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1. REPORT DATE *(DD-MM-YYYY)*	2. REPORT TYPE	3. DATES COVERED *(From - To)*
27-08-2014	Final	December 2011 - May 2012

4. TITLE AND SUBTITLE

Remedial Investigation Report for RVAAP-002-R-01 Erie Burning Grounds MRS, Version 1.0

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

5b. GRANT NUMBER
N/A

5c. PROGRAM ELEMENT NUMBER
N/A

6. AUTHOR(S)

Laura O'Donnell
Rachel Vavra
David Crispo, P.E.

5d. PROJECT NUMBER
136147

5e. TASK NUMBER
1200320

5f. WORK UNIT NUMBER
N/A

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

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

8. PERFORMING ORGANIZATION REPORT NUMBER
N/A

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

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

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

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

12. DISTRIBUTION/AVAILABILITY STATEMENT
Reference distribution page.

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

14. ABSTRACT

This Remedial Investigation (RI) Report presents the findings and conclusions of the RI field activities conducted at RVAAP-002-R-01 Erie Burning Grounds Munitions Response Site (MRS) between December 2011 and May 2012 at the former Ravenna Army Ammunition Plant under the Military Munitions Response Program. The purpose of the RI is to determine whether the Erie Burning Grounds 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 is intended to determine the nature and extent of munitions and explosives of concern (MEC) and munitions constituents (MC) and subsequently determine the likely hazards and risks posed to human and environmental receptors by MEC and MC. This RI Report also presents additional data to support the identification and evaluation of alternatives in the Feasibility Study (FS), if required. This RI Report was prepared in accordance with the U.S. Army's Final Munitions Response RI/FS guidance dated November 2009.

15. SUBJECT TERMS
Erie Burning Grounds, Remedial Investigation, Military Munitions Response Program

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			David Crispo
Unclassified	Unclassified	Unclassified	UU	822	19b. TELEPHONE NUMBER *(Include area code)* 781.821.3513

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CB&I Federal Services LLC has completed the *Final Remedial Investigation Report for RVAAP-002-R-01 Erie Burning Grounds MRS* at the former Ravenna Army Ammunition Plant in Portage and Trumbull Counties, Ohio. Notice is hereby given that an independent technical review has been conducted that is appropriate to the level of risk and complexity inherent in the project. During the independent technical review, compliance with established policy, principles and procedures, utilizing justified and valid assumptions, was verified. This included review of data quality objectives; technical assumptions; methods, procedures and materials to be used; the appropriateness of data used and level of data obtained; and reasonableness of the results, including whether the product meets customer's needs consistent with law and existing United States Army Corps of Engineers policy.

Reviewed/Approved by: _____ Date: August 27, 2014

David Crispo, P.E.
Project Manager

Reviewed/Approved by: _____ Date: February 27, 2014

Jody Perwak
Human Health Risk Assessor

Reviewed/Approved by: _____ Date: February 27, 2014

Jon Lindberg
Ecological Risk Assessor

Reviewed/Approved by: _____ Date: February 27, 2014

Maqsud Rahman
Project Chemist

Reviewed/Approved by: _____ Date: February 27, 2014

Laura O'Donnell
Project Engineer

Final Remedial Investigation Report for RVAAP-002-R-01 Erie Burning Grounds MRS Version 1.0

Former Ravenna Army Ammunition Plant
Portage and Trumbull Counties, Ohio

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

Prepared for:



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

August 27, 2014

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Appendix N Ohio EPA Approval Letter

Acronyms and Abbreviations

>	greater than
<	less than
%D	percent difference
°F	degrees Fahrenheit
µg/L	micrograms per liter
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
atm-m^3/mole	atmospheric cubic meters per mole
BAF	bioaccumulation factor
BERA	baseline ecological risk assessment
bgs	below ground surface
bss	below sediment surface
BSV	background screening value
bws	below water surface
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
cm	centimeter
cm/s	centimeters per second
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
D	discrete (grab) sample
DERP	Defense Environmental Restoration Program
DGM	digital geophysical mapping
DID	Data Item Description
DNT	dinitrotoluene
DoD	U.S. Department of Defense
DOI	U.S. Department of the Interior
DQO	data quality objective
dw	dry weight

Acronyms and Abbreviations (continued)

e^2M	engineering-environmental Management, Inc.
ELAP	Environmental Laboratory Accreditation Program
EOD	explosive ordnance disposal
EPA	U.S. Environmental Protection Agency
EPC	exposure point concentration
ERA	ecological risk assessment
ESA	Endangered Species Act
ESL	ecological screening level
ESV	ecological screening value
EU	exposure unit
FS	Feasibility Study
ft	foot/feet
FWBWQS	*Facility-Wide Biological and Water Quality Study*
FWCUG	facility-wide cleanup goal
FWSAP	*Facility-Wide Sampling and Analysis Plan for Environmental Investigations at the RVAAP*
GP	general purpose
gpm	gallons per minute
GPS	global positioning system
HA	Hazard Assessment
HE	high-explosive
HHRA	human health risk assessment
HHRAM	*RVAAP's Facility-Wide Human Health Risk Assessor Manual*
HI	hazard index
HMX	octogen explosives
HQ	hazard quotient
HRR	*Final Military Munitions Response Program Historical Records Review*
HSDB	Hazardous Substances Data Bank
ID	identification
IDW	investigation-derived waste
INRMP	Integrated Natural Resources Management Plan
IRP	Installation Restoration Program
ISM	incremental sampling methodology
IVS	instrument verification strip
kg	kilogram(s)
K_{oc}	organic carbon/water partition coefficient
K_{ow}	octanol/water partition coefficient
L	liter
LANL	Los Alamos National Laboratory
lb	pound
LCS	laboratory control sample
LOAEL	lowest observed adverse effect level

Acronyms and Abbreviations (continued)

LOD	limit of detection
MC	munitions constituents
MD	munitions debris
MDAS	material determined as safe
MDL	method detection limit
MEC	munitions and explosives of concern
mg/kg	milligrams per kilogram
mg/kg/d	milligrams per kilogram per day
mg/L	milligrams per liter
mm	millimeter(s)
MMRP	Military Munitions Response Program
MPPEH	material potentially presenting an explosive hazard
MRL	method reporting limit
MRS	Munitions Response Site
MRSPP	Munitions Response Site Prioritization Protocol
MS	matrix spike
MSD	matrix spike duplicate
mV	millivolt(s)
NA	not applicable/available
NCP	*National Oil and Hazardous Substances Pollution Contingency Plan*
ND	not detected
NFA	no further action
NGT	National Guard Trainee
NOAEL	no observed adverse effect level
OB	open burning
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
PETN	pentaerythritol tetranitrate
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	*DoD Quality Systems Manual for Environmental Laboratories, Version 2.0*
RDX	research department explosives
redox	oxidation/reduction
R(A)	Resident Receptor (Adult)

Acronyms and Abbreviations (continued)

R(C)	Resident Receptor (Child)
RA	risk assessment evaluation
RCRA	*Resource Conservation and Recovery Act*
RDX	research department explosives
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	Ravenna Army Ammunition Plant
SAIC	Science Applications International Corporation
SAP	Sampling and Analysis Plan
Shaw	Shaw Environmental & Infrastructure, Inc.
SI	Site Inspection
SLERA	screening-level ecological risk assessment
SMDP	scientific management decision point
SOP	standard operating procedure
sq ft	square feet
SRC	site-related chemical
SU	standard unit
SUXOS	Senior UXO Supervisor
SVOC	semivolatile organic compound
TBC	to be considered
TEC	threshold effect concentration
TNT	2,4,6-trinitrotoluene
TOC	total organic carbon
TRV	toxicity reference value
U.S.	United States
UCL	upper confidence limit
USACE	U.S. Army Corps of Engineers
USC	U.S. Code
USDA	U.S. Department of Agriculture
UV	ultraviolet
UXO	unexploded ordnance
UXOQCS	UXO Quality Control Supervisor
VQ	validation qualifier
Work Plan Addendum	*Final Work Plan Addendum for Military Munitions Response Program Remedial Environmental Services*

EXECUTIVE SUMMARY

This Remedial Investigation (RI) Report documents the findings and conclusions of the RI field activities for the Erie Burning Grounds (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 (CB&I) under Delivery Order 0002 for Military Munitions Response Program (MMRP) environmental services at the facility 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 Erie Burning Grounds MRS warranted further response action pursuant to the *Comprehensive Environmental Response, Compensation, and Liability Act* (CERCLA) 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 potential hazards and risks posed to human health and the environment by MEC and MC. Additional data is also presented in this RI Report to support the identification and evaluation of alternatives in a Feasibility Study, if required.

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." Data collected during previous sampling events at the Erie Burning Grounds Area of Concern (AOC) under the Installation Restoration Program (IRP) were also reviewed for applicability for evaluation in this RI Report. The Erie Burning Grounds AOC is collocated within the same boundaries as the MRS.

The IRP data were reviewed, and it was determined that incorporation of soil and dry sediment data into this RI Report was not required, as it has been determined under the IRP that detected chemicals in soil and dry sediment do not pose risks to likely human and ecological receptors (Science Applications International Corporation [SAIC], 2007). The human receptors identified for the AOC under the IRP included the Hunter Trapper, the Fire/Dust Suppression Worker, and the Resident Receptor (Adult and Child). Surface water

samples collected for the IRP were not evaluated, since the surface water samples collected during the RI are considered to be more representative of current surface water conditions at the MRS. Evaluation of wet sediment under the IRP consisted primarily of discrete sampling methods. Wet sediment is one of the media of focus of the RI field activities, and the wet sediment samples for the RI were collected using the incremental sampling methodology (ISM). In addition to providing results that are more representative of current conditions, the wet sediment samples collected during the RI using ISM provide for a more representative concentration over a spatial area in comparison to discrete sampling methods. Therefore, the results for the wet sediment samples collected under the IRP were not included for evaluation in this RI Report.

