL CONTACT	●	●	◎	◎	◎	X	X	X	X
SURFACE SOIL	INHALATION (FUGITIVE DUST)	X	X	◎	◎	◎	X	X	X	X
SUBSURFACE SOIL	INGESTION	X	X	X	X	X	X	X	X	X
SUBSURFACE SOIL	DIRECT/DERMAL CONTACT	X	X	X	X	X	X	X	X	X
SUBSURFACE SOIL	INHALATION (FUGITIVE DUST)	X	X	X	X	X	X	X	X	X
FOOD CHAIN	PLANTS	X	X	●	◎	◎	X	X	X	X
FOOD CHAIN	INVERTEBRATES	X	X	◎	●	◎	X	X	X	X
FOOD CHAIN	HERBIVORES	X	X	X	X	●	X	X	X	X
FOOD CHAIN	OMNIVORES	X	X	X	X	●	X	X	X	X
SURFACE WATER/ SEDIMENT	INGESTION	X	X	X	X	X	X	X	X	X
SURFACE WATER/ SEDIMENT	DIRECT/DERMAL CONTACT	X	X	X	X	X	X	X	X	X
FOOD CHAIN	PLANTS	X	X	X	X	X	X	X	X	X
FOOD CHAIN	INVERTEBRATES	X	X	X	X	X	X	X	X	X
FOOD CHAIN	FISH	X	X	X	X	X	X	X	X	X
GROUNDWATER	INGESTION	X	X	X	X	X	X	X	X	X
GROUNDWATER	DIRECT/DERMAL CONTACT	X	X	X	X	X	X	X	X	X
GROUNDWATER	INHALATION (VAPORS)	X	X	X	X	X	X	X	X	X

(ECOLOGICAL RECEPTORS)

→ Major route
- - → Minor route (not quantified)

● Complete exposure pathway, major
◎ Complete exposure pathway, minor
X Incomplete exposure pathway or not evaluated

U.S. ARMY CORPS OF ENGINEERS
BALTIMORE DISTRICT

MILITARY MUNITIONS RESPONSE PROGRAM

RAMSDELL QUARRY LANDFILL 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_RamsdellQuarryLandfill\2014_Sept\RVAAP_RQL_028_Figure 8-2 Prelim_Level III CSMa_r2.mxd; Analyst: gwt; Date: 9/8/2014 11:45:03 AM

FIGURE 8-2 PRELIMINARY LEVEL III CONCEPTUAL SITE MODEL

MMRP were for the 0- to 0.5-foot (0 to 6 inches) bgs sample depth. The samples were collected at 0.5-foot intervals since this was the predominate depth that MD was encountered during the intrusive activities conducted during the RI field work. This is the likely depth interval that MC associated with the MD found on and just below the ground surface would be expected to be encountered.

8.3.1.3 Selection of Exposure Units

From the ecological assessment viewpoint, an EU is the area where ecological receptors potentially are exposed to the chemical source and the source medium. Although some ecological receptors are likely to gather food, seek shelter, reproduce, and move around, spatial boundaries of the ecological EUs are the same as the spatial boundaries of aggregates defined for historical use, nature and extent of chemical contamination, fate and transport, and the HHRA. Surface soil to a maximum depth of 0.5 feet is representative of the terrestrial EU at the Area 2 section of the Ramsdell Quarry Landfill MRS. No other EUs are identified for this MRS.

8.3.1.4 Transport Mechanisms

Potential transport mechanisms at Area 2 include volatilization into the air, biota uptake, erosion to surface water and sediment, and leaching to groundwater. Biota uptake is a transport mechanism because some of the detected chemicals are known to accumulate in biota, which may act as a vehicle to spatially disperse chemicals, as well as represent a secondary exposure medium for upper trophic level receptors that prey on the biota.

8.3.1.5 Exposure Media

Sufficient time has elapsed for chemicals in the source medium to have migrated to potential exposure media, resulting in possible exposure of plants and animals that come in contact with these media. Potential exposure media include air, surface soil, and the food chain. Surface soil (typically 0 to 1 foot bgs for the facility) was not collected greater than 0.5 feet bgs at Area 2 since most MC would be expected to have concentrated in the top several inches of soil where the majority of the MD was found. Subsurface soil includes soil at depths that ecological receptors typically do not come into contact with (greater than 1 foot bgs), and is not evaluated at the Ramsdell Quarry Landfill MRS. Groundwater is not considered an exposure medium because ecological receptors are unlikely to contact groundwater. Therefore, surface soil (0 to 0.5 feet bgs) and biota comprising of prey items for higher-trophic-level receptors are the two principal exposure media for Area 2.

8.3.1.6 Exposure Routes

Exposure routes are functions of the characteristics of the media in which the sources occur, and reflect how both the released chemicals and receptors interact with those media. For example, for MRSs with aquatic habitat, chemicals in surface water may be dissolved or suspended as particulates and be highly mobile, whereas those same constituents in soil may be much more stationary. The ecology of the receptors is important because it dictates their home range, whether the organism is mobile or immobile, local or migratory, burrowing or above ground, plant eating, animal eating, or omnivorous.

For the Level II Screening CSM (**Figure 8-1**), specific exposure routes were not identified because the screen is not receptor-specific and only focuses on the comparison of the maximum detected concentrations of chemicals in the exposure media to published ecological toxicological benchmark concentrations derived for those media. However, the preliminary Level III Baseline ecological CSM (**Figure 8-2**) identifies specific exposure routes and indicates whether the exposure routes from the exposure media to the ecological receptors are major or minor. Major exposure routes are evaluated quantitatively, whereas minor routes are evaluated qualitatively. The preliminary Level III Baseline ecological CSM (**Figure 8-2**) shows major exposure routes of soil to ecological receptors and an incomplete exposure route of groundwater.

Ecological receptors to be evaluated in the Level II Screening are presented in Section 8.3.1.7. The major exposure routes for chemical toxicity from surface soil include ingestion (for terrestrial invertebrates, voles, shrews, robins, foxes, and hawks) and direct contact (for terrestrial invertebrates). The ingestion exposure routes for voles, shrews, robins, foxes, and hawks include soil, as well as plant and/or animal food items (i.e., food chain transfer) that were also exposed to the surface soil. Minor exposure routes for surface soil include direct contact and inhalation of fugitive dust. Inhalation and dermal contact, however, are typically not assessed in terrestrial ERAs because these routes are not well studied for wildlife. Additionally, most wildlife also have protective features such as fur or feathers which typically result in dermal contact being a negligible exposure pathway (though dermal contact with soil is a potentially significant exposure route for soil-dependent terrestrial animals such as invertebrates) (USACE, 2010c).

Exposure to groundwater is an incomplete pathway for all ecological receptors because receptors typically do not come into direct contact with groundwater. If the groundwater outcrops via seeps or springs into wetlands or ditches, it becomes part of the surface water and would be evaluated as surface water.

8.3.1.7 Ecological Receptors

For the Level II Screening, specific ecological receptors were not identified; rather, terrestrial biota is considered as a whole. However, for the Level III Baseline evaluation, specific terrestrial ecological receptors were identified as part of the ecological CSM (**Figure 8-2**). The terrestrial receptors include terrestrial invertebrates (earthworms), voles, shrews, robins, foxes, and hawks (USACE, 2003c). These receptors are discussed in more detail below.

8.3.1.8 Selection of MRS-Specific Ecological Receptor Species

The selection of ecological receptors for the MRS-specific analysis screen was based on plant and animal species that are likely to occur in the terrestrial habitats at the Area 2 section of the MRS. The following three criteria were used to identify the site-specific receptors:

1. **Ecological Relevance—**The receptor has or represents a role in an important function such as energy fixation (i.e., plants), nutrient cycling (i.e., earthworms), and population regulation (i.e., hawks). Receptor species were chosen to include representatives of all applicable trophic levels identified by the ecological CSM for Area 2. These species were selected to be predictive of assessment endpoints (including protected species/species of special concern and recreational species).
2. **Susceptibility—**The receptor is known to be sensitive to the SRCs detected at Area 2, and given their food and habitat preferences, their exposure is expected to be high. The species have a likely potential for exposure based upon their residency status, home range size, sedentary nature of the organism, habitat compatibility, exposure to contaminated media, exposure route, and/or exposure mechanism compatibility. Ecological receptor species were also selected based on the availability of toxicological effects and exposure information.
3. **Management Goals—**The receptor represents a valued component of Area 2's ecological significance. Furthermore, as a significant natural resource, its presence should be managed in a manner that is compatible with the military mission at the facility (AMEC, 2008).

At Area 2, the following types of ecological receptors are likely to be present: terrestrial invertebrates, meadow voles (*Microtus pennsylvanicus*), short-tailed shrews (*Blarina brevicauda*), American robins (*Turdus migratoris*), red foxes (*Vulpes vulpes*), and red-tailed hawks (*Buteo jamaicensis*). Each of these receptors is described in the following paragraphs.

Terrestrial Invertebrate Exposure to Soil

Terrestrial invertebrate exposure to soil is applicable to soils for Area 2. Earthworms represent the receptor for the terrestrial invertebrate class, and there is sufficient habitat present for them onsite. Earthworms have ecological relevance because they are important for decomposition of detritus and for energy and nutrient cycling in soil (Efroymson et al., 1997a), and as prey items for other species. Earthworms are probably the most important of the terrestrial invertebrates for promoting soil fertility due to the volume of soil that they process.

Earthworms are susceptible to exposure to and toxicity from COPECs in soil. Earthworms are nearly always in contact with soil and ingest soil, which results in constant exposure. Earthworms are sensitive to various chemicals. Toxicity benchmarks are available for earthworms (Efroymson et al., 1997a). Although management goals for earthworms are not immediately obvious, the role of earthworms in soil fertility and as a food source is significant. Thus, there is sufficient justification to warrant the earthworm as a representative receptor for the Area 2 section of the Ramsdell Quarry Landfill MRS.

Mammalian Herbivore Exposure to Soil

Mammalian herbivore exposure to soil is applicable for Area 2. Cottontail rabbits and meadow voles represent mammalian herbivore receptors, and there is suitable habitat present for them at Area 2. Both species have ecological relevance by consuming vegetation, which helps in the regulation of plant populations and in the dispersion of some plant seeds. Small herbivorous mammals such as cottontail rabbits and voles are prey items for top terrestrial predators.

Both cottontail rabbits and meadow voles are susceptible to exposure to and toxicity from COPECs in soil and vegetation. Herbivorous mammals are exposed primarily through ingestion of plant material and incidental ingestion of contaminated surface soil containing chemicals. Exposures by inhalation of COPECs in air or on suspended particulates, as well as exposures by direct contact with soil, were assumed to be negligible. Dietary toxicity benchmarks are available for many COPECs for mammals (Sample et al., 1996), and there are management goals for rabbits because they are an upland small game species protected under Ohio hunting regulations. There are no specific management goals for meadow voles at the Ramsdell Quarry Landfill MRS. Meadow voles have smaller home ranges than rabbits, which make them potentially more susceptible to localized contamination. Therefore, they are a more conservative selection as a representative mammalian herbivore than rabbits, and are selected as representative receptors for this foraging guild at the Area 2 section of the Ramsdell Quarry Landfill MRS.

Insectivorous Mammal and Bird Exposure to Soil

Insectivorous mammal and bird exposure to soil is applicable for Area 2. Short-tailed shrews and American robins represent the receptors for the insectivorous mammal and bird terrestrial exposure class, respectively. There is sufficient, suitable habitat present at Area 2 for these receptors. Both species have ecological relevance because they help to control aboveground invertebrate community size by consuming large numbers of invertebrates. Shrews and robins are a prey item for terrestrial top predators.

Both short-tailed shrews and American robins are susceptible to exposure to and toxicity from COPECs in soil as well as contaminants in vegetation and terrestrial invertebrate.