The Erie Burning Grounds MRS is a 33.93-acre MRS located at the northeast portion of the facility. From 1941 to 1951, Erie Burning Grounds was used to thermally treat bulk, obsolete, and off-specification propellants; conventional explosives; rags; and large, explosive-contaminated items (e.g., railcars) by open burning on the ground surface. During operations, open railcars were staged at the end of Track 49 and items were tipped out of the railcars in order to be burned. Ash residue from open burn activities was left on site after the burn. In addition to open burn activities, bomb bodies were transported to Erie Burning Grounds for flashing after they were cleaned out (e^2M, 2007).

Several former burn areas have been identified at the MRS; however, filled bombs were most likely not burned at the MRS, since the site is located too close to the installation boundaries (USACE, 2004). The Former Borrow Area, which is located in the western portion of the MRS, was also used for bomb-flashing activities. Partially buried debris (i.e., munitions debris [MD]), tentatively identified by installation and USACE personnel as remnants of burned-out bombs (size and type not identified), have been observed across the MRS (e^2M, 2007).

Current conditions at the Erie Burning Grounds MRS differ greatly from when the site was active. The area became inundated in the early 1990s as a consequence of sedimentation, vegetation growth, and beaver damming of the small stream that drains the former burning grounds. Surface water basins with high-quality wetlands now occupy the lowlands at the MRS. The largest surface water basin north of Track 49 has periodically drained on its own. The water reaches a maximum depth of 5 feet within the former drainage channel, but is generally less than 3 feet in most areas. Wetlands extend to the north and east beyond Erie Burning Grounds. Surface water within Erie Burning Grounds is connected to these adjacent wetlands by two culverts beneath Blackberry Lane, along the east and north border of the MRS. Surface water flow is from the north into the MRS, with drainage from the MRS to the southwest through a 48-inch–diameter, reinforced concrete pipe beneath Track 10. A second

exit culvert in the northwest portion of the MRS flows only during periods of very high rainfall (SAIC, 2005).

Cultural features that remain at the MRS consist mainly of the gravel access road, former rail beds, and man-made ditches that traverse or bound the MRS. There are no buildings present at the MRS. Remnants of Track 49 still exist along the crest of the embankment, including railroad ties and miscellaneous associated metal debris (rail spikes, plates, etc.).

The Erie Burning Grounds MRS is currently managed as an "Authorized Access" area due to the high-quality wetlands that are present (SAIC, 2007) and the potential for MEC. Current activities at the Erie Burning Grounds MRS include maintenance and natural resource management activities.

The MRS is located within a larger area designated for military training; however, since the MRS is a high-quality wetland, training activities are unlikely to occur there (Ohio Army National Guard, 2008). The MRS may be used for hunting/trapping and fire suppression activities (Shaw Environmental & Infrastructure, Inc. [Shaw], 2011). Therefore, the Security Guard/Maintenance Worker, Hunter/Trapper, and Fire/Dust Suppression Worker were identified and evaluated as potential receptors for the MRS under the MMRP. In order to assess Unrestricted Land Use and to follow CERCLA guidance, the Resident Receptor (Adult and Child) was also evaluated. 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 (RVAAP) Installation Restoration Program, Portage/Trumbull Counties, Ohio* (Army National Guard [ARNG], 2014) and Unrestricted Land Use was achieved, the Commercial Industrial Land Use using the Industrial Receptor was not included.

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 Addendum for Military Munitions Response Program Remedial Environmental Services* (Shaw, 2011), hereafter referred to as the "Work Plan Addendum." 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 Erie Burning Grounds 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.
- Collect surface water and wet sediment samples at predetermined locations to characterize the nature and extent of contamination associated with previous activities at the MRS.
- Collect additional samples in areas of concentrated MEC/MD if necessary.
- Process the information to evaluate whether there are unacceptable risks to human health and the environment associated with MEC/MC and make a determination if further investigation is required under the CERCLA process.

Geophysical Investigation

In January and February of 2012, CB&I performed a DGM investigation to identify potential subsurface areas of MEC and/or MD at the Erie Burning Grounds MRS. The DGM data were collected in all accessible areas within the MRS, and the spatial coverage was calculated to be 6.8 acres, which represents MRS coverage of 20 percent and exceeds the proposed sampling coverage of 5.2 acres presented in the Work Plan Addendum (Shaw, 2011). The 6.8 acres equates to a total transect distance of 17 miles, where each transect width covered was 1 meter wide.

Anomaly Selection

A total of 3,824 anomalies were identified at the entire MRS through the DGM process. The anomalies ranged in intensity from 5 to 11,401 millivolts (mV) (Channel 2). The Work Plan Addendum (Shaw, 2011) specified that the anomaly selection criteria would be the 8-mV (Channel 2) threshold; however, the 5-mV threshold (Channel 2) was considered appropriate for anomaly selection in the areas of the MRS covered by water in order to compensate for the variable water depth at the MRS. The more stringent 5-mV threshold was also used to evaluate for targets at the terrestrial high-density anomaly areas. The 8-mV threshold was still used for the selection of point-source anomalies in the terrestrial areas of the MRS. Since complete DGM coverage was not performed at the MRS, the intrusive investigation activities required 100-percent reacquisition of individual non-culturally related anomalies that exceed the 8-mV threshold in the terrestrial portion of the MRS and the 5-mV threshold in the underwater portions of the MRS.

A high-density anomaly area that consisted of 2,233 clusters of anomalies above 5 mV was found at the terrestrial areas of the MRS. Two hundred anomaly clusters were within approximately 3 feet of one another and were merged together to form one target location

south of Burn Area D. Forty-nine anomaly clusters were located outside of the high-density anomaly area and were found to be either related to cultural features identified by the DGM team during field operations or nails placed by the DGM team for quality control purposes for the DGM activities. Another 266 anomaly clusters were identified to be slightly outside of the MRS boundary. In all, 1,719 clusters of anomalies above 5 mV were identified in the high-density anomaly areas, and total of 15 trenches were proposed for intrusive investigation. The proposed length for each trench was 20 feet to adequately investigate the detected subsurface anomalies.

With regards to the 266 clusters of anomalies along the MRS boundary, approximately 25 to 30 percent of the clusters were on one transect along the portion of Blackberry Lane that bounds the northern portion of the MRS. Blackberry Lane forms both the north and east boundaries of the MRS that is itself bound by a fence that has existed since the MRS was in operation. Surface water and wetland areas are present to the north of the Blackberry Lane fence line, and an operational range is situated to the east of the fence line adjacent to the east of Blackberry Lane. The south and west portions of the MRS are bound by former elevated railroad beds in relation to the MRS that are covered with ballast material. A majority of the remaining portions of the 266 anomaly clusters were identified at the southwest and western edges of the MRS, along the slopes of the former railroad beds. Based on the distinct boundaries that are presented by Blackberry Lane and the former elevated railroad beds, the extent of the DGM survey along the edges of the MRS are considered to be adequately characterized.

Outside of the high-density anomaly areas, 1,076 point-source anomalies that were detected at intensities greater than 5 mV remained at the terrestrial and underwater portions of the MRS. Following the evaluation of the DGM survey results, 186 of 214 targets within the terrestrial zone were greater than 8 mV and were recommended for intrusive investigation. Within the underwater areas, 862 targets greater than 5 mV were recommended for investigation. Four anomalies that were located in a high-density anomaly area west of Burn Area D were recommended for intrusive investigation as point-source anomalies by the USACE geophysicists following review of CB&I's proposed investigation locations. In all, 1,052 point-source anomalies were identified as requiring intrusive investigation at both the terrestrial and underwater areas of the MRS.

Intrusive Investigation Activities

Intrusive investigation activities were conducted at the terrestrial and underwater areas of the MRS between April and May 2012, at the locations recommended following the DGM survey. Fourteen of the 15 proposed exploratory trench locations were successfully investigated. One trench was underwater at the time of the intrusive investigation activities and was considered inaccessible. Only 350 of the proposed 1,052 combined terrestrial and

underwater point-source anomalies were accessible for exploration, since many of the point-source anomalies at the underwater areas were found to be buried deep in the sediment and could not be safely investigated.

No MEC was identified during the intrusive investigation activities; however, MD items were found at the various trenches and point-source anomaly locations that were able to be investigated. A total of 33 MD items, weighing approximately 910 pounds (lbs), were identified at 5 of the exploratory trenches, and a total of 29 MD items that weighed approximately 385 lbs were identified at the point-source anomaly locations. All of the MD items found in the trenches and at most of the point-source anomaly locations were various parts associated with the AN-M64A1-series 500-lb general purpose bomb. MD items associated with the M48-series 75-millimeter and the M309-series 75-millimeter high-explosive projectiles were encountered at several of the point-source anomaly locations.

MC Sampling

Sampling for MC was predetermined during the DQO decision-making process to further characterize the nature and extent of contamination associated with previous activities at the MRS. Three surface water samples and six ISM wet sediment samples were collected at the MRS during the RI field activities. Surface water samples were collected at each of the main surface water areas at the MRS: the North Surface Water Basin, the South Surface Water Basin, and the East Surface Water Basin. The wet sediment samples were collected at sampling units of approximately the same size and from the same basin areas as where the surface water samples were collected. Three ISM sediment samples were collected from the North Surface Water Basin (2.8 acres each), two ISM sediment samples were collected from the South Surface Water Basin (3.2 acres each), and one ISM sediment sample was collected from the East Surface Water Basin (1.5 acres). It was proposed in the Work Plan Addendum (Shaw, 2011) that additional samples be collected in areas with concentrated MEC/MD. No MEC was found at the MRS during the RI field activities; however, MD was identified. Additional ISM soil samples were collected from the bottom of two trenches at depths between 3 to 4 feet below ground surface (bgs) where the buried MD was encountered during the intrusive investigation activities.

ES.3 MEC Hazard Assessment

The *Interim Munitions and Explosives of Concern Hazard Assessment Methodology* (U.S. Environmental Protection Agency, 2008a) 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 during this RI, the MEC Hazard Assessment (HA) evaluation will include the information available for the MRS up to and including the RI field activities and will provide

a scoring summary for the current and future land-use activities. If no explosive hazard is found at the MRS, then there is no need to calculate a MEC HA score, since there are no human health safety concerns. No MEC items were identified at the MRS during the RI field activities. These results indicate that no MEC source or explosive safety hazard is present at the MRS. Therefore, calculation of a MEC HA score was not warranted for the Erie Burning Grounds MRS.

ES.4 MC Risk Assessment Summary

The site-related chemicals (SRCs) for the Erie Burning Grounds MRS were determined for surface water, wet sediment, and subsurface soil collected during the RI field activities through the facility data screening process as presented in the *Final Facility-Wide Human Health Cleanup Goals for the Ravenna Army Ammunition Plant* (SAIC, 2010). All surface water, wet sediment, and subsurface soil samples were analyzed for the identified MC associated with historical munitions-related activities at the MRS. The identified MC included metals (aluminum, antimony, barium, cadmium, chromium [total and hexavalent], copper, iron, lead, mercury, strontium, and zinc), explosives, semivolatile organic compounds (SVOCs), nitrocellulose, and pH. The wet sediment and soil samples were also analyzed for polychlorinated biphenyls (PCBs) and total organic carbon. The detected chemicals that were retained as SRCs following the screening process included the following:

- **Surface Water (1.5 feet below water surface)**
  - *Metals:* barium, chromium (as trivalent chromium [Cr^{+3}]), lead, copper, iron, strontium, and zinc
- **Wet Sediment (0 to 0.5 feet below sediment surface)**
  - *Metals:* aluminum, antimony, barium, cadmium, chromium (as Cr^{+3}), copper, iron, lead, mercury, and strontium
  - *Explosives:* 2,4,6-trinitrotoluene and 4-amino-2,6-dinitrotoluene
  - *SVOCs:* benzo(b)fluoranthene, benzoic acid, chrysene, dibenzofuran, fluoranthene, phenanthrene, and pyrene
  - *PCBs:* Aroclor-1254
  - *General Chemistry:* Hexavalent chromium (Cr^{+6}) and nitrocellulose
- **Subsurface Soils (3 to 4 feet bgs)**
  - *Metals:* Cadmium and strontium

No explosives, propellants, or SVOCs were detected in the surface water and subsurface soil samples. PCBs were also analyzed for the subsurface soil samples and none were detected. The identified SRCs were then carried through the human health and ecological risk assessments process to evaluate for potential receptors. The risk assessment results are presented below.

Human Health Risk Assessment

A human health risk assessment (HHRA) was conducted for surface water, wet sediment, and subsurface soil samples collected at the Erie Burning Grounds MRS to determine if the SRCs identified were chemicals of potential concern (COPCs) or chemicals of concern (COCs) that may pose a risk to current or future human receptors. The MRS is located within a larger area where the land will be used for military training; however, since the MRS is a high-quality wetland, training activities are unlikely to occur there. Therefore, rather than evaluate the National Guard Trainee, the Security Guard/Maintenance Worker was selected as a receptor for potential training activities. It should be noted that the Security Guard/Maintenance Worker was also assessed under the IRP investigations. The evaluation of potential risks to human receptors was completed by identifying COCs in the RI. For the facility, the Resident Receptor (Adult and Child) is evaluated for COCs for Unrestricted Land Use at the MRS in accordance with the CERCLA process to evaluate for baseline conditions and the no action alternative, and as outlined in the *RVAAP's Facility-Wide Human Health Risk Assessor Manual* (HHRAM) (USACE, 2005a).

Iron was identified as a COC for the Resident Receptor (Adult and Child) in wet sediment; however, weight of evidence suggests that the one elevated iron concentration is most likely associated with background and does not pose a hazard. No other COCs were identified in surface water, wet sediment, or soil for any of the receptors. Since no COCs were identified for the Resident Receptor, Unrestricted Land Use was achieved for MC.

Ecological Risk Assessment

Two chemicals of potential ecological concern (COPECs) in surface water (copper and iron) and 10 COPECs in sediment samples (antimony, barium, cadmium, copper, iron, lead, mercury, nitrocellulose, Aroclor-1254, and dibenzofuran) were recommended to be evaluated in the Level III Baseline following the Level II Screening. The COPECs are determined in the ecological risk assessment (ERA) and may differ from COPCs. Evaluation of the selected COPECs in the Level III Baseline suggested that impacts to upper trophic-level receptors are minimal, and adverse effects to populations of these receptors are not expected. These findings are supported by the facility-wide biological and water quality study that was performed at the facility in 2003. This study included the evaluation of several reaches of the West Branch of the Mahoning River downstream of the Erie Burning Grounds MRS and found no biological impacts associated with chemical contamination (USACE, 2005b).

ES.5 Conceptual Site Model

The information collected during the RI field activities was used to update the CSMs for MEC and MC for the Erie Burning Grounds 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 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 investigation at the Erie Burning Grounds MRS; and portions of the MRS were investigated by visual survey, DGM survey, and intrusive investigation. No MEC was identified during the RI field activities; however, numerous MD items were encountered at depths ranging from ground surface to 48 inches bgs. The MD items were solid and/or inert and posed no explosives safety hazard.

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

MC Exposure Analysis

Since the RI was completed prior to the finalization of the U.S. Army's technical memorandum (ARNG, 2014), the Commercial Industrial Land Use using the Industrial Receptor was not included. Use of the MRS is currently limited because of the potential presence of MEC and the presence of a high-quality wetland; therefore, the National Guard Trainee was not selected as the most likely user. Instead, the Security Guard/Maintenance Worker, Hunter/Trapper, and Fire/Dust Suppression Worker were identified as potential receptors for the MRS. The exposure scenarios for these receptors can be found in the HHRAM (USACE, 2005a). The exposure scenario for the Security Guard/Maintenance Worker has no exposure to surface water or wet sediment. However, there is exposure to subsurface soil (i.e., greater than 1 foot bgs) for the Security Guard/Maintenance Worker, Hunter/Trapper, and Fire/Dust Suppression Worker (SAIC, 2010). The exposure scenario for the ecological receptors in the ERA is assumed to be 0 to 1 foot bgs.

The HHRA and ERA determined that SRCs in surface water, wet sediment, and subsurface soil are not present at concentrations great enough to pose risks to the human or the ecological receptors, including the Resident Receptor (Adult and Child). These results are consistent with the previous investigations under the IRP that determined detected

contaminants in soil and dry sediment also do not pose risks to human or ecological receptors (SAIC, 2007). Although MD was verified during the RI field activities, given the extent of environmental media coverage achieved for the sampling activities for the RI and the results for the MC characterization, it is unlikely that SRCs will leach from the MD. The CSM for MC has been updated to reflect incomplete pathways for all receptors in the terrestrial and aquatic environments.

Groundwater beneath the former 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 at depths that were at or just beneath the soil and groundwater interface (3 to 4 feet bgs). Although SRCs were detected in environmental media that was sampled during the RI field work, evaluation for fate and transport of the chemicals and review of the Phase II RI (SAIC, 2005) indicate that that groundwater has not been significantly impacted from past activities at the MRS. Additionally, it is not expected that the likely human or ecological receptors will come into contact with groundwater at the MRS. No groundwater samples were collected at the Erie Burning Grounds MRS during the RI field work, 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 includes evaluations for explosives hazards and potential sources of MC that may pose threats to likely receptors. The following statements can be made for the Erie Burning Grounds MRS based on the results of the RI field activities:

- A total of 6.8 acres were investigated at the MRS during the RI, which exceeded the proposed spatial coverage of 5.2 acres.
- Intrusive investigation activities identified the vertical extent of buried MD at the MRS to range between ground surface and 4 feet bgs.
- The detected SRCs that were evaluated as MC in surface water, wet sediment, and subsurface soil do not pose potential risks to human or ecological receptors at the MRS; therefore, no further action is required for MC at the MRS.

The RI included risk assessments for explosives hazards and MC that may pose threats to likely receptors. The field work results suggest it is statistically possible that MEC may be present at the MRS, although confirmed discoveries have not been made to date. Although MD was recovered during the field activities, the items were solid and/or inert and posed no

explosives safety hazard. A Feasibility Study is recommended as the next course of action for the MRS under the MMRP to assess possible response action alternatives because MD has been found and some statistical uncertainty remains for MEC.

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1.0 INTRODUCTION

This Remedial Investigation (RI) Report documents the findings and conclusions of the RI field activities for the Erie Burning Grounds (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 (CB&I), under Delivery Order 0002 for Military Munitions Response Program (MMRP) environmental services at the facility 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 Erie Burning Grounds MRS between January and May of 2012. This RI Report was developed in accordance with the *Final Work Plan Addendum for Military Response Program Remedial Environmental Services*, Version 1.0 (Shaw Environmental & Infrastructure, Inc. [Shaw], 2011), hereafter referred to as the "Work Plan Addendum"; 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 (FS), 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, and DoD policy states that such responses shall be conducted in accordance with CERCLA and the *National Oil and Hazardous Substances Pollution Contingency Plan* (NCP).

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

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

1.2 Problem Identification

The Erie Burning Grounds was used to thermally treat munitions. In addition, open burning of bulk, obsolete, and off-specification propellants; conventional explosives; rags; and large, explosive-contaminated items was performed at the MRS. Therefore, there is the potential for surface and subsurface MEC as well as MC in concentrations posing a risk to human health or the environment. The *Final Site Inspection Report* (engineering-environmental Management, Inc. [e^{2}M], 2008), hereafter referred to as the "Site Inspection (SI) Report," recommended further characterization of the MRS to address MEC and MC concerns.