Insectivorous mammals such as short-tailed shrews and birds such as American robins are primarily exposed by ingestion of contaminated prey (i.e., earthworms, insect larvae, and slugs), as well as ingestion of soil. In addition, shrews ingest a small amount of leafy vegetation, and the robin's diet consists of 50 percent each of seeds and fruit. Dietary toxicity benchmarks are available for mammals and birds (Sample et al., 1996). Both species are recommended as receptors because there can be different toxicological sensitivity between mammals and birds exposed to the same contaminants. There are management goals for robins because they are federally protected under the *Migratory Bird Treaty Act of 1993*, as amended (16 USC 703–711). There are no specific management goals for shrews at the MRS. Based on the management goals for robins, plus the susceptibility to contamination and ecological relevance for both species, there is sufficient justification to warrant shrews and robins as representative receptors for the Area 2 section of the Ramsdell Quarry Landfill MRS.

Terrestrial Top Predators

Exposure of terrestrial top predators is applicable to Area 2. Red foxes and red-tailed hawks represent the mammal and bird receptors for the terrestrial top predator exposure class, and there is a limited amount of suitable habitat available for them at Area 2. Both species have ecological relevance; as representatives of the top of the food chain for the Area 2 terrestrial EUs, they control populations of prey animals such as small mammals and birds.

Both red foxes and red-tailed hawks are susceptible to exposure to and toxicity from COPECs in soil, vegetation, and/or animal prey. Terrestrial top predators feed on small mammals and birds that may accumulate constituents in their tissues following exposure at Area 2. There is a potential difference in toxicological sensitivity between mammals and birds exposed to the same COPECs so it is prudent to examine a species from both the *Mammalia* and *Aves* classes. Red foxes are primarily carnivorous but consume some plant material. The red-tailed hawk consumes only animal prey. The fox may incidentally consume soil. There are management goals for both species. Laws (Ohio Trapping Season Regulations for foxes, and federal protection of raptors under the *Migratory Bird Treaty Act of 1993*, as amended [16 USC 703–711]) also protect these species. In addition, both species are susceptible to contamination and have ecological relevance as top predators in the terrestrial ecosystem. Thus, there is sufficient justification to warrant these two species as representative receptors for Area 2 at the Ramsdell Quarry Landfill MRS.

8.3.1.9 Relevant and Complete Exposure Pathways

Relevant and complete exposure pathways for the ecological receptors at Area 2 were described in the previous sections. There are relevant and complete exposure pathways for various ecological receptors including terrestrial invertebrates, and terrestrial herbivores, insectivores, and carnivores. Thus, these types of receptors could be exposed to COPECs in surface soil at the Area 2 section of the Ramsdell Quarry Landfill MRS.

8.3.2 Ecological Endpoint (Assessment and Measurement) Identification

The protection of ecological resources, such as habitats and species of plants and animals, is a primary motivation for conducting ERAs. Key aspects of ecological protection are presented as general management goals. These are non-facility–specific goals established by legislation or agency policy that are based on societal concern for the protection of certain environmental resources. For example, environmental protection is mandated by a variety of legislation and government agency policies (i.e., CERCLA and the *National Environmental Policy Act*). Other legislation includes the ESA, as amended (16 USC 1531–1544) and the *Migratory Bird Treaty Act of 1993*, as amended (16 USC 703–711). To evaluate whether a general management goal has been met, assessment endpoints, measures of effects, and decision rules were formulated. General management goals, assessment endpoints, measures of effects, and decision rules are discussed below.

Because only terrestrial habitat is being evaluated, there is only one general management goal for Area 2. However, the assessment endpoints differ between the general screen and the site-specific analysis screen. The general management goal for the ERA is to protect terrestrial populations and communities from adverse effects due to the release-- or potential release-- of chemical substances associated with past MRS activities.

Ecological assessment endpoints are selected to determine whether this general management goal is met at the unit. An ecological assessment endpoint is a characteristic of an ecological component that may be affected by exposure to a stressor (i.e., COPEC). Assessment endpoints are “explicit expressions of the actual environmental value that is to be protected” (EPA, 1992). Assessment endpoints often reflect environmental values that are protected by law, provide critical resources, or provide an ecological function that would be significantly impaired if the resource was altered. Unlike the HHRA process, which focuses on individual receptors, the ERA focuses on populations or groups of interbreeding nonhuman, nondomesticated receptors. Accordingly, assessment endpoints generally refer to characteristics of populations and communities. In the ERA process, risks to individuals are assessed only if they are protected under the ESA, as amended, or other species-specific legislation, or if the species is a candidate for listing as a threatened, endangered, and rare species. Because no threatened, endangered, and rare species are known to be present at the Ramsdell Quarry Landfill MRS, potential impacts to populations is the appropriate criterion for consideration at Area 2.

Due to the uniqueness of local flora and fauna communities, as well as varying societal values placed on these ecological features, a universally applicable list of assessment endpoints does not exist. The Ohio EPA guidance (2008) was used to select assessment endpoints for this ERA.

For the Level II Screening, the assessment endpoints are any potential adverse effects on ecological receptors, where receptors are defined as any plant or animal population, communities, habitats, and sensitive environments (Ohio EPA, 2008). Although the assessment endpoints for the Level II Screening are to protect terrestrial biota—including invertebrate communities and animal populations—from adverse effects due to the release or potential release of chemical substances associated with past MRS activities, specific receptors are not identified with the assessment endpoints.

Table 8-1 shows the general management goal for terrestrial resources, associated assessment endpoints, measures of effect, and decision rule by assessment endpoint number. Furthermore, the table provides definitions of Assessment Endpoints 1, 2, 3, and 4 for terrestrial receptors. As stated, the assessment endpoint table includes a column describing the conditions for making a decision depending on whether the HQ is less than or more than 1. If the HQ is greater than 1, the scientific management decision point options from Ohio EPA/U.S. Army guidance are provided (i.e., no further action, risk management, monitoring, remediation, or further investigation).

For the Level III Baseline evaluation, the assessment endpoints are more specific and stated in terms of types of specific ecological receptors associated with the general management goals. Assessment Endpoints 1, 2, 3, and 4 entail the growth, survival, and reproduction of terrestrial receptors such as earthworms and terrestrial biota, herbivorous mammals, and birds, and carnivorous top predator mammals and birds, respectively. Assessment Endpoints 1 through 4 are associated with General Management Goal 1, protection of terrestrial populations, communities, and ecosystems.

The assessment endpoints are evaluated through the use of measurement endpoints. The EPA defines measurement endpoints as ecological characteristics used to quantify and predict change in the assessment endpoints. They consist of measures of receptor and population characteristics, measures of exposure, and measures of effect. For example, measures of receptor characteristics include parameters such as home range, food intake rate, and dietary composition. Measures of exposure include attributes of the environment such as chemical concentrations in soil, sediment, surface water, and biota. The measurement endpoints of effect for the Level II Screening evaluation consist of the comparison of the maximum detected concentration of each chemical in soil to the ESV benchmarks. Measurement endpoints for the Level III Baseline include the comparison of estimated doses of chemicals in various receptor animals such as rabbits, voles, shrews, robins, foxes, and hawks to toxicity reference values (TRVs).

In the Level II Screening, the maximum detected concentrations in surface soil were used as the EPCs for comparison to generic screening values that are defined as concentrations that are not expected to cause harm to ecological populations. Per the facility-wide Unified Approach for performing ERAs (USACE, 2011), any COPECs retained following the Level II Screening are potentially subject to a Level III Baseline analysis using EPCs that are more representative of the exposures expected for the representative receptors. The Level III Baseline analysis includes evaluation of exposure of a variety of receptors to the reasonable maximum exposure concentrations of COPECs at each EU, using default dietary and uptake factors. The representative ecological receptors may not all be present at each EU. However, all representative receptors were evaluated at this step.

For the Level III Baseline, decision rules for COPECs were obtained from the Ohio EPA guidance (2008) for chemicals. Briefly, the first decision rule for COPECs is based on the ratio (or HQ) of the dose to a given receptor species (i.e., a vole, representing terrestrial herbivorous mammals) associated with a chemical's concentration in the environment (numerator) to the ecological effects or TRV (denominator) of the same chemical. A ratio of 1 or less means that ecological risk is negligible, while a ratio of greater than 1 means that ecological risk from that individual chemical is possible and that additional investigation should follow to confirm or refute this prediction. The second decision rule is that if "no other observed significant adverse effects on the health or viability of the local individuals or populations of species are identified" (Ohio EPA, 2008) and the HQ does not exceed 1, "the site is highly unlikely to present significant risks to endpoint species" (Ohio EPA, 2008). Potential outcomes for the Level III Baseline are: (1) no significant risks to endpoint species so no further analysis is needed, (2) conduct field baseline assessment to quantify adverse effects to populations of representative species that were shown to be potentially impacted based on hazard calculations in the Level III Baseline, and (3) remedial action taken without further study.

8.3.3 Identification of COPECs

This section presents the screening of analytical data obtained from surface soil samples collected from the Area 2 section of the Ramsdell Quarry Landfill MRS. After the Level II Screening is complete, any COPECs identified are discussed in greater detail, and a recommendation is made as to whether the ERA should proceed to a Level III Baseline or Level IV Baseline.

8.3.3.1 Data Used in the ERA

The available data set used in the SLERA includes two ISM surface soil samples that were collected during the RI field effort to characterize for the nature and extent of SRCs

Table 8-1
General Management Goal, Ecological Assessment Endpoints, Measures of Effect, and Decision Rules Identified During the Level II Screening at the Ramsdell Quarry Landfill MRS

General Management Goal	Assessment Endpoint	Measures of Effect	Decision Rule
General Management Goal 1: The protection of terrestrial populations, communities, and ecosystems	**Assessment Endpoint 1:** Growth, survival, and reproduction of plant and soil invertebrate communities and tissue concentrations of contaminants low enough such that higher trophic levels that consume them are not at risk Receptors: plants and earthworms	**Measures of Effect 1:** Plant and earthworm soil toxicity benchmarks and measured RME concentrations of constituents in soil	**Decision Rule for Assessment Endpoint 1:** If HQs, defined as the ratios of COPEC RME concentrations in surface soil to soil toxicity benchmarks for adverse effects on plants and soil invertebrates, are less than or equal to 1, then Assessment Endpoint 1 has been met and plants and soil-dwelling invertebrates are not at risk. If the HQs are >1, a SMDP is reached, at which point it will be necessary to decide what is needed: no further action, risk management of ecological resources, monitoring of the environment, remediation of any site-usage-related COPECs and applicable media, or further investigation such as a Level III and Level IV Field Baseline
	Assessment Endpoint 2: Growth, survival, and reproduction of herbivorous mammal populations and low enough concentrations of contaminants in their tissues so that higher trophic level animals that consume them are not at risk Receptor: meadow vole	**Measures of Effect 2:** Estimates of receptor home range area, body weights, feeding rates, and dietary composition based on published measurements of endpoint species or similar species; modeled COPEC concentrations in food chain based on measured concentrations in physical media; chronic dietary NOAELs applicable to wildlife receptors based on measured responses of similar species in laboratory studies	**Decision Rule for Assessment Endpoint 2:** If HQs, based on ratios of estimated exposure concentrations predicted from COPEC RME concentrations in surface soil to dietary limits corresponding to NOAEL TRV benchmarks for adverse effects on herbivorous mammals are less than or equal to 1, Assessment Endpoint 2 is met, and the receptors are not at risk. If the HQs are >1, a SMDP is reached, at which point it will be necessary to decide what is needed: no further action, risk management of ecological resources, monitoring of the environment, remediation of any site-usage-related COPECs in applicable media, or further investigation such as a Level III and Level IV Field Baseline
	Assessment Endpoint 3: Growth, survival, and reproduction of worm-eating and insectivorous mammal and bird populations and low enough concentrations of contaminants in their tissue so that predators that consume them are not at risk Receptors: shrews and robins	**Measures of Effect 3:** Estimates of receptor home range area, body weights, feeding rates, and dietary composition based on published measurements of endpoint species or similar species; modeled COPEC concentrations in food chain based on measured concentrations in physical media; chronic dietary NOAELs applicable to wildlife receptors based on measured responses of similar species in laboratory studies	**Decision Rule for Assessment Endpoint 3:** If HQs based on ratios of estimated exposure concentrations predicted from COPEC RME concentrations in surface soil to dietary limits corresponding to NOAEL TRV benchmarks for adverse effects on worm-eating and insectivorous mammals and birds is less than or equal to 1, then Assessment Endpoint 3 is met, and these receptors are not at risk. If the HQs are >1, a SMDP is reached, at which point it will be necessary to decide what is needed: no further action, risk management of ecological resources, monitoring of the environment, remediation of any site-usage-related COPECs in applicable media, or further investigation such as a Level III and Level IV Field Baseline Decision Rule for Assessment Endpoint 4:
	Assessment Endpoint 4: Growth, survival, and reproduction of carnivorous mammal and bird populations Receptor: red-tailed hawk and red fox	**Measures of Effect 4:** Estimates of receptor home range area, body weights, feeding rates, and dietary composition based on published measurements of endpoint species or similar species; modeled COPEC concentrations in food chain based on measured concentrations in physical media; chronic dietary NOAELs applicable to wildlife receptors based on measured responses of similar species in laboratory studies	**Decision Rule for Assessment Endpoint 4**: If HQs based on ratios of estimated exposure concentrations predicted from COPEC RME concentrations in surface soil to dietary limits corresponding to NOAEL TRV benchmarks for adverse effects on carnivorous mammals and birds are less than or equal to 1, then Assessment Endpoint 4 is met, and the receptors are not at risk. If the HQs are >1, a SMDP is reached, at which point it will be necessary to decide what is needed: no further action, risk management of ecological resources, monitoring of the environment, remediation of any site-usage-related COPECs in applicable media, or further investigation such as a Level III and Level IV Field Baseline

COPEC denotes chemical of potential ecological concern.
HQ denotes hazard quotient.
NOAEL denotes no observed adverse effect level.
RME denotes reasonable maximum exposure.
SMDP denotes scientific management decision point.
TRV denotes toxicity reference value.

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associated with previous activities at the MRS. Data from the surface soil samples were collected from representative locations as discussed in Section 3.2, "MC Characterization." The soil samples were collected from nonoverlapping ISM spatial areas within Area 2 that were biased to locations where MD was well distributed across or just beneath the ground surface. The soil samples were collected from the top 0.5 feet (6 inches) of soil, which represents the soil depth where most biological exposure occurs. Samples included in the SLERA data set are identified in **Table 8-2**.

Table 8-2
Summary of Data Used in the Ecological Risk Assessment

Sample Number	Sample Date	Sample Unit Area (acres)	Depth (feet bgs)	Sample Type	Analysis
Surface Soil					
RQLss-075(I)-0001-SS	8/22/2011	0.46	0–0.5	ISM	Metals[1] Explosives Nitrocellulose SVOCs PCBs TOC pH
RQLss-076(I)-0001-SS	8/22/2011	0.46	0–0.5	ISM	

[1] Metals analysis for surface soil and sediment includes aluminum, antimony, barium, cadmium, chromium (total and hexavalent), copper, iron, lead, mercury, strontium, and zinc.
bgs denotes below ground surface.
ISM denotes incremental sampling methodology.
SVOC denotes semivolatile organic compound.
PCB denotes polychlorinated biphenyl.
TOC denotes total organic carbon.

The MC analytical data were reviewed and evaluated for quality, usefulness, and uncertainty, as described in Section 4.3. From the MC chemical results of samples described above, a selection process was performed to develop a subset of chemicals that are identified as COPECs.

8.3.3.2 COPEC Selection Criteria

The section describes the selection criteria used to identify COPECs in the SLERA. All detected chemicals that are SRCs and potentially associated with the historical activities at the MRS are included in the COPEC screening step. The SRCs identified for the surface soil samples collected at Area 2 included the following:

- *Explosives and Propellants*: nitroguanidine
- *Metals*: antimony, cadmium, chromium (as Cr^{+3}), copper, lead, mercury, and strontium

- *SVOCs*: bis-2(ethylhexyl) phthalate, di-n-butyl phthalate, and fluoranthene

Soil samples were analyzed for total chromium and Cr^{+6}. Since Cr^{+6} was not detected in either soil sample, the detected chromium concentrations are assumed to be in the trivalent form.

Comparison to Ecological Screening Values

The COPECs were identified through a comparison to biologically relevant benchmark values that are considered "safe," i.e., few, if any, no impacts would be expected after chronic exposure to media containing the concentrations reflected by the benchmark under most conditions. The maximum detected concentrations of chemicals detected in the surface soil samples were compared with the ESVs used as ecological endpoints following recommendations in the Ohio EPA guidance (2008), and consistent with the Unified Approach for performing ERAs at the facility (USACE, 2011). The SRCs that exceed the ESVs, or for which no ESVs are available, were retained as COPECs. The following ESV hierarchy was used for the ecological evaluation of soil:

- *Ecological Soil Screening Level Guidance* (EPA, 2010)
- *Preliminary Remediation Goals for Ecological Endpoints* (Efroymson et al., 1997b)
- *Region 5 Resource Conservation and Recovery Act Ecological Screening Levels* (EPA, 2003)
- *ECORISK Database* (Los Alamos National Laboratory, 2013)
- *Nitroaromatic Munitions Compounds: Environmental Effects and Screening Values* (Talmage et al., 1999)

The ESVs used for the ERA are presented in **Appendix K**.

8.3.4 Summary of COPEC Selection

The results of the COPEC screening for the surface soil samples evaluated in the ERA are presented in **Table 8-3**. The table presents the following information:

- SRCs (as evaluated in Section 4.3.1.3)
- Range of detected concentrations
- Range of detection limits
- BSV
- ESV

- HQ
- Determination as to whether the SRC is a persistent, bioaccumulative, or toxic (PBT) compound
- Determination as to whether the SRC is a COPEC

The HQ is calculated as the detected concentration divided by the ESV. An HQ greater than 1 indicates that the concentration in the medium exceeds the conservative ESV, and may indicate that a potential ecological threat exists. Chemicals with HQs less than 1 are considered to be of low concern, and are not carried forward as COPECs, unless the chemical is a PBT pollutant and its ESV is not protective of food chain effects. Evaluation of the surface soil SRCs in **Table 8-3** identified seven COPECs: antimony, cadmium, chromium (as Cr^{+3}), lead, mercury, nitroguanidine, and di-n-butyl phthalate. With the exception of di-n-butyl phthalate and nitroguanidine, the concentrations for all of these chemicals exceeded the applicable ESVs and have HQs greater than 1 and were retained as COPECs for further evaluation in surface soil. Nitroguanidine lacked an ESV, and was conservatively retained as a COPEC. Di-n-butyl phthalate was detected at a concentration below its ESV; however, this chemical is a PBT compound, and its ESV may not be protective of food chain effects. Therefore, it was conservatively retained as a COPEC as well.

8.3.5 Refinement of COPECs (Step 3a)

Of primary importance in an ERA is determining whether any ecological threats exist, and if so, whether they are related to chemical contamination (USACE, 2010c). Prior to making the determination as to whether a Level III Baseline is warranted, it is appropriate to evaluate various lines of evidence that might suggest whether or not additional ecological investigation is needed at Area 2. Although any chemical with an HQ greater than 1 must be identified as a COPEC and is recognized as being a potential concern, if exceedances are low, and other corroborating information suggests that the potential for ecological impacts is minimal, then a recommendation for no additional investigation may be warranted (Ohio EPA, 2008). As a general consideration, it should be noted that HQs are not measures of risk, are not population-based statistics, and are not linearly scaled statistics. Therefore, an HQ above 1, even exceedingly so, does not definitively indicate that there is even one individual expressing the toxicological effect associated with a given chemical to which it was exposed (Tannenbaum, 2005; Bartell, 1996).

This portion of the Level II Screening represents the Step 3a COPEC refinement, where additional factors are considered that offer more information as to whether a chemical is selected as a COPEC during the conservative screening step truly represents an unacceptable risk for ecological receptors. The additional factors to be considered are presented in the

Unified Approach for performing ERAs (USACE, 2011) list of possible evaluation and refinement factors. Some of these factors are discussed in the following paragraphs.

Due to the highly conservative nature of the Level II Screening, the identification of COPECs does not necessarily indicate that the potential for adverse effects is realistic at Area 2. For example, HQs developed during the initial (screening) steps of an ERA typically assume that chemicals are 100 percent bioavailable. Another source of uncertainty in the Level II Screening results from the fact that toxicity studies upon which the benchmark values are based are highly conservative. These studies typically use naïve (i.e., laboratory) organisms comprised of a single genetic strain that have no inherent resistance to chemical insults. Nonlaboratory organisms have both a more diverse genetic makeup and exposure history to ambient levels of chemicals (both natural and anthropogenic in origin) that favor the development of resistances to chemical exposure in nature. Also, toxicity studies usually dose the test organisms with a chemical that is fully bioavailable (i.e., in solution) and use the most toxic chemical form. However, when a chemical is released to the environment, it reacts with other compounds and is affected by ambient conditions that often reduce the chemical's ability to be absorbed by and/or retained in an organism. For example, metals released to terrestrial systems often sorb to the soil matrix, reducing their bioavailability. The form of the chemical may change in the natural environment as well, which often results in the reduction of its toxic properties. For example, under reducing conditions, Cr^{+6} is readily transformed to less toxic Cr^{+3} in soil (however, it should be noted that conversion of a chemical to a more toxic form in the environment is also possible, such as the conversion of inorganic mercury to methyl mercury by microorganisms under certain conditions).

Because of these factors, the correlation between total concentration of a chemical in a given medium and its toxic effect is often quite poor, and predictions regarding potential toxicity of a given chemical from the results of the Level II Screening must be used with caution. Furthermore, the spatial area affected and the magnitude of the HQ exceedance must be taken into account when considering the potential for local populations (rather than individuals) to experience adverse effects, because population-level effects are the endpoints of concern in the ERA (see **Table 8-1**). To account for some of these uncertainties, HQs less than 10 are considered to represent a low potential for environmental effects, HQs from 10 up to but less than 100 are considered to represent a significant potential that effects could result from greater exposure, and HQs greater than 100 represent the highest potential for expected effects (Wentsel et al., 1996). The findings of the Level II Screening are discussed in additional detail in the following paragraphs to support final recommendations for this stage of the ERA process.