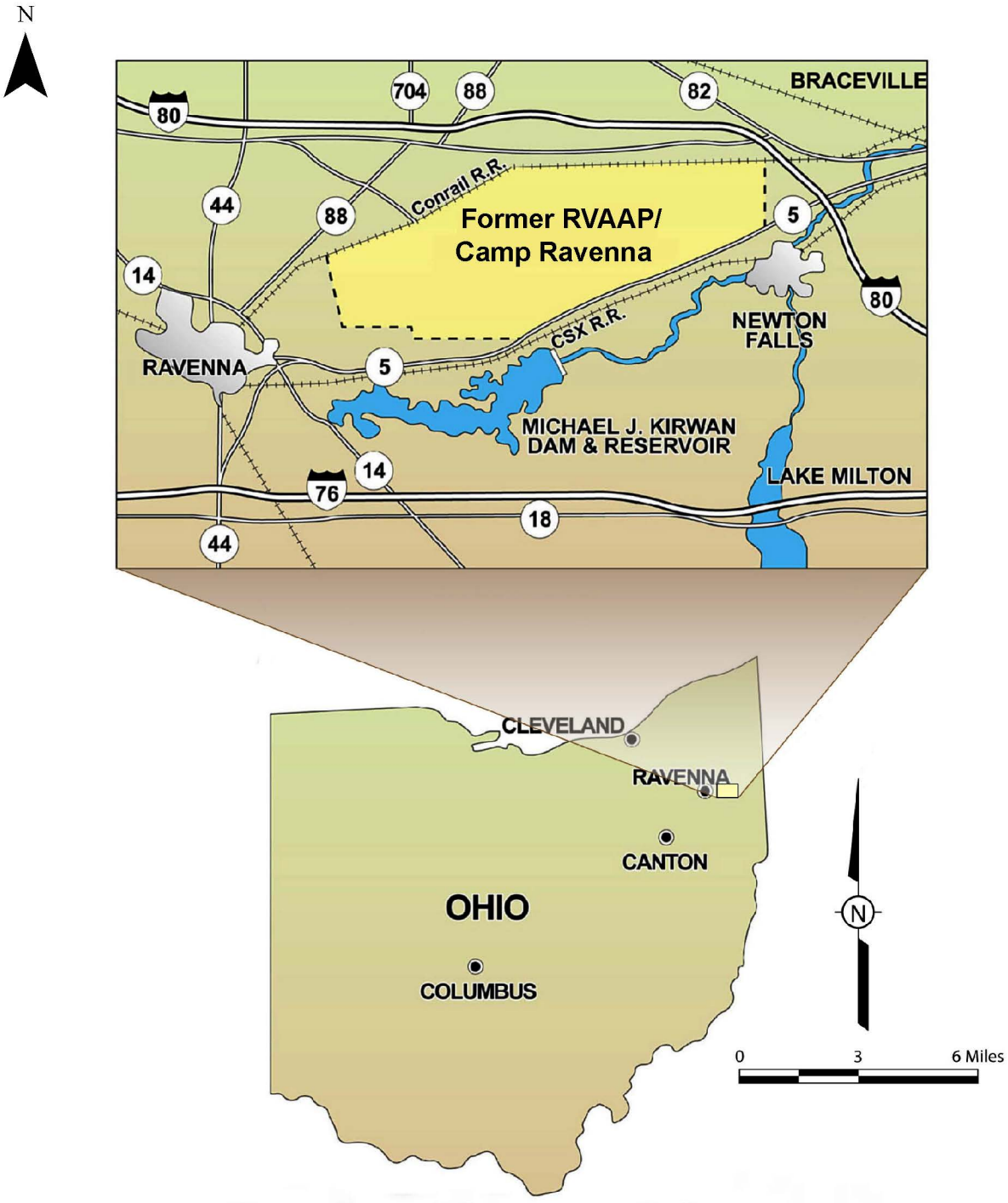
1.3 Physical Setting

This section presents the physical characteristics of the facility, the Erie Burning Grounds MRS, and the surrounding environments that are factors in understanding fate and transport, the conceptual site model (CSM), 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^{2}M, 2008) that included the Erie Burning Grounds 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 former RVAAP (Federal Facility ID No. OH213820736), now known as the Camp Ravenna Joint Military Training Center (Camp Ravenna), is located in northeastern Ohio within Portage and Trumbull Counties and is approximately 3 miles east-northeast of the city of Ravenna. The facility is approximately 11 miles long and 3.5 miles wide. The facility is bounded by State Route 5, the Michael J. Kirwan Reservoir, and the CSX System Railroad to the south; Garret, McCormick, and Berry Roads to the west; the Norfolk Southern Railroad to the north; and State Route 534 to the east. In addition, the facility is surrounded by the communities of Windham, Garrettsville, Newton Falls, Charlestown, and Wayland (**Figure 1-1**).

The Erie Burning Grounds MRS is an approximate 33.93-acre parcel located at the northeast corner of the facility (**Figure 1-2**). The MRS is collocated with an Installation Restoration Program (IRP) Area of Concern (AOC) identified as Army Environmental Database-Restoration Module (AEDB-R) number RVAAP-02.



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



U.S. ARMY
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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

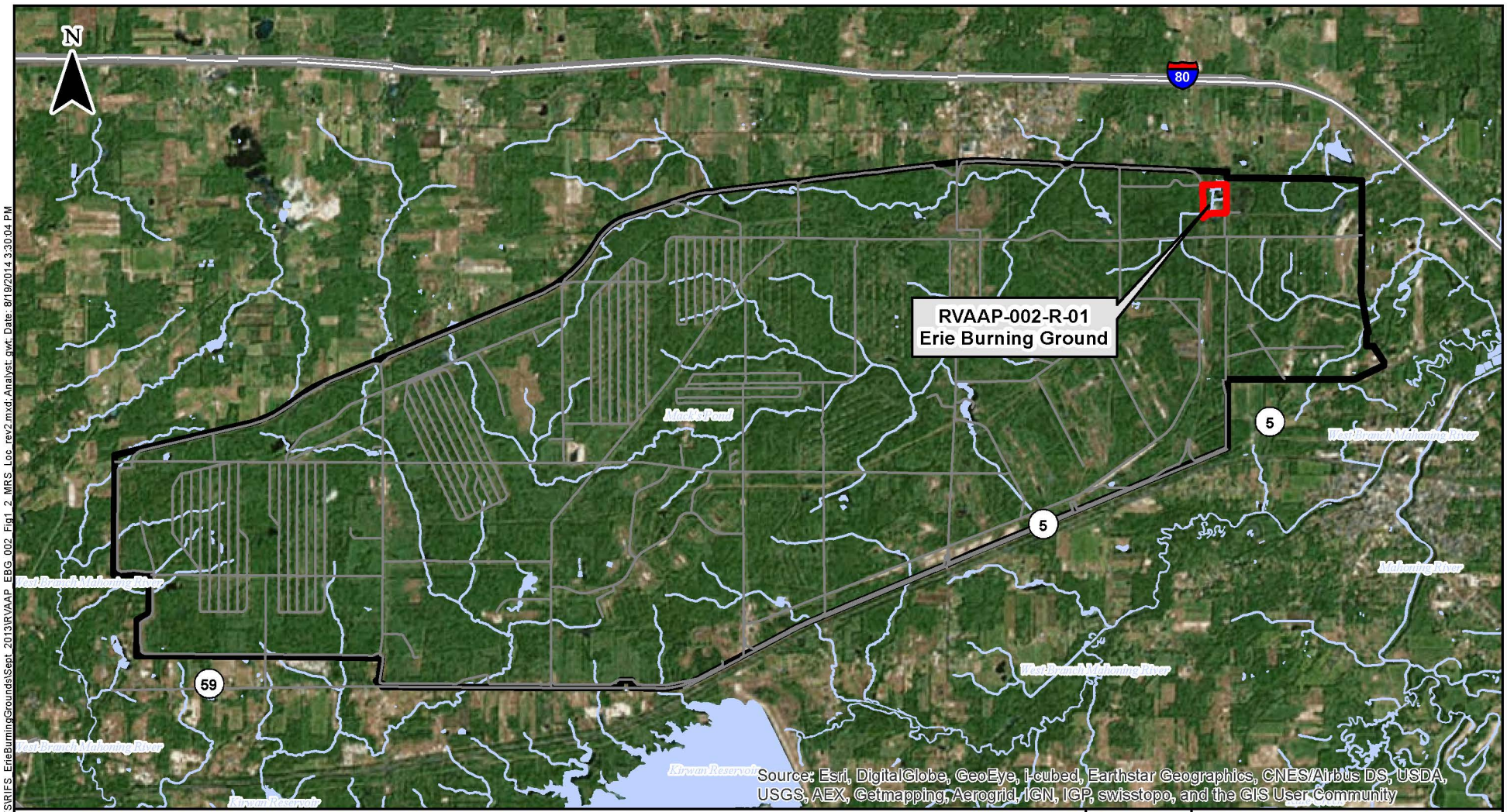


FIGURE 1-2 MRS LOCATION MAP

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

The MRS is located on federal property that is managed by the Army National Guard (ARNG) and the OHARNG. **Table 1-1** summarizes the administrative description for the Erie Burning Grounds MRS. The table includes the facility AEDB-R numerical designation for the MRS, the current MRS acreage, and the agencies responsible for the MRS.

Table 1-1
Administrative Summary of the Erie Burning Grounds MRS

MRS Name	AEDB-R MRS Number	MRS Area (acres)	MRS Management Responsibility
Erie Burning Grounds	RVAAP-002-R-01	33.93	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.

1.3.2 Current and Projected Land Use

This section presents the current and anticipated future land use for the Erie Burning Grounds MRS. The future land use is based on information provided in the *RVAAP's Facility-Wide Human Health Risk Assessor Manual* (HHRAM) (USACE, 2005a, and information provided by the OHARNG during preparation of the Work Plan Addendum (Shaw, 2011).