Table 8-3
Statistical Summary and Ecological Screening of Surface Soil (0 to 0.5 feet)

Site-Related Chemical	Range of Values, mg/kg						Location of MDC	BSV[1] (mg/kg)	ESV[1] (mg/kg)	Below ESV?	HQ	PBT?[1]	COPEC?[2]
	Detected Concentrations				Reporting Limits								
	Minimum	VQ	Maximum	VQ	Minimum	Maximum							
Explosives and Propellants													
Nitroguanidine	0.18	J	0.28	J	0.25	0.25	RQLss-076(I)	*NA*	NA	NA	NA	No	Yes
Metals													
Antimony	1.3		1.8	J	0.81	0.81	RQLss-075(I)	*0.96*	0.27	No	6.7	No	Yes
Cadmium	0.55		0.65	J	0.041	0.041	RQLss-076(I)	*0*	0.36	No	1.8	Yes	Yes
Chromium (as Cr^{+3})	117	J	165		0.14	0.14	RQLss-075(I)	*17.4*	26	No	6.3	No	Yes
Copper	10.5		23.3		0.41	0.41	RQLss-075(I)	*17.7*	28	Yes	0.8	Yes	No
Lead	18.4		30.5		0.25	0.25	RQLss-075(I)	*26.1*	11	No	2.8	No	Yes
Mercury	0.056		0.063		0.0084	0.0085	RQLss-076(I)	*0.036*	0.00051	No	124	Yes	Yes
Strontium	3.5		3.6		0.081	0.081	RQLss-076(I)	*0*	96	Yes	0.04	No	No
Semivolatile Organic Compounds													
Bis(2-ethylhexyl)phthalate	0.25	J	0.81		0.41	0.41	RQLss-075(I)	*NA*	0.925	Yes	0.9	Yes	No
Di-n-butylphthalate	0.11	J	0.11	J	0.41	0.41	RQLss-076(I)	*NA*	200	Yes	0.0006	Yes	Yes
Fluoranthene	0.032	J	0.032	J	0.12	0.12	RQLss-076(I)	*NA*	29	Yes	0.001	No	No

[1] See screening values in ***Appendix K****.*
[2] Selection of COPECs:
Yes = COPEC exceeds the ESV and BSV, was retained as a COPEC due to lack of an ESV, or is a PBT pollutant whose ESV is not protective of food chain effects.
No = COPEC is not a PBT (or is a PBT, but the ESV is protective of food chain effects) and the MDC is less than the ESV (the HQ did not exceed 1, when rounded).
BSV denotes background screening value.
COPEC denotes chemical of potential ecological concern.
Cr^{+3} denotes trivalent chromium.
ESV denotes ecological screening value.
HQ denotes hazard quotient.
J denotes that the reported result is an estimated value.
MDC denotes maximum detected concentration.
mg/kg denotes milligrams per kilogram.
NA denotes not applicable/available.
PBT denotes persistent, bioaccumulative, and toxic.
SRC denotes site-related chemical.
VQ denotes validation qualifier.

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8.3.5.1 Weight of Evidence Discussion for Surface Soil Samples

Five metals (antimony, cadmium, chromium, lead, and mercury), one explosives and propellant compound (nitroguanidine), and one SVOC (di-n-butyl phthalate) were identified as COPECs in the surface soil samples collected at Area 2 (**Table 8-3**). **Table 8-4** presents the concentrations of all COPECs by individual sample.

Table 8-4
Summary of COPECs in Surface Soil

			Sample Location:	**RQLss-075(I)**		**RQLss-076(I)**	
			Sample Number:	**RQLss-075(I)-0001-SS**		**RQLss-076(I)-0001-SS**	
			Sample Date:	**8/22/2011**		**8/22/2011**	
			Sample Depth (feet bgs):	**0–0.5**		**0–0.5**	
COPEC	**BSV**	**ESV**	**Units**	**Result**	**VQ**	**Result**	**VQ**
Explosives and Propellants							
Nitroguanidine	*NA*	NA	mg/kg	0.18	J	0.28	J
Metals							
Antimony	*0.96*	0.27	mg/kg	***1.8***	***J***	***1.3***	
Cadmium	*0*	0.36	mg/kg	***0.55***		***0.65***	***J***
Chromium (as Cr^{+3})	*17.4*	26	mg/kg	***165***		***117***	***J***
Lead	*26.1*	11	mg/kg	***30.5***		**18.4**	
Mercury	*0.036*	0.00051	mg/kg	***0.056***		***0.063***	
Semivolatile Organic Compounds							
Di-n-butylphthalate	*NA*	200	mg/kg	ND		0.11	J

Detects in bold exceed the ESV; detects in italics exceed the BSV or indicate that a BSV is not available.
bgs denotes below ground surface.
BSV denotes background screening value.
COPEC denotes chemical of potential ecological concern.
ESV denotes ecological screening value.
J denotes that the reported result is an estimated value.
mg/kg denotes milligrams per kilogram.
NA denotes not applicable/available.
ND denotes not detected.
VQ denotes validation qualifier.

Table 8-5 presents the HQs associated with each COPEC in each of the samples.

Table 8-5
Summary of HQs for COPECs in Surface Soil

Sample Location:	RQLss-075(I)	RQLss-076(I)
Sample Number:	**RQLss-075(I)-0001-SS**	**RQLss-076(I)-0001-SS**
Sample Date:	**8/22/2011**	**8/22/2011**
Sample Depth (feet bgs):	**0–0.5**	**0–0.5**
COPEC	**HQ**	**HQ**
Metals		
Antimony	6.7	4.8
Cadmium	1.5	1.8
Chromium (as Cr^{+3})	6.3	4.5
Lead	2.8	1.7
Mercury	**110**	**124**

*Only results that exceed the background and ecological screening values in **Table 8-4** are present.*
Only HQs greater than 1.0 are shown.
Cells in bold exceed an HQ of 10.
Shaded cells exceed an HQ of 100.
bgs denotes below ground surface.
COPEC denotes chemical of potential ecological concern.
HQ denotes hazard quotient.

With the exception of mercury, none of the COPEC HQs exceeded a value of 10. The COPEC with the next highest HQ was antimony with a value of 6.7 (**Table 8-5**). The HQ for mercury was over 100 in both soil samples; however, the concentrations of mercury in these samples only exceeded the metal's BSV by less than a factor of 2. The elevated mercury HQs result from the use of the extremely low ESV of 0.00051 mg/kg that was used in the Level II Screening (**Table 8-3**). This ESV was developed from a study that evaluated the toxicity of mercury in the form of methyl mercury in soil (Efroymson et al., 1997b). Methyl mercury is highly toxic, and is formed in the environment from the methylation of inorganic mercury by microorganisms, which typically occurs only in anaerobic conditions. The soil conditions at the sample locations were not saturated; therefore, it is unlikely that the top 6 inches of soil where the samples were collected were anaerobic, or that the detected mercury in the soil was methylated. If an alternate soil ESV for mercury that is based on inorganic mercury toxicity is used, such as the value of 0.1 mg/kg from the Region 5 ESLs (**Appendix K**), then the HQ for mercury falls below 1. Therefore, in spite of the elevated HQs, the potential for actual adverse impacts associated with exposure to mercury is considered to be low.

Two organic compounds, nitroguanidine and di-n butyl phthalate, were also identified as COPECs. Nitroguanidine was identified as a COPEC because it lacked an ESV. The compound was detected in both ISM samples at concentrations that approximated its reporting limit (**Table 8-3**). Explosives compounds typically are not bioaccumulative, and this chemical was not identified as a PBT compound. Therefore, although the presence of this chemical represents a small uncertainty in this SLERA, nitroguanidine is unlikely to pose a significant threat to ecological receptors. Di-n butyl phthalate was detected at a concentration that is more than three orders of magnitude below its ESV, but it was retained as a COPEC because its ESV may not be protective of potential food chain effects. Di-n butyl phthalate is a PBT compound; however, it was only detected in one of the two sample locations at an estimated (i.e., J-qualified) concentration that was below its reporting limit and was three orders of magnitude below its ESV. Therefore, it is highly unlikely that food chain exposure to this chemical would adversely affect populations of ecological receptors at Area 2.

8.3.6 Level II Screening Conclusion and Recommendations

Several SRCs detected in the surface soil samples collected at the Area 2 section of the Ramsdell Quarry Landfill MRS were present at concentrations that exceed the ESVs (and BSVs in metals) in one or both of the ISM samples. With the exception of mercury, all COPECs had HQs below 10. Although the HQ for mercury was elevated, mercury only marginally exceeded its BSV. The elevated HQ of 124 resulted from the use of an ESV that is based on the toxic properties of methyl mercury, a form of mercury that is unlikely to be present in soil at Area 2 in appreciable quantities. Comparison to an alternate ESV for mercury resulted in HQs less than 1 for both ISM samples.

The two organic chemicals identified as COPECs, nitroguanidine and di-n-butyl phthalate, are unlikely to pose a serious threat to populations of ecological receptors. Nitroguanidine was detected in both ISM samples at low (estimated) concentrations approximating its reporting limit, is not considered bioaccumulative, and was only identified as a COPEC due to a lack of an ESV. Di-n-butyl phthalate, although a bioaccumulative compound, was only detected in one of the two samples at a low (estimated) concentration that was below both its reporting limit and three orders of magnitude below its ESV. Therefore, adverse effects associated with trace concentrations of these two chemicals are considered unlikely.

Based on the evaluation process presented in this ERA and the subsequent weight of evidence discussion, no COPECs were recommended for evaluation in a Level III Baseline for the surface soil samples collected at Area 2. Although some slightly elevated concentrations of metals were detected between the ISM soil samples, and two organic chemicals were initially identified as COPECs, further evaluation suggests that it is highly unlikely that population-level impacts resulting from soil exposure could adversely affect ecological receptors. This was determined since both of the detected values were relatively low and because the small size of the decision unit (approximately 1 acre) precludes regular daily exposure to most motile species that may be present at the MRS. Based on the results of the COPEC evaluation process and the weight of evidence discussion presented herein, no further investigation (i.e., a Level III Baseline) or action was considered to be necessary at the Area 2 section of the Ramsdell Quarry Landfill MRS for ecological purposes.

9.0 REVISED CONCEPTUAL SITE MODELS

This section presents the revised CSMs for MEC and MC at the Ramsdell Quarry Landfill MRS based on the results of the data collected for the RI. The preliminary CSMs for MEC and MC, which were based on previous information provided in the SI Report and the HRR (e^2M, 2007 and 2008), were discussed in Section 2.0, “Project Objectives.” The summary of the RI results were presented in Section 4.0, “Remedial Investigation Results.” Potential human health and environmental risks for the Ramsdell Quarry Landfill MRS were evaluated in Section 7.0, “Human Health Risk Assessment,” and Section 8.0, “Ecological Risk Assessment,” respectively. Following the integration of the RI results into the CSM, the MRSPP was reevaluated to include the results of the RI and are discussed at the end this section.

9.1 MEC Exposure Analysis

This section summarizes the RI data results for the MEC exposure pathway analyses for the Ramsdell Quarry Landfill MRS. As discussed in Section 2.1, 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 (MEC) 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

The Ramsdell Quarry Landfill MRS is comprised of two sections: a northern section (Area 1) and southern section (Area 2). Within Area 1, OB/OD operations took place in an old quarry. Area 1 was initially mined to recover material for roads and construction ballasts. When quarry operations were discontinued in 1941, the excavation was reportedly at a depth of 30 to 40 feet below the current surface. From 1946 to 1950, Area 1 was used to thermally treat waste explosives from Load Line 1. In addition, surface burning was performed on approximately 18,000 500-lb incendiary or napalm bombs. Area 2 contained a small inactive soil borrow pit and wooded area where installation personnel had historically observed MD (e^2M, 2008). It is not known how or why the MD items arrived at Area 2.

The DGM surveys were successfully completed over 4.19 acres between the Area 1 and Area 2 portions of the MRS during the RI. A total of 543 point-source anomalies and 8 trenches at areas of high anomaly density were identified for intrusive investigation at

Area 1. Nearly 100 percent of the selected targets at Area 1 (536 of 543 anomalies) were successfully reacquired; however, only 76 percent of the reacquired targets (410 of 536 anomalies) and 6 of the 8 trenches could be investigated due to the increase in water levels between the reacquisition and intrusive investigation activities. Within Area 2, 558 point-source anomalies were identified for intrusive investigation and 508 anomalies (90 percent) were successfully reacquired and investigated.

No MEC was observed during the intrusive investigations at the MRS. No MD was found at Area 1, however, 187 MD items were found at 161 locations at Area 2. The MD items found consisted of fragments and parts associated with the 20-lb AN-M41 series bomb, the 155mm MK-1 series projectile, the 250-lb AN-M57 series GP bomb, and the 500-lb AN-M64 series GP bomb. Although not considered as MD, small arms ammunition consisting of expended 12-gauge shells was found at three of the target locations. The maximum depth of MD was 24 inches; however, most MD was encountered at depths less than 6 inches. The MD items found were solid and/or inert, and posed no explosives safety hazard.

The underwater tactile investigation was performed in the sediment at the bottom of the Area 1 quarry pond. No MEC or MD was found during the underwater investigation activities in the quarry pond.

9.1.2 Activity

Activity describes ways that receptors come into contact with a source. Current activities at Area 1 include inspections, maintenance, sampling and remedial activities, and natural resource management activities. Current activities at Area 2 include military training and natural resource management activities. The future land use of Area 1 is anticipated to remain the same as the current use (restricted access). The future land use of Area 2 is military training. Biota activities at the MRS may include foot traffic or burrowing activities.

9.1.3 Access

Access is the degree to which a MEC source or environment containing MEC is available to potential receptors. Once on the facility, there are no physical barriers or signs to prevent or warn receptors from accessing the MRS. Once on the MRS, receptors would have access to any MEC on the surface. Future access to this MRS is expected to remain similar to current access conditions; however, Area 2 will likely have increased traffic/access due to the future land use.

9.1.4 Receptors

A receptor is an organism (human or ecological) that comes into physical contact with MEC. Human receptors identified for the Ramsdell Quarry Landfill MRS include both current and anticipated future land users. Ecological receptors (biota) are based on animal species that are likely to occur in the terrestrial habitats at the MRS. The primary MRS-specific biota identified for the MRS include terrestrial invertebrates (earthworms), voles, shrews, robins, foxes, barn owls, hawks, muskrat, mink, mallards, great blue heron, benthic invertebrates, and aquatic biota (USACE, 2003c).

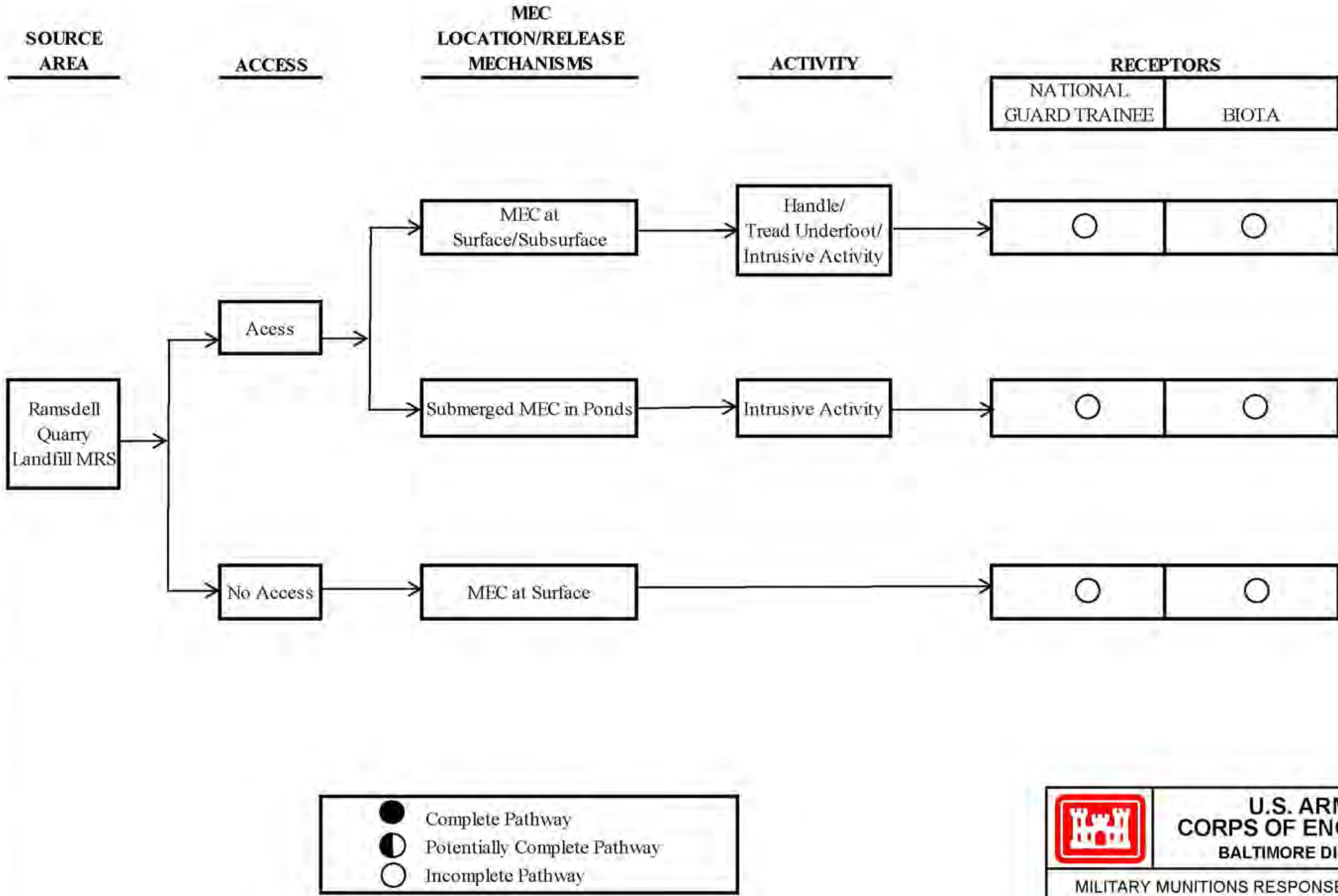
Potential users associated with the current activities at the MRS include facility personnel, contractors, and potential trespassers (e^2M, 2008). The Representative Receptor for the future land use at Area 1 is the Security Guard/Maintenance Worker. The Representative Receptor for the future land use at Area 2 is the National Guard Trainee (Shaw, 2011).

9.1.5 MEC Exposure Conclusions

The information collected during the RI was used to update the preliminary MEC CSM for the Ramsdell Quarry Landfill MRS and to identify all complete, potentially complete, or incomplete source-receptor interactions for the MRS for current and anticipated future land uses. Evaluation of the end use receptors for future land use in the revised CSM is consistent with the facility HHRA approach (USACE, 2005). The revised MEC Exposure Pathway Analysis is presented as **Figure 9-1**.

A statistical approach using the UXO Estimator® module was taken for the characterization of MEC at the Ramsdell Quarry Landfill MRS and portions of the MRS were investigated by visual survey, DGM survey, and intrusive investigation to provide a statistical confidence for the proportion of MEC to non-MEC related material. The agreed upon inputs into the module was 95-percent confidence and 0.5 MEC per acre assuming 100 percent of identified targets are investigated. In actuality, not all of the selected targets were successfully investigated. At Area 1, nearly 100 percent of the selected targets were successfully reacquired; however, only 76 percent of the reacquired targets could be investigated due to the increase in water levels between the reacquisition and intrusive investigation activities. At Area 2, 90 percent of the selected targets were successfully reacquired and investigated. No MEC was encountered at the MRS during the intrusive investigation activities; however, 187 MD items were confirmed to be present either on the ground surface or in the subsurface at Area 2. The MD items were solid and/or inert, and posed no explosives safety hazards. An underwater tactile investigation was also performed at the quarry pond in Area 1 and no evidence of MEC or MD was found.

Based on the results of the RI field investigation, the use or introduction of munitions at the MRS is confirmed. However, since no MEC was found during the RI field work, the calculated MEC density met the target density of 0.5 MEC per acre at a 95-percent confidence level and indicates that the performance criteria were achieved. Statistically, there is a potential for remaining MEC since not all of the target anomalies were successfully investigated; however, the uncertainty is low since no MEC was found during the field work.



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MILITARY MUNITIONS RESPONSE PROGRAM

RAMSDELL QUARRY LANDFILL MRS
FORMER RVAAP/CAMP RAVENNA
PORTAGE AND TRUMBULL COUNTIES, OHIO

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

FIGURE 9-1 REVISED MEC CONCEPTUAL SITE MODEL

Because no direct evidence of an explosive hazard exists, the pathways for MEC were considered incomplete for the Ramsdell Quarry Landfill MRS.

9.2 MC Exposure Analysis

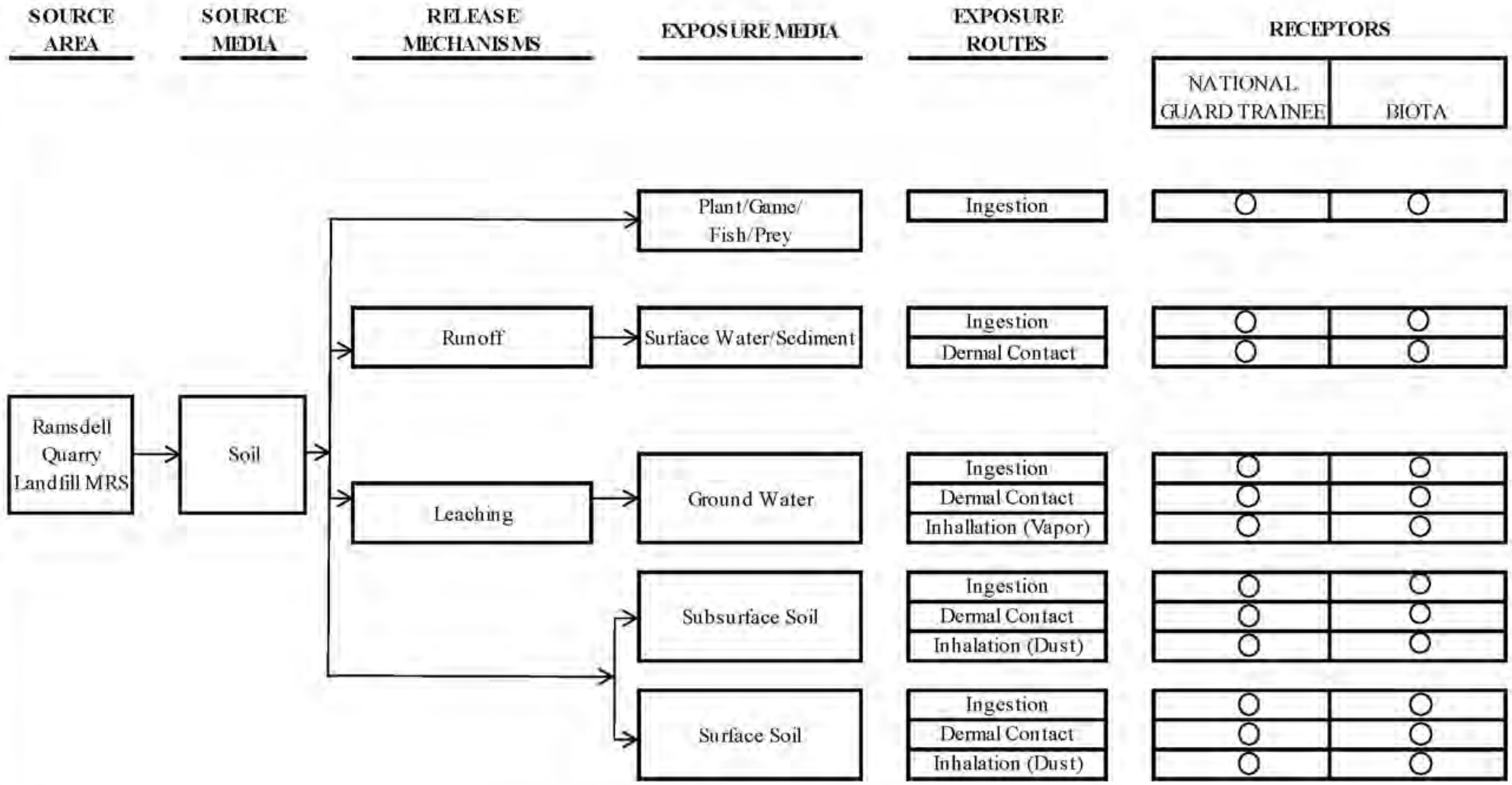
MC is defined as any material originating from MPPEH or munitions, or other military munitions including explosive and nonexplosive material, and emission degradation, or breakdown elements of such ordnance and munitions (10 USC 2710(e)(4)). The information collected during the RI was used to update 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 revised MC exposure pathway analysis for the Ramsdell Quarry Landfill MRS is presented in **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 anticipated MC source at the Ramsdell Quarry Landfill MRS was the OB/OD activities in Area 1 and the disposal of MD in Area 2. These activities resulted in the potential for MC to have leached directly to surrounding soil, resulting in a point-source for potential migration of MC. Any MC distributed to surface soil may have since leached to subsurface soil, sediment, surface water, and groundwater.