The Erie Burning Grounds MRS is currently managed as an "Authorized Access" area due to the high-quality wetlands that are present (Science Applications International Corporation [SAIC], 2007) and the potential for MEC. Current activities at the Erie Burning Grounds MRS include maintenance and natural resource management activities. Potential users associated with the current land uses at the MRS include facility personnel, contractors, and potential trespassers.

The MRS is located within a larger area designated for military training; however, since the MRS is a high-quality wetland, training activities are unlikely to occur there (OHARNG, 2008). The MRS may be used for hunting/trapping and fire suppression activities. Since the RI was completed prior to finalization of the U.S. Army's *Final Technical Memorandum: Land Uses and Revised Risk Assessment Process for the Ravenna Army Ammunition Plant (RVAAP) Installation Restoration Program, Portage/Trumbull*

Counties, Ohio (ARNG, 2014) and Unrestricted Land Use was demonstrated, the Commercial Industrial Land Use was not evaluated.

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).

Erie Burning Grounds MRS Topography

Approximately 80 percent of the Erie Burning Grounds MRS is inundated, and the topography at the terrestrial portions of the MRS is relatively flat with ground surface elevation ranging from approximately 938.1 to 942.4 feet above mean sea level (amsl) (SAIC, 2005). Natural drainage at the terrestrial portions of the MRS is toward the water basins and wetland areas that now make up most of the MRS. The topographical features at the Erie Burning Grounds MRS are presented in **Figure 1-3**.

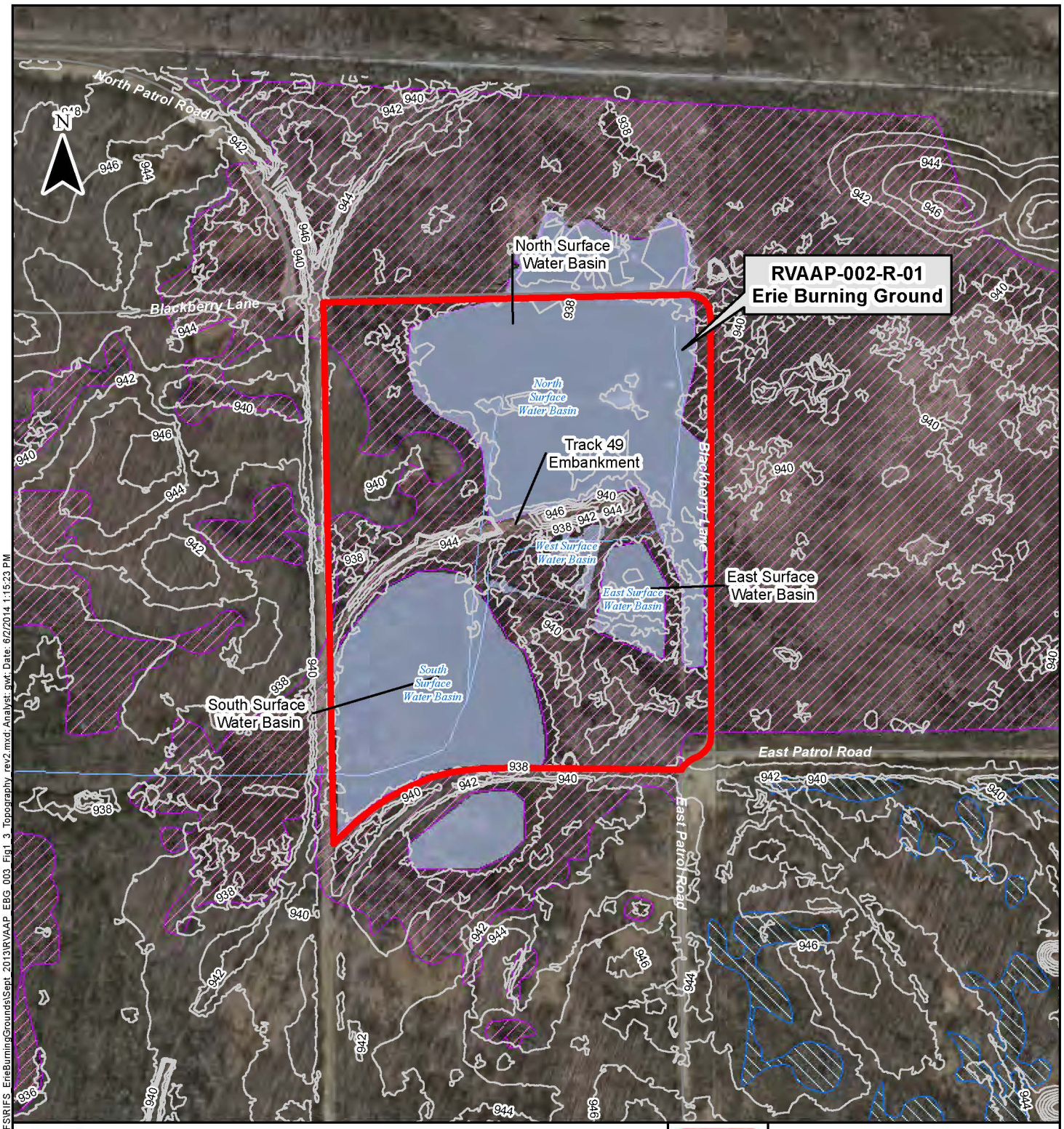


FIGURE 1-3 TOPOGRAPHY

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.

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, which overlies the conglomerate in some locations; however,

it has been eroded throughout the majority of the facility. The Sharon Member outcrops in many locations in the eastern half of the facility.

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

The Connoquenessing Sandstone Member, which is 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/second (cm/s) (U.S. Department of Agriculture [USDA] et al., 1978). Much of the native soil at the facility was disturbed during construction activities in former production and operational areas of the facility (SAIC, 2011a).

Erie Burning Grounds MRS Geology and Soils

The Erie Burning Grounds MRS is located over the Sharon Member conglomerate unit, and the bedrock elevation is approximately 900 feet amsl (AMEC, 2008). The estimated depth to bedrock at the MRS is approximately 40 feet bgs (SAIC, 2005). **Figure 1-4** presents the bedrock geology at the Erie Burning Grounds MRS.

The native soil types at the MRS were substantially reworked to prepare the area for use as an open burning ground. This is evidenced by sand fill, ballast, and slag that were observed at the collocated AOC during the 2005 Phase II RI (SAIC, 2005). The native soils across the Erie Burning Grounds MRS include various soil types. The primary native soil type at the MRS is the Sebring variant. Other identified soil types include the Sebring silt loam, Damascus loam, Lakin loamy sand with 2 to 6 percent slopes, and Mahoning silt loam with 2 to 6 percent slopes. **Figure 1-5** presents the native soil types at the Erie Burning Grounds MRS.