The determinations as to whether MC characterization was required at the Area 1 and Area 2 portions of the MRS were made based on the recommendations made in the SI Report (e^2M, 2008), historical activities that occurred at the MRS, and the results of the RI intrusive investigation. The DQOs stated that ISM samples and/or discrete samples (surface and subsurface soil) may be collected in areas with concentrated MEC or MD (Shaw, 2011). Areas of concentrated MD were encountered during the intrusive investigation activities at Area 2 and two ISM surface soil samples were collected. No MEC or MD was found at Area 1; therefore, no samples were collected at this section of the MRS.

The detected chemicals were evaluated in accordance with the data use evaluation process to identify SRCs. A total of 11 SRCs were identified in the ISM surface soil samples that are considered as MC associated with the historical disposal and OB/OD activities that occurred at the MRS.

An HHRA was conducted for the surface soil samples to determine if the identified SRCs were COPCs and COCs that may pose a risk to human receptors. The evaluation of the receptor for military training at Area 2, in conjunction with the evaluation of the Resident Receptor (Adult and Child) for Unrestricted Land Use, form the basis for identifying COCs in the RI. Evaluation for Unrestricted Land Use is performed to assess for baseline



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

- ● Complete Pathway
- ◐ Potentially Complete Pathway
- ○ Incomplete Pathway

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FIGURE 9-2 REVISED MC CONCEPTUAL SITE MODEL

conditions and the no action alternative under CERCLA, and as outlined in the HHRAM (USACE, 2005). For Area 2, the National Guard Trainee—the most stringent OHARNG receptor—and the Resident Receptor (Adult and Child) were considered for COPC evaluation. No COPCs were identified through this process and no further evaluation of COCs was conducted.

An ERA was completed for the surface soil samples to evaluate for COPECs that may pose a risk to the ecological receptors. Based on the COPEC evaluation process presented in the ERA and the subsequent weight of evidence discussion, no COPECs were recommended for evaluation in a Level III Baseline for the surface soil samples collected at Area 2.

The HHRA and ERA determined that the detected SRCs in surface soil at Area 2 are not present at concentrations great enough to pose risks to the human and ecological receptors. For the development of the MC CSM in Area 1, the findings of no MEC, MPPEH, or even MD that would be indicative of a MC source are taken into consideration. Low concentrations of explosives were detected in surface soil and dry sediment at Area 1 under the IRP; however, the only COCs identified for human receptors at Area 1 during previous investigations under the IRP were SVOCs. It is possible that the SVOCs originated from the historical OB/OD activities that occurred at Area 1; however, there is no evidence to suggest that they originated solely from these activities. Additionally, the U.S. Army has determined that the SVOCs identified as COCs in surface soil and dry sediment at Area 1 will continue to be addressed under the IRP. Therefore, there is no known or suspected MC hazard at the MRS and the CSM for MC has been updated to reflect incomplete pathways for all human and ecological receptors.

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 significant impact from a MEC source. A MEC source was not found during the RI field activities; however, various MD items were encountered in the surface and subsurface soil. Although SRCs were detected in environmental media that was sampled during the RI field work, evaluation for fate and transport of the chemicals indicates that that groundwater has likely not been impacted from past munitions-related activities at the MRS. Additionally, it is not expected that the human or ecological receptors will come into contact with groundwater at the MRS. No groundwater samples were collected at the Ramsdell Quarry Landfill MRS during the RI field work and the MC exposure pathway for groundwater was considered incomplete for all receptors.

9.3 Uncertainties

The purpose of the DQO process is to adequately characterize and define hazards/risks posed by the MRS; however, the process does not remove all uncertainty associated with the MRS.

There are minimal levels of uncertainties associated with the RI results at the Ramsdell Quarry Landfill MRS, which are presented in this section.

The primary uncertainty related to the evaluation of the RI results at the Ramsdell Quarry Landfill MRS is associated with the lack of information of the historical operations at Area 2. Review of the HRR (e^2M, 2007) indicates that no information can be found regarding the historical activities conducted at this portion of the MRS and the reason why there is MD present at Area 2 is unknown. It was theorized in the SI Report that OB/OD activities may have been conducted in the former soil borrow pit at Area 2 and the MD in the surrounding area was the result of kick-out (e^2M, 2008). This concept is unlikely since MD was found outside the former borrow pit as deep as 24 inches during the RI field activities and miscellaneous other debris was found as deep as 48 inches which is not indicative of kick-out. Based on the findings of the RI field activities, the most likely scenario is that this portion of the MRS was used as a disposal area for the munitions that were thermally treated at Area 1 along with other debris. It is noted that there is no direct evidence to support this possible explanation. No MEC was found during the RI or any of the previous investigations at the MRS and the findings of only MD at Area 2 suggest that only nonexplosive items were disposed at this portion of the MRS.

Uncertainties also exist with regards to the statistical investigation approach utilized for the RI. The DGM survey coverage for the RI was designed based on the UXO Estimator® module that at a 95-percent confidence level, a minimum MEC density of 0.5 MEC per acre was expected to be found at the MRS. The UXO Estimator® module calculated the statistical upper bound density of MEC to be 0.5 MEC per acre at a 95-percent confidence level based on actual field results. Since not all of the target anomalies were successfully investigated during the RI field work, it is statistically possible that MEC may be present at the MRS even though confirmed discoveries have not been made to date. However, since no MEC was discovered during the RI field activities, the uncertainty that MEC is present at the MRS is greatly reduced.

There is uncertainty and limitations associated with the lateral extent of the MD that was found in Area 2. The northern boundary of Area 2 is considered to be defined due to the presence of a topographically lower former rail bed that bisects Area 2 and the closed landfill and there have been no reports of MD along the rail bed. The southwest portion of Area 2 is bound by the existing Load Line 1 fence line that was historically present when activities occurred at the Ramsdell Quarry. The east side of Area 2 is bound by the former soil borrow pit with exposed bedrock and it is improbable that there is extensive buried MD at this area (e^2M, 2008). The intrusive investigation activities were conducted at the grid locations within Area 2 where the DGM activities were completed, and approximate 100-foot Schonstedt-assisted step outs were completed to the west and south of the grids where MD was encountered within 100 feet of the Area 2 boundary (Grids D01, D06, D07, D08, D09, E08, and E09). Miscellaneous metal debris was encountered on or just below the ground surface during the step-out activities; however, no MEC or MD was found. Additionally, no MEC or MD was found during the intrusive investigations at Grids E10 and E11 that are situated along the southwest boundary of Area 2. Based on the results of the intrusive investigation, the results of the Schonstedt-assisted step-out activities along the Area 2 west and south boundaries, and the presence of the cultural features that surround Area 2, it appears that the concentration of MD items at Area 2 have been bound. It is possible that the lateral extent of MD at Area 2 is underestimated; however, the most prevalent concentrations of MD appear to be at the central portion of Area 2 and the uncertainties are minimal.

Finally, there are uncertainties as to whether the detected SRCs in the surface soil at Area 2 are actually MC associated with historical munitions activities at the MRS. It cannot be definitively stated that the detected chemicals are not MC as they are considered to be chemicals that are attributed with the munitions used and/or disposed at the MRS. Additionally, the detected SRCs are primarily metals and SVOCs that do not readily degrade or mobilize easily even decades after activities have ceased. With the exception for the low concentrations of nitroguanidine that may be naturally occurring, no explosives or propellants were detected in the surface soil samples, no MEC or evidence of the historical OB/OD activities was found during the RI activities, and the MD items found were solid and/or inert and posed no explosives safety hazard. The results of the RI field work indicate that there is no MEC or enough MD that would result in MC leaching to the surrounding environment. Therefore, the uncertainty is reduced that the detected are SRCs are actual MC associated with the historical munitions-related activities at the MRS.

9.4 Munitions Response Site Prioritization Protocol

The DoD proposed the MRSPP (32 CFR 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 CFR 179.3]). The MRSPP tables were updated/created in accordance with the *Munitions Response Site Prioritization Protocol Primer* (DoD, 2007).

Based on the results of the RI field work and the relative risk priorities considered for each of the areas investigated at the MRS, separate MRSPPs have been prepared for Area 1 and Area 2. No MEC or MC hazards were identified at the Area 1 portion of the MRS during the RI field work, and further evaluation for MEC and MC concerns at Area 1 is no longer required. Therefore, a separate MRSPP has been prepared for Area 1 to assist in administratively closing out the acreage at this portion of the MRS. A low relative risk priority has been assigned to the Area 2 portion of the MRS based on the MD found and the potential for remaining MEC. The revised MRSPP documents for the Area 1 and Area 2 sections of the Ramsdell Quarry Landfill MRS are included in **Appendix L** for reference only.

10.0 SUMMARY AND CONCLUSIONS

This section summarizes the results of the RI field activities conducted at the Ramsdell Quarry Landfill MRS. The purpose of the RI was to determine whether the Ramsdell Quarry Landfill 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 potential MEC hazards and MC risks posed to the human and environmental receptors. Additional data was also presented in this RI Report to support the identification and evaluation of alternatives in a Feasibility Study, if required. A summary of the RI results for the Ramsdell Quarry Landfill MRS is presented in **Table 10-1**.

Table 10-1
Summary of Remedial Investigation Results

MRS Name	Proposed Investigation Area (Acres)	Actual Area Investigated (Acres)	MEC and/or MD Found?	MC Identified?	MC Risk Analysis
Ramsdell Quarry Landfill	4.16	4.19	MD at Area 2	No	No Further Action

MC denotes munitions constituents.
MD denotes munitions debris.
MEC denotes munitions and explosives of concern.
MRS denotes Munitions Response Site.

10.1 Summary of Remedial Investigation Activities

The information available for the Ramsdell Quarry Landfill MRS relating to the potential presence of MEC and MC was compiled and evaluated in this RI Report. The sources of this information were obtained from previous investigations and historical records including the ASR (USACE, 2004), the HRR (e^{2}M, 2007), and the SI Report (e^{2}M, 2008).

The preliminary MEC and MC CSMs for the MRS were developed during the SI (e^{2}M, 2008) phase of the CERCLA process and were used to identify the data needs and DQOs outlined in the Work Plan (Shaw, 2011). The data needs and DQOs for the MRS were determined at the planning stage and included characterization of MEC and MC associated with former 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. The DQOs identified the following decision rules that were implemented in evaluating the Ramsdell Quarry Landfill MRS:

- Perform a DGM investigation to identify if significant areas of buried anomalies were present at the MRS.
- Perform an intrusive investigation of anomalies identified during the geophysical investigation to evaluate if MEC/MD were present at the MRS.
- Perform and underwater investigation to identify if MEC/MD items were present in the sediment in the saturated areas at the MRS.
- Collect additional ISM or discrete soil samples if concentrated MEC/MD items were identified during the target anomaly investigation at the terrestrial portions of the MRS.
- Process the information to evaluate whether there were unacceptable risks to human and the ecological receptors associated with MEC/MC and make a determination if further investigation was required under the CERCLA process.

10.1.1 Geophysical Investigation

From May through August of 2011, a DGM investigation was performed at the Ramsdell Quarry Landfill MRS to identify potential subsurface areas of MEC and/or MD. The DGM data were collected in all accessible areas within the MRS and the spatial coverage was calculated to be 4.19 acres. This represents area coverage of 35 percent and exceeded the proposed sampling coverage of 4.16 acres presented in the Work Plan (Shaw, 2011). Within Area 1, the DGM data were acquired over transects spaced approximately 3 meters (10 feet) apart over the land-based areas and shallow surface water areas which resulted in a spatial coverage of 2.05 acres. Within Area 2, approximately 2.14 acres of DGM data were acquired over six 0.25-acre grids and portions of thirteen 0.25-acre grids.

Interpretation of the geophysical data indicated that the anomaly density at Area 1 was saturated along the along the west and east portions and towards the center of the MRS that were saturated with water. The area of highest anomaly densities was at the east side of Area 1. Regions that exhibited relatively low densities were also present within Area 1, particularly at the northern portion of Area 1. At Area 1, 595 anomalies with signal intensities greater than 4 mV on Channel 2 were identified for potential intrusive investigation.

The anomaly density at Area 2 was found to be relatively low and distributed throughout the area; however, highly saturated linear target features were identified near the northwest corner and the southern portions of Area 2 that were believed to be a cultural features (i.e., utility lines). A total of 558 anomalies with signal intensities greater than 4 mV were identified for potential intrusive investigation at Area 2.

10.1.2 Anomaly Selection

Distinct zones of localized high anomaly density along the edges of Area 1 were identified during the DGM investigation, and eight trenches were proposed for intrusive investigation. No areas of high anomaly density were identified at Area 2 that required investigation using the trenching methodology.

In Area 2, 100 percent of the 558 individual target anomalies at signal intensities greater than the 4-mV threshold were selected for intrusive investigation since less than full DGM coverage was completed for this area. The anomaly selection criterion of 4 mV was in accordance with the Work Plan (Shaw, 2011). Additionally, the linear features at Area 2 were selected for intrusive investigation based on recommendations made by the USACE.

In Area 1, 595 anomalies were identified as potential targets for intrusive investigation per the anomaly selection criteria presented in the Work Plan (Shaw, 2011). Intrusive activities at Area 2 were completed prior to the anomaly selection process for Area 1 and the results indicated that nearly 30 percent of the anomalies at signal intensities less than 5 mV were "no finds." Based on the results of the Area 2 intrusive investigation, as well as the results of the IVS installed at Load Line 7 where smaller MEC items in the near-surface produced responses exceeding 8 mV (Channel 2), it was proposed to investigate 100 percent of anomalies greater than or equal to 8 mV (491 anomalies) and to randomly select and investigate 50 percent of the anomalies between 4 and 8 mV (52 anomalies). In all, of 543 anomalies were selected for intrusive investigation in Area 1. It was proposed that if any MEC/MD items were identified from the 52 randomly selected anomalies below 8 mV, then the remaining 50 percent of anomalies in Area 1 would be investigated.

10.1.3 Intrusive Investigations

Anomaly reacquisition and intrusive investigation activities for Area 2 were performed between July and August 2011. Within Area 2, 565 individual anomalies were selected for the intrusive investigation and 508 anomalies (90 percent) were successfully reacquired. The findings of the intrusive investigation resulted in no MEC; however, 187 MD items were found at 161 locations. The MD items found consisted of fragments and parts associated with the 20-lb AN-M41 series bomb, the 155mm MK-1 series projectile, the 250-lb AN-M57 series GP bomb, and the 500-lb AN-M64 series GP bomb. Although not considered as MD, small arms ammunition consisting of expended 12-gauge shells was found at three of the target locations. The maximum depth of MD was 24 inches; however, most MD was encountered at depths less than 6 inches. In all, 635 lbs of MD was found during the intrusive investigation activities at Area 2. The remaining target locations consisted primarily of "Other Debris" at depths between the ground surface to a maximum depth of 48 inches. The "Other Debris" consisted of materials such as wire, pipes, nails, bolts, cables, remnants of rusted drums, slag (i.e., hot rocks), and miscellaneous scrap metal items. The combined total weight of the "Other Debris" at Area 2 was approximately 300 lbs.

Anomaly reacquisition activities were conducted at Area 1 in November 2011 and 536 of the 543 point-source anomalies identified for intrusive investigation were successfully reacquired (98.7 percent). The intrusive investigation activities were delayed at Area 1 until adequate investigation controls and procedures associated with the potential for encountering buried ACM were approved by the Army. The intrusive investigation activities at Area 1 commenced in August 2013; however, the water levels in the quarry pond had increased significantly since the November 2011 reacquisition activities and only 410 of the reacquired 536 point-source anomaly locations (76 percent) and 6 of the 8 trenches at the areas of high anomaly density were successfully investigated. No MEC or MD was identified at any of the trenches or the individual target anomaly locations that were successfully investigated. Approximately 3,499 lbs of "Other Debris" items that consisted primarily of miscellaneous scrap metal and iron were identified between the investigated trench locations and the individual point-source anomaly locations. The maximum depth of the intrusive investigations at any of the target locations at Area 1 was approximately 5 feet bgs.

10.1.4 Underwater Investigation

On August 6, 2011, former Navy EOD divers performed an underwater investigation for potential MEC over the bottom of the Area 1 quarry pond that covered approximately 1 acre. The underwater investigation identified small quantities of metallic debris; however, no evidence of MEC or MD was found. The metal debris in the ponds consisted primarily of construction debris and miscellaneous scrap metal and iron. Most of the debris was encountered in the sediment along the southeast portion of the ponded area and is consistent with the high anomaly density areas at the land-based area at this portion of Area 1 that were intrusively investigated during the RI field activities.

10.1.5 MC Sampling

The determinations as to whether MC characterization was required at the Area 1 and Area 2 portions of the MRS were made based on the recommendations made in the SI Report (e^2M, 2008), historical activities that occurred at the MRS, the types of munitions that may have been treated/disposed at the MRS, and the results of the RI intrusive investigation. The DQOs stated that samples may be collected at the MRS in surface and/or subsurface soil using the ISM and/or discrete methods where concentrated MEC or MD was found, if any (Shaw, 2011). Areas of concentrated MD were encountered during the intrusive investigation activities at Area 2, and two ISM surface soil samples were collected at locations that were biased to where MC would be expected to be found. The ISM soil samples were collected at same sized sampling units (0.46 acres each) and at the same depth interval (0 to 0.5 feet).

The sampling units were combined to make up the decision unit for surface soil at the Area 2 section of the Ramsdell Quarry Landfill MRS. No MEC or MD was found at Area 1 during the RI field work; therefore, no samples were required to be collected for MC characterization at this portion of the MRS.

10.2 Nature and Extent of SRCs

The SRCs were determined for the surface soil samples collected at the Area 2 section of the Ramsdell Quarry Landfill MRS during the RI field activities through the data screening process as presented in the USACE Position Paper (USACE, 2012). The surface soil samples were analyzed for the identified MC associated with historical munitions-related activities at the MRS that included metals (aluminum, antimony, barium, cadmium, chromium [total and Cr^{+6}], copper, iron, lead, mercury, strontium, and zinc), explosives, nitrocellulose, SVOCs, PCBs, TOC and pH. The detected chemicals that were retained as SRCs in the surface soil samples following the screening process included the following:

- *Explosives and Propellants*: nitroguanidine
- *Metals*: antimony, cadmium, chromium, chromium (as Cr^{+3}), copper, lead, mercury, and strontium
- *SVOCs:* bis(2-ethylhexyl)phthalate, di-n-butyl phthalate, and fluoranthene

No PCBs were detected in the subsurface soil samples. The identified SRCs were then carried through the HHRA and the ERA processes to evaluate for potential receptors.

10.3 Fate and Transport of MEC and MC

Transport of MEC at a 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. No MEC was found at the Ramsdell Quarry Landfill MRS during the RI field activities; however, numerous MD items were encountered on the ground surface and at various depths to a maximum depth of 2 feet bgs at the Area 2 portion of the MRS. It was apparent from the corroded conditions of the MD items encountered during the RI field activities, that many of the MD items appeared to have succumbed to oxidation caused by exposure to water and air, which may have released MC to the environment.

The areas where any MEC is encountered become the points of potential direct contact exposure to the personnel engaged in the various activities. The future land use at the Area 2 portion of the MRS is military training under which intrusive activities may occur. As a result, there is a potential for human activities to expose receptors to subsurface MEC that may remain at the MRS. The future land use at Area 1 is expected to continue to be managed as an "Authorized Access" area. No MD was encountered during the RI field activities at this portion of the MRS and the likelihood of encountering MEC at Area 1 is considered to be low.

With the exception for the soil borrow pit at the eastern portion of Area 2, the extent of ground disturbance where the concentrated areas of MD were found during the RI field activities is not known. The native soils at Area 2 consist primarily of the Mitiwanga silt loam that has moderately slow permeability and slow runoff (USDA et al., 1978). Bedrock is typically found at depths less than 5 feet in this soil type and evidence of exposed bedrock is present in Area 2 at the former soil borrow pit. Based on the local topography, some of the precipitation falling as rainfall and snow likely leaves Area 2 as surface runoff or drains to the former soil borrow pit or the small wetland area at the eastern portion of Area 2. The precipitation that does not leave Area 2 as surface runoff infiltrates into the subsurface. Some of the infiltrating water is lost to the atmosphere as evapotranspiration. The remainder of the infiltrating water recharges the groundwater. The rate of infiltration and eventual recharge of the groundwater is controlled by soil cover, ground slope, saturated hydraulic conductivity of the soil, and meteorological conditions throughout Area 2.

Of the SRCs detected in soils at Area 2, nitroguanidine is generally considered to have the highest mobility in soil. Nitroguanidine was retained as a SRC since it was a detected explosive analyte; however, the detected concentrations were low (estimated) values. The detected SVOCs are anticipated to sorb to soils based on the K_{oc} values (i.e., have the tendency to be sorbed to the organic fraction of soil) and are not expected to leach into surface water runoff or migrate through the soil column. Based on the detected results, significant sources of explosives and SVOCs were most likely not released during previous activities at Area 2.

The inorganic SRCs have a tendency to sorb to soil at a pH of 4 or greater depending on the specific analyte. Although the inorganics were detected, the site-specific pH for Area 2 is greater than 5, indicating that these inorganic SRCs would be expected to be found in the general location where they were released, with only limited downward or overland migration.

The depth to groundwater at the MRS ranges between 0 to 39.5 feet bgs, and typically surface water and groundwater interact at the saturated portions of Area 1, which is significantly lower than the surrounding landfill areas. Depth to groundwater is consistently deeper at approximately 30 feet bgs at Area 2. Evaluation of the groundwater beneath the

Ramsdell Quarry Landfill MRS is included as part of the facility-wide groundwater monitoring program and three well locations are RCRA wells that are required for monitoring of the regulated closed landfill. Based on the evaluation of the most recent groundwater sampling events at the MRS, it appears that SRCs identified in surface soil have not migrated to shallow groundwater in bedrock (EQM, 2012).

In summary, the soil conditions and shallow bedrock at Area 2 limit downward or overland migration of inorganics and SVOCs. The dense vegetation conditions at Area 2 are also a limiting factor for overland migration of both MEC and MC. Detected metals and SVOCs are expected to remain in the top several inches of soil on the ground surface or in subsurface soils beneath concentrated areas of buried MEC or MD where they were released. Nitroguanidine is an explosive that is considered relatively mobile in soil; however, the concentrations are either naturally occurring or significant concentrations were not released in surface soils as a result of historical activities at Area 2. Evaluation of available information for groundwater indicates that groundwater at the MRS has not been significantly impacted. Groundwater at the MRS will continue to be monitored under the RCRA requirements for the closed landfill and the facility-wide groundwater monitoring program.