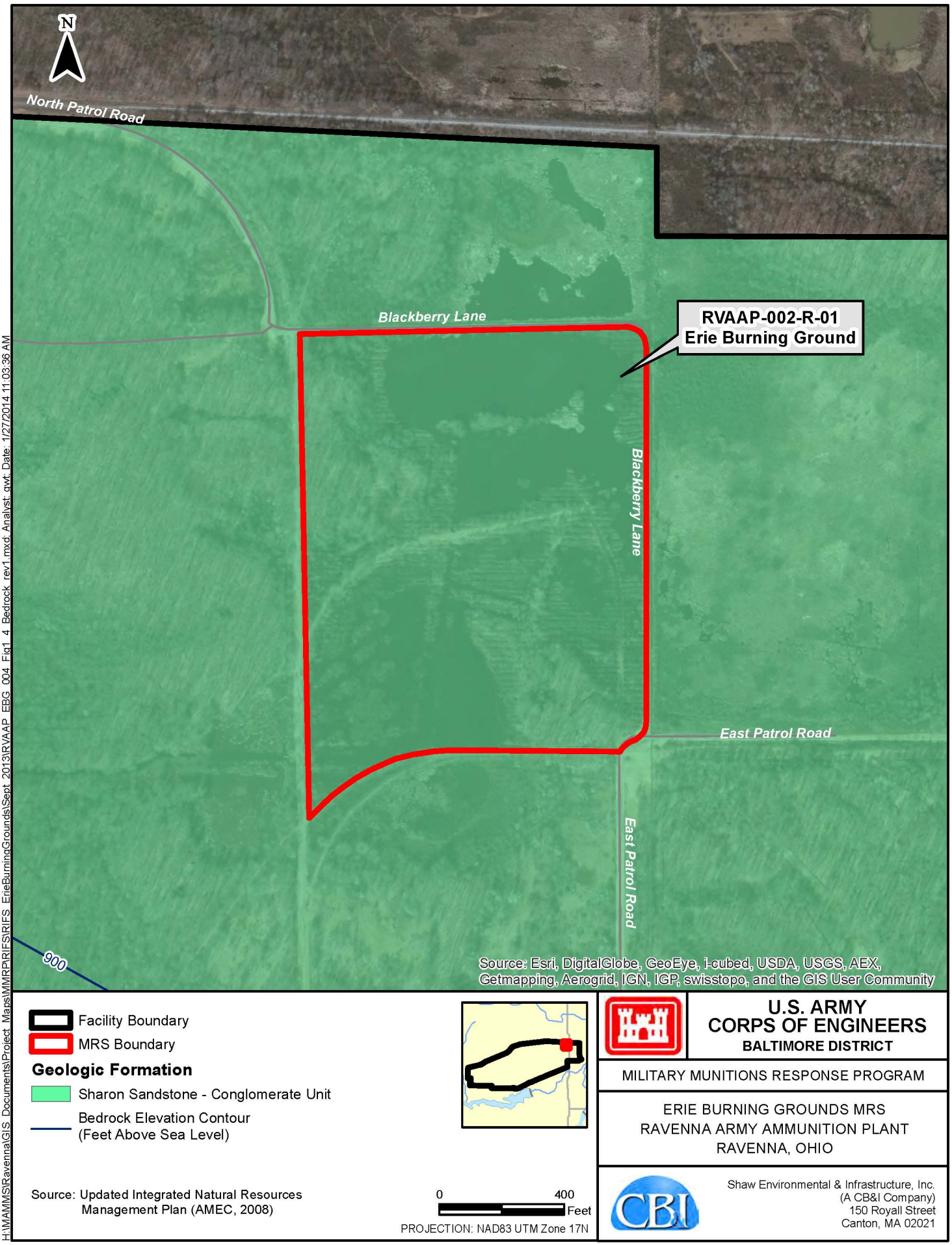
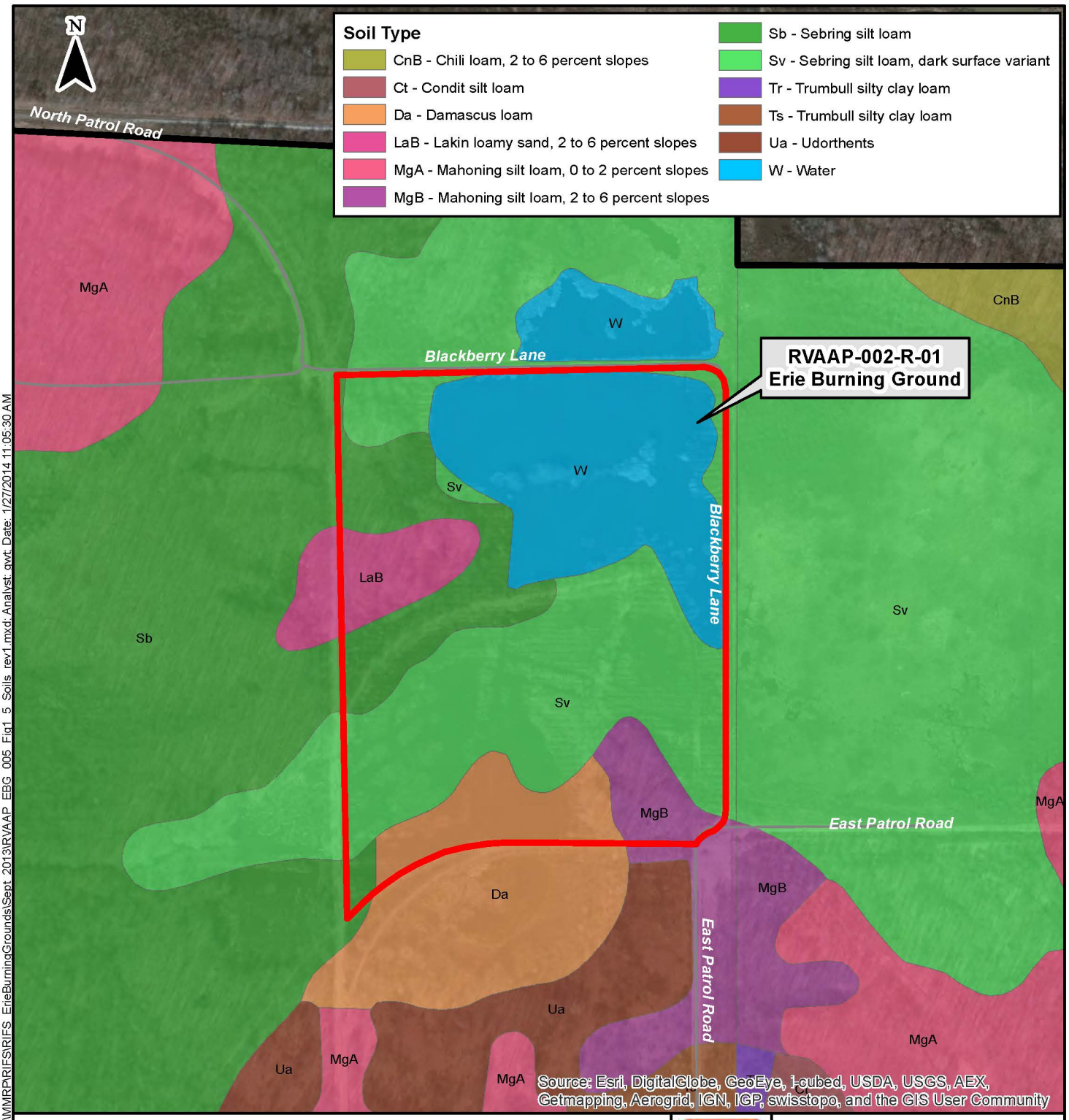


FIGURE 1-4 BEDROCK MAP



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Facility Boundary
MRS Boundary

Source: Updated Integrated Natural Resources Management Plan (AMEC, 2008)

0 400 Feet

PROJECTION: NAD83 UTM Zone 17N

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MILITARY MUNITIONS RESPONSE PROGRAM

ERIE BURNING GROUNDS MRS
RAVENNA ARMY AMMUNITION PLANT
RAVENNA, OHIO

Shaw Environmental & Infrastructure, Inc.
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150 Royall Street
Canton, MA 02021

FIGURE 1-5 SOILS MAP

The Sebring variant soil type is primarily located at the central and northeast portion of the MRS. This soil type consists of deep, very poorly drained, nearly level soils that are formed in lacustrine sediments. These soils are in old glacial lakebeds and in small depressions in uplands. These soils have a high available water capacity, and permeability is moderately slow in the subsoil and substratum. The permeability of the Sebring variant ranges from 1.4×10^{-4} cm/s to 4.2×10^{-4} cm/s (USDA et al., 1978).

The Sebring silt loam is situated at the central western portion of the MRS adjacent to the Lakin loam. The Sebring silt loam is a nearly level soil on broad, low, and level terraces. Runoff is slow to ponded, and the surface layer is susceptible to crusting. This soil type is very poorly drained with a permeability rate that ranges between 4.2×10^{-4} cm/s to 1.4×10^{-3} cm/s (USDA et al., 1978).

The Lakin loamy sand formation is located in a small area at the central western portion of the MRS. This soil type is a gently sloping soil that occupies variable shaped areas on kames, terraces, and uplands. Runoff is slow, and water moves readily into this soil. The permeability of this soil is relatively quick with rates greater than 4.2×10^{-3} cm/s (USDA et al., 1978).

The Damascus loam covers a small area at the southern portion of the MRS and is a nearly level soil on outwash terraces. Runoff associated with this soil type is slow to ponded. The permeability range for the Damscus loam is 4.2×10^{-4} cm/s to 4.2×10^{-3} cm/s. The permeability tends to increase with soil depth (USDA et al., 1978).

The Mahoning silt loam covers a small area at the southeast portion of the MRS. This soil type is characterized with medium to rapid runoff, severe seasonal wetness, and slow permeability. The average permeability of the Mahoning silt loam with a 2 to 6 percent slope is 9.1×10^{-5} cm/s (USDA et al., 1978).

1.3.6 Surface Water

The facility is located within the Ohio River Basin. The major surface stream at the facility is the West Branch of the Mahoning River, which flows adjacent to the western end of the facility, generally from north to south, before flowing into the Michael J. Kirwan Reservoir. After leaving the reservoir, the West Branch of the Mahoning River 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 creek 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 Erie Burning Grounds 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. Sand and gravel aquifers are present within the buried-valley and outwash deposits in Portage County. In general, the aquifer is too thin and localized to provide large quantities of water; however, yields are sufficient for residential water supplies. Wells located on the facility were primarily located within the sandstone facies of the Sharon Member (MKM Engineers, Inc., 2007).

Erie Burning Grounds MRS Surface Water Features

The MRS has been largely inundated since the early 1990s as a result of the subdued topography and beaver activity that blocked the former surface water drainage channel just downstream of the large culvert under Track 10 where the water exits the MRS. The surface water basins themselves are shallow and subject to seasonal fluctuations in water level. The water level in the ponds occasionally drops low enough so that no outflow occurs at the exit point. Seasonal high water may occasionally inundate the access road around the MRS. Sediment accumulations within the basins are greatest along the axis of the former drainage channel. Elsewhere in the ponds, a thin veneer of sediment overlies sandstone fill, construction debris, or other hard substrate. The nature and time of placement of these materials is not precisely known (SAIC, 2005).

A facility-wide surface water and sediment investigation was conducted at the facility in 2003 by the USACE with cooperation from the Ohio Environmental Protection Agency (Ohio EPA) (USACE, 2005b). For the investigation, water and sediment samples were taken from locations along major stream and tributaries, ponds, and wetlands throughout the facility at locations that could have been impacted by former facility activities and sites where the streams entered the facility. This investigation included surface water basins at the Erie Burning Grounds as well as downgradient streams. The results of the investigation

indicated that surface water quality at the Erie Burning Grounds water basins, although slightly exceeding several chronic water quality criteria, did not appear to impact the biological community. Water quality conditions were comparable to reference ponds. Based on results of the sediment samples collected at the Erie Burning Grounds during the 2003 investigation, moderate contamination was evident at the Erie Burning Grounds. Particularly noteworthy were elevated levels of several explosive compounds in the sediment (SAIC, 2005).

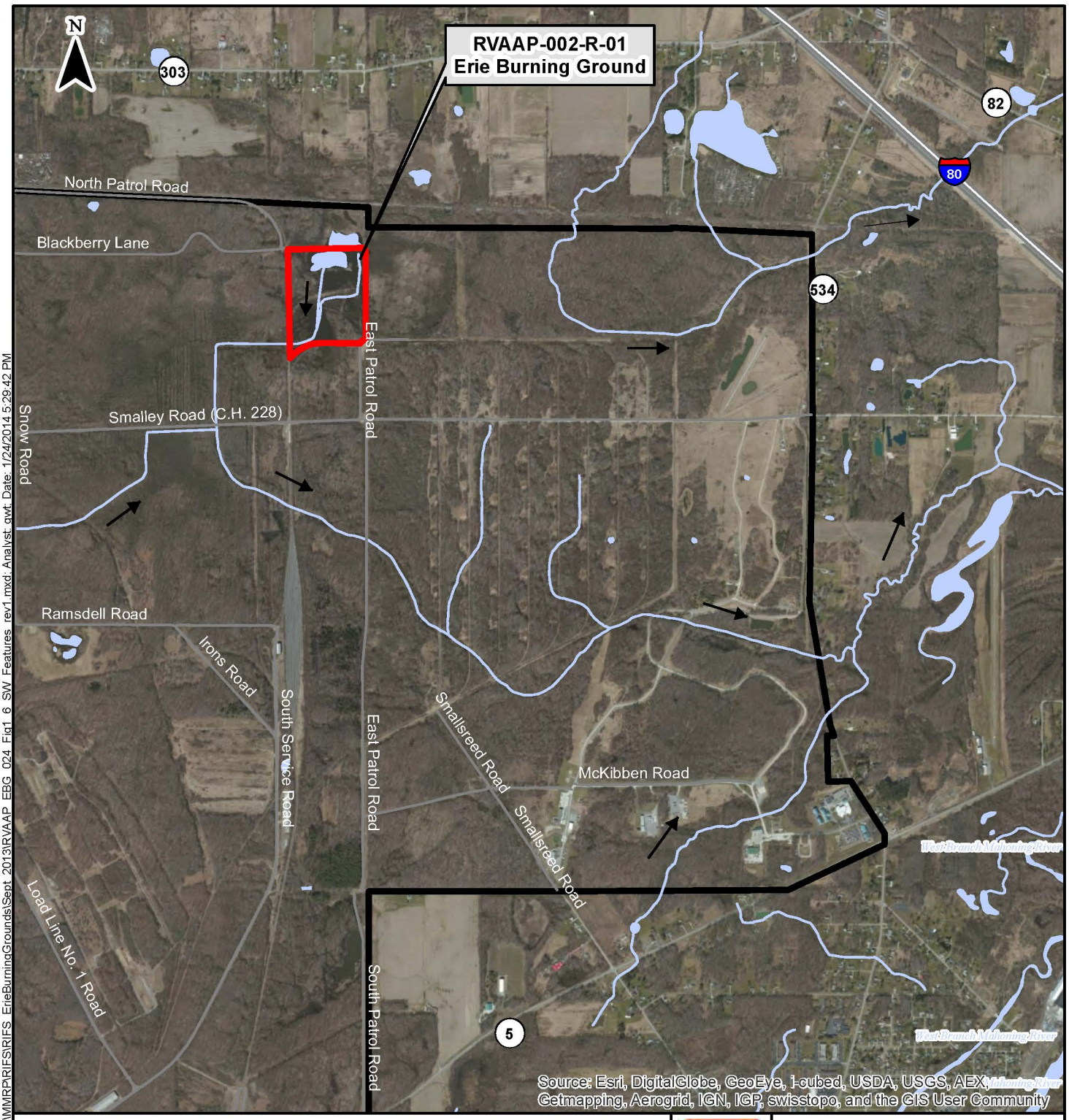
Surface water drainage flows from the north to the southwest across the Erie Burning Grounds MRS. Surface water enters the MRS from the north along a drainage ditch and culvert pipe beneath Blackberry Lane. Although it is largely obscured by flooding and vegetative cover, the trend of this ditch within the MRS that extends to the north of the MRS boundary is still visible. Surface water drainage is also thought to enter the MRS from the east through at least one culvert beneath Blackberry Lane. Surface water exits the pond at the southwest corner through a 48-inch–diameter reinforced concrete culvert beneath Track 10 at the southwest corner of the MRS. All surface water that exits the MRS forms the headwaters of a perennial stream, which flows south then east and exits the facility immediately west of Route 534 (SAIC, 2005). The surface water features at the MRS are presented in **Figure 1-3**. The local and regional surface water features associated with the MRS are presented in **Figure 1-6**.

A planning-level survey for wetlands was conducted at the facility, including the MRS, and 31.5 acres, which constitutes over 90 percent of the MRS, is identified as an open water area or wetlands that are considered high quality (AMEC, 2008). No bogs, kettle lakes, or kames have been identified as being present within the MRS. Wetland areas identified at the MRS during the planning-level survey are shown on **Figure 1-3**.

1.3.7 Hydrology and Hydrogeology

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

The thickness of the unconsolidated interval at the facility ranges from thin to absent in the eastern and northeastern portion of the facility to an estimated 150 feet in its south-central portion. The groundwater table occurs within the unconsolidated zone in many areas of the



Facility Boundary
MRS Boundary
Surface Water
Stream
Direction of Flow

Source: Updated Integrated Natural Resources Management Plan (AMEC, 2008)

0 2,000 Feet

PROJECTION: NAD83 UTM Zone 17N

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MILITARY MUNITIONS RESPONSE PROGRAM

ERIE BURNING GROUNDS MRS
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Canton, MA 02021

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FIGURE 1-6 SURFACE WATER FEATURES

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 (e.g., 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).

Erie Burning Grounds 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 (AMEC, 2008). The Erie Burning Grounds MRS is located at the northeast, more level portion of the facility and is not presumed to be in a groundwater recharge area.

Groundwater at the Erie Burning Grounds MRS generally flows in a southerly direction. The depth to groundwater at the MRS ranges from approximately 2 to 3 feet bgs with a groundwater elevation between 937 and 939 feet amsl. The depth-to-groundwater measurements were taken from existing monitoring wells installed at the collocated AOC under the IRP (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

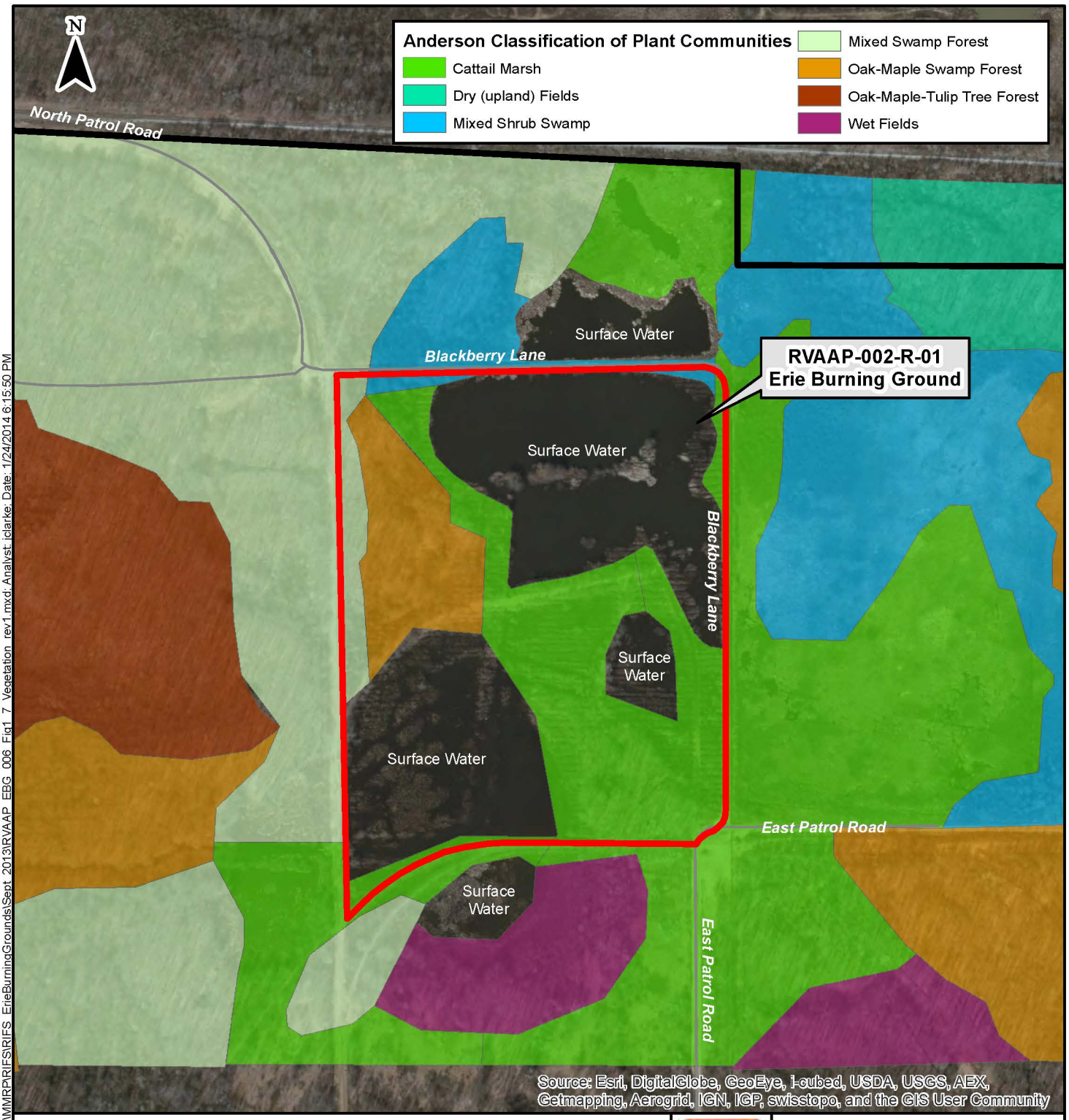
4,200 acres. A plant species survey identified 18 vegetation communities on the facility. The facility has as total of seven forest formations, four shrub formations, eight herbaceous formations, and one nonvegetated formation (AMEC, 2008).