10.4 MEC Hazard Assessment

The MEC HA guidance (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 the RI, the MEC HA evaluation would 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 was found at the MRS, then there would be no need to calculate a MEC HA score since there were no human health safety concerns. These results of the RI field work indicated that no MEC source or explosive safety hazard was present at the MRS. Therefore; calculation of a MEC HA was not warranted for the Ramsdell Quarry Landfill MRS.

10.5 MC Risk Assessment Summary

Following the identification of the SRCs at the Ramsdell Quarry Landfill MRS through the data screening process, the SRCs were then carried through the HHRA and ERA processes to evaluate for potential receptors. The risk assessments resulted in the following conclusions.

10.5.1 Human Health Risk Assessment

An HHRA was conducted for the surface soil samples that were collected at the Area 2 portion of the Ramsdell Quarry Landfill MRS to determine if the SRCs identified were

COCs that may pose a risk to current or future human receptors. The future land use at Area 2 is military training, and the Representative Receptor is the National Guard Trainee. The evaluation of the receptor for military training, in conjunction with the evaluation of the Resident Receptor (Adult and Child) for Unrestricted Land Use, form the basis for identifying COCs in the RI. Evaluation for Unrestricted Land Use is performed to assess for baseline conditions and the no action alternative under CERCLA, and as outlined in the HHRAM (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.

10.5.2 Ecological Risk Assessment

An ERA was completed for the surface soil samples collected at Area 2 to evaluate for COPECs that may pose a risk to the ecological receptors. Seven COPECs were identified in the surface soil samples: five metals (antimony, cadmium, chromium [as Cr^{+3}], lead, and mercury), one propellant consisting of nitroguanidine, and one SVOC consisting of di-n-butyl phthalate. Based on the COPEC evaluation process presented in the ERA and the subsequent weight of evidence discussion, no COPECs were recommended for evaluation in a Level III Baseline for the surface soil samples collected at Area 2.

10.6 Conceptual Site Models

The information collected during the RI field activities were used to update the CSMs for MEC and MC for the Ramsdell Quarry Landfill MRS as presented in the SI Report (e^2M, 2008). The purpose of a CSM is to identify all complete, potentially complete, or incomplete source-receptor interactions for current and 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.

10.6.1 MEC Exposure Analysis

A statistical approach using the UXO Estimator® module was taken for the characterization of MEC at the Ramsdell Quarry Landfill MRS and portions of the MRS were investigated by visual survey, DGM survey, and intrusive investigation to provide a statistical confidence for the proportion of MEC to non-MEC related material. The agreed upon inputs into the module was 95-percent confidence and 0.5 MEC per acre assuming 100 percent of identified targets are investigated. In actuality, not all of the selected targets were successfully investigated. At Area 1, nearly 100 percent of the selected targets were successfully reacquired; however, only 76 percent of the reacquired targets could be investigated due to the increase in water levels between the reacquisition and intrusive investigation activities. At Area 2, 90 percent of the selected targets were successfully reacquired and investigated. No MEC was encountered at the MRS during the intrusive investigation activities; however, 187 MD items were confirmed to be present either on the ground surface or in the subsurface at Area 2. The MD items were solid and/or inert, and posed no explosives safety hazards. An underwater tactile investigation was also performed at the quarry pond in Area 1 and no evidence of MEC or MD was found.

Based on the results of the RI field investigation, the use or introduction of munitions at the MRS is confirmed. However, since no MEC was found during the RI field work, the calculated MEC density met the target density of 0.5 MEC per acre at a 95-percent confidence level and indicates that the performance criteria were achieved. Statistically, there is a potential for remaining MEC since not all of the target anomalies were successfully investigated; however, the uncertainty is low since no MEC was found during the field work. Because no direct evidence of an explosive hazard exists, the pathways for MEC were considered incomplete for the Ramsdell Quarry Landfill MRS.

10.6.2 MC Exposure Analysis

The HHRA and ERA determined that the detected SRCs in surface soil at Area 2 are not present at concentrations great enough to pose risks to the human and ecological receptors. For the development of the MC CSM in Area 1, the findings of no MEC, MPPEH, or even MD that would be indicative of a MC source, are taken into consideration. Low concentrations of explosives were detected in surface soil and dry sediment at Area 1 under the IRP; however, the only COCs identified for human receptors at Area 1 during previous investigations under the IRP were SVOCs. It is possible that the SVOCs originated from the historical OB/OD activities that occurred at Area 1; however, there is no evidence to suggest that they originated solely from these activities. Additionally, the U.S. Army has determined that the SVOCs identified as COCs in surface soil and dry sediment at Area 1 will continue to be addressed under the IRP. Therefore, there is no known or suspected MC hazard at the MRS and the CSM for MC has been updated to reflect incomplete pathways for all human and ecological receptors.

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 significant impact from a MEC source. A MEC source was not found during the RI field activities; however, various MD items were encountered in the surface and subsurface soil. Although SRCs were detected in environmental media that was sampled during the RI field work, evaluation for fate and transport of the chemicals indicates that that groundwater has likely not been impacted from past munitions-related activities at the MRS. Additionally, it is not expected that the human or ecological receptors will come into contact with groundwater at the MRS. No groundwater samples were collected at the Ramsdell Quarry

Landfill MRS during the RI field work and the MC exposure pathway for groundwater was considered incomplete for all receptors.

10.7 Uncertainties

The primary uncertainty related to the evaluation of the RI results at the Ramsdell Quarry Landfill MRS is associated with the lack of information of the historical operations at Area 2. Review of the HRR (e^2M, 2007) indicates that no information can be found regarding the historical activities conducted at this portion of the MRS and the reason why there is MD present at Area 2 is unknown. It was theorized in the SI Report that OB/OD activities may have been conducted in the former soil borrow pit at Area 2 and the MD in the surrounding area was the result of kick-out (e^2M, 2008). This concept is unlikely since MD was found outside the former borrow pit as deep as 24 inches during the RI field activities and miscellaneous other debris was found as deep as 48 inches which is not indicative of kick-out. Based on the findings of the RI field activities, the most likely scenario is that this portion of the MRS was used as a disposal area for the munitions that were thermally treated at Area 1 along with other debris. It is noted that there is no direct evidence to support this assertion. No MEC was found during the RI or any of the previous investigations at the MRS and the findings of only MD at Area 2 suggest that only nonexplosive items were disposed at this portion of the MRS.

Uncertainties also exist with regards to the statistical investigation approach utilized for the RI. The DGM survey coverage for the RI was designed based on the UXO Estimator® module that at a 95-percent confidence level, a minimum MEC density of 0.5 MEC per acre was expected to be found at the MRS. The UXO Estimator® module calculated the statistical upper bound density of MEC to be 0.5 MEC per acre at a 95-percent confidence level based on actual field results. Since not all of the target anomalies were successfully investigated during the RI field work, it is statistically possible that MEC may be present at the MRS even though confirmed discoveries have not been made to date. However, since no MEC was discovered during the RI field activities, the uncertainty that MEC is present at the MRS is greatly reduced.

There is uncertainty and limitations associated with the lateral extent of the MD that was found in Area 2. The northern boundary of Area 2 is considered to be defined due to the presence of a topographically lower former rail bed that bisects Area 2 and the closed landfill and there have been no reports of MD along the rail bed. The southwest portion of Area 2 is bound by the existing Load Line 1 fence line that was historically present when activities occurred at the Ramsdell Quarry. The east side of Area 2 is bound by the former soil borrow pit with exposed bedrock and it is improbable that there is extensive buried MD at this area (e^2M, 2008). The intrusive investigation activities were conducted at the grid locations within

Area 2 where the DGM activities were completed, and approximate 100-foot Schonstedt-assisted step outs were completed to the west and south of the grids where MD was encountered within 100 feet of the Area 2 boundary (Grids D01, D06, D07, D08, D09, E08, and E09). Miscellaneous metal debris was encountered on or just below the ground surface during the step-out activities; however, no MEC or MD was found. Additionally, no MEC or MD was found during the intrusive investigations at Grids E10 and E11 that are situated along the southwest boundary of Area 2. Based on the results of the intrusive investigation, the results of the Schonstedt-assisted step-out activities along the Area 2 west and south boundaries, and the presence of the cultural features that surround Area 2, it appears that the concentration of MD items at Area 2 have been bound. It is possible that the lateral extent of MD at Area 2 is underestimated; however, the most prevalent concentrations of MD appear to be at the central portion of Area 2 and the uncertainties are minimal.

Finally, there are uncertainties as to whether the detected SRCs in the surface soil at Area 2 are actually MC associated with historical munitions activities at the MRS. It cannot be definitively stated that the detected chemicals are not MC as they are considered to be chemicals that are attributed with the munitions used and/or disposed at the MRS. Additionally, the detected SRCs are primarily metals and SVOCs that do not readily degrade or mobilize easily even decades after activities have ceased. With the exception for the low concentrations of nitroguanidine that may be naturally occurring, no explosives or propellants were detected in the surface soil samples, no MEC or evidence of the historical OB/OD activities was found during the RI activities, and the MD items found were solid and/or inert and posed no explosives safety hazard. The results of the RI field work indicate that there is no MEC or enough MD that would result in MC leaching to the surrounding environment. Therefore, the uncertainty is reduced that the detected are SRCs are actual MC associated with the historical munitions-related activities at the MRS.

10.8 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 human and environmental receptors. The following statements can be made for the Ramsdell Quarry Landfill MRS based on the results of the RI field activities:

- DGM coverage was completed over 4.19 acres at the MRS during the RI, which exceeded the proposed spatial coverage of 4.16 acres.
- No MEC was encountered during the intrusive investigation activities at the MRS; however, MD was found at Area 2 only at depths between ground surface and 24 inches bgs.

- An underwater tactile investigation was performed at the quarry pond in Area 1 and no MEC or MD was found.
- The detected SRCs in surface soil at Area 2 do not pose potential risks to the human and ecological receptors at the MRS.

The RI included risk assessments for explosives hazards and MC that may pose threats to the human and ecological receptors. The RI field work suggests that it is statistically possible that MEC or MPPEH may remain at both the Area 1 and Area 2 portions of the MRS, although no confirmed discoveries have been made to date. MD was found during the RI field work at Area 2 only; however, the items were solid and/or inert and posed no explosives safety hazard. The risk assessments for MC prepared for this RI Report indicated the detected SRCs at Area 2 did not pose risks to any human or ecological receptors. MC at Area 1 will continue to be addressed under the IRP.

A Feasibility Study is recommended under the MMRP as the next course of action for the Area 2 portion of the MRS to assess possible response action alternatives where concentrated areas of MD were found and some statistical uncertainty remains for MEC. No Further Action is recommended under the MMRP for Area 1, since there is no evidence of MEC/MD. Following a No Further Action determination for Area 1, the Ramsdell Quarry Landfill MRS should be reduced to include the 6.93 acres Area 2 only.

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Appendix A
Digital Geophysical Mapping Report

Appendix B
Ohio EPA Correspondence

Appendix C
Field Documentation

Appendix D
Data Evaluation Report

Appendix E
Summary of Laboratory Data Results

Note: Laboratory data reports are submitted on a separate compact disc.

Appendix F
Investigation-Derived Waste Management

Appendix G
Photograph Documentation Log

Appendix H
Intrusive Investigation Data Sheets

Appendix I
Asbestos Abatement Report

Appendix J
Munitions Debris Waste Shipment and Disposal Records

Appendix K
Ecological Screening Values

Appendix L
Munitions Response Site Prioritization Protocol Worksheets