Erie Burning Grounds MRS Vegetation

The vegetation communities at the Erie Burning Grounds MRS are predominantly categorized as a mixture of mixed cold-deciduous successional forest, and semi-permanently and permanently flooded herbaceous alliances that are classified as Cattail Marsh and Oak-Maple Swamp Forest. The Cattail Marsh community consists of hydrophytic vegetation that is primarily situated along the edges of the pond basins (SAIC, 2005). The Oak-Maple Swamp Forest community is located along the less inundated areas at the western portion of the MRS. Portions of Mixed Swamp Forest and Mixed Shrub Swamp communities are found along the eastern and northern edges of the MRS, respectively (AMEC, 2008). White ash, wild black cherry, red maple, cattails, spatterdock, and white water lily are dominant species in these associations (AMEC, 2008). **Figure 1-7** illustrates the plant communities at the Erie Burning Grounds MRS.

1.3.9 Threatened, Endangered, and Other Rare Species

Information regarding threatened, endangered, and other rare species at the facility was obtained from the Camp Ravenna *Rare Species List* (2010). 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). The wetlands area within the Erie Burning Grounds MRS is considered to be high quality, although an official jurisdictional delineation has not been completed (SAIC, 2007 and AMEC, 2008). A species of state special interest, the green-winged teal (*Anas crecca*); and two state species of concern, the Virginia rail (*Rallus limicola*) and the sora (*Porzana carolina*), have been identified at locations immediately adjacent to the MRS. 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. **Table 1-3** presents state-listed species that have been identified to be on the facility by biological inventories and confirmed sightings.



Facility Boundary
MRS Boundary

Source: Updated Integrated Natural Resources Management Plan (AMEC, 2008)

0 400 Feet

PROJECTION: NAD83 UTM Zone 17N

U.S. ARMY CORPS OF ENGINEERS
BALTIMORE DISTRICT

MILITARY MUNITIONS RESPONSE PROGRAM

ERIE BURNING GROUNDS MRS
RAVENNA ARMY AMMUNITION PLANT
RAVENNA, OHIO

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150 Royall Street
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FIGURE 1-7 VEGETATION MAP

Table 1-3
Camp Ravenna Rare Species List

Common Name	Scientific Name
State Endangered	
American bittern	*Botaurus lentiginosus*
Northern harrier	*Circus cyaneus*
Yellow-bellied sapsucker	*Sphyrapicus varius*
Golden-winged warbler	*Vermivora chrysoptera*
Osprey	*Pandion haliaetus*
Trumpeter swan	*Cygnus buccinator*
Mountain brook lamprey	*Ichthyomyzon greeleyi*
Graceful underwing moth	*Catocala gracilis*
Tufted moisture-loving moss	*Philonotis fontana var. Caespitosa*
Bobcat	*Felis rufus*
Narrow-necked Pohl's moss	*Pohlia elongata var. Elongata*
Sandhill crane (probable nester)	*Grus canadensis*
Bald eagle (nesting pair)	*Haliaeetus leucocephalus*
State Threatened	
Barn owl	*Tyto alba*
Dark-eyed junco (migrant)	*Junco hyemalis*
Hermit thrush (migrant)	*Catharus guttatus*
Least bittern	*Ixobrychus exilis*
Least flycatcher	*Empidonax minimus*
Caddisfly	*Psilotreta indecisa*
Simple willow-herb	*Epilobium strictum*
Woodland horsetail	*Equisetum sylvaticum*
Lurking leskea	*Plagiothecium latebricola*
Pale sedge	*Carex pallescens*
State Potentially Threatened Plants	
Gray birch	*Betula populifolia*
Butternut	*Juglans cinerea*
Northern rose azalea	*Rhododendron nudiflorum var. Roseum*
Hobblebush	*Viburnum alnifolium*

Table 1-3 (continued)
Camp Ravenna Rare Species List

Common Name	Scientific Name
Long beech fern	*Phegopteris connectilis*
Straw sedge	*Carex straminea*
Large St. Johnswort	*Hypericum majus*
Water avens	*Geum rivale*
Shinning lady's tresses	*Spiranthes lucida*
Swamp oats	*Sphenopholis pensylvanica*
Arborvitae	*Thuja occidentalis*
American chestnut	*Castanea dentata*
Tufted moisture-loving moss	*Philonotis fontana var. Caespitosa*
State Species of Concern	
Pygmy shrew	*Sorex hoyi*
Woodland jumping mouse	*Napaeozapus insignis*
Star-nosed mole	*Condylura cristata*
Sharp-shinned hawk	*Accipiter striatus*
Marsh wren	*Cistothorus palustris*
Henslow's sparrow	*Ammodramus henslowii*
Cerulean warbler	*Dendroica cerulea*
Prothonotary warbler	*Protonotaria citrea*
Bobolink	*Dolichonyx oryzivorus*
Northern bobwhite	*Colinus virginianus*
Common moorhen	*Gallinula chloropus*
Great egret (migrant)	*Ardea alba*
Sora	*Porzana carolina*
Virginia rail	*Rallus limicola*
Creek heelsplitter	*Lasmigona compressa*
Eastern box turtle	*Terrapene carolina*
Four-toed salamander	*Hemidactylium scutatum*
Mayfly	*Stenonema ithaca*
Coastal plain apamea	*Apamea mixta*

Table 1-3 (continued)
Camp Ravenna Rare Species List

Common Name	Scientific Name
Willow peasant	*Brachylomia algens*
Sedge wren	*Cistothorus platensis*
State Special Interest	
Canada warbler	*Wilsonia canadensis*
Little blue heron	*Egretta caerulea*
Magnolia warbler	*Dendroica magnolia*
Northern waterthrush	*Seiurus noveboracensis*
Winter wren	*Troglodytes troglodytes*
Black-throated blue warbler	*Dendroica caerulescens*
Brown creeper	*Certhia Americana*
Mourning warbler	*Oporornis philadelphia*
Pine siskin	*Carduelis pinus*
Purple finch	*Carpodacus purpureus*
Red-breasted nuthatch	*Sitta canadensis*
Golden-crowned kinglet	*Regulus satrapa*
Blackburnian warbler	*Dendroica fusca*
Blue grosbeak	*Guiraca caerulea*
Common snipe	*Gallinago gallinago*
American wigeon	*Anas americana*
Gadwall	*Anas strepera*
Green-winged teal	*Anas crecca*
Northern shoveler	*Anas clypeata*
Redhead duck	*Aythya Americana*
Ruddy duck	*Oxyura jamaicensis*

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

1.3.10 Cultural and Archeological Resources

A number of archeological surveys have been conducted at the facility. Cultural and archeological resources have been identified at the facility during past surveys. The Erie Burning Grounds 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 the MRS (AMEC, 2008).

1.4 Facility History and Background

During operations as an ammunition plant, the former 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 (TNT) and Composition B into large-caliber shells and bombs. The operations on the load lines produced explosive dust, spills, and vapors that collected on the floors and walls of each building. Periodically, the floors and walls were cleaned with water and steam. Following cleaning, the "pink water" waste water, which contained TNT and Composition B, was collected in concrete holding tanks, filtered, and pumped into unlined ditches for transport to earthen settling ponds. Load Lines 5 through 11 were used to manufacture fuzes, primers, and boosters. 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.

In 1950, the former 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 former 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).

Erie Burning Grounds MRS History and Background

The Erie Burning Grounds MRS is a 33.93-acre MRS located in the northeast portion of the facility. From 1941 to 1951, the Erie Burning Grounds MRS was used to thermally treat bulk, obsolete, and off-specification propellants; conventional explosives; rags; and large, explosive-contaminated items (e.g., railcars) by open burning on the ground surface. During operations, open railcars were staged at the end of Track 49 and items were tipped out of the car in order to be burned. Ash residue from the open burn activities was left on site after the

burn. In addition to open burn activities, bomb bodies were transported to Erie Burning Grounds for flashing after they were cleaned out (e^2M, 2007).

According to the *Final Archives Search Report* (ASR), filled bombs were most likely not burned at the MRS, since the site is located too close to the installation boundaries (USACE, 2004). The *Final Military Munitions Response Program Historical Records Review* (HRR), identified several former burn areas at Erie Burning Grounds: Burn Area A, Burn Area B, Burn Area C, and Burn Area D. The Former Borrow Area, which is located in the western portion of the MRS, was also used for bomb-flashing activities. Partially buried debris (i.e., munitions debris [MD]), tentatively identified by installation and USACE personnel as remnants of burned-out bombs (size and type not identified), have been observed across the MRS (e^2M, 2007). Historical aerial photographs were reviewed for the evaluation of potential source areas at the MRS and the aerial photograph presented as **Figure 1-8** best represents the source areas that were identified.

Current conditions at the Erie Burning Grounds differ greatly from when the site was active. The area became inundated in the early 1990s as a consequence of sedimentation and vegetation growth and beaver damming of the small stream that drains the former burning ground. Surface water basins now occupy the lowlands at the MRS. The largest surface water basin north of Track 49 has periodically drained on its own. The water reaches a maximum depth of 5 feet within the former drainage channel, but is generally less than 3 feet in most areas. Wetlands extend to the north and east beyond the Erie Burning Grounds (SAIC, 2005).

Cultural features that remain at the MRS consist mainly of the gravel access road, former rail beds, and man-made ditches that traverse or bound the MRS. There are no buildings present at the MRS. Remnants of Track 49 still exist along the crest of the embankment, including railroad ties and miscellaneous associated metal debris (rail spikes, plates, etc.). Current conditions and cultural features that remain at the Erie Burning Grounds MRS are presented in **Figure 1-9**.

1.5 Previous Investigations and Actions

This section briefly summarizes the investigations and actions as it pertains to the Erie Burning Grounds MRS. This information was obtained primarily from the HRR (e^2M, 2007) and the SI Report (e^2M, 2008).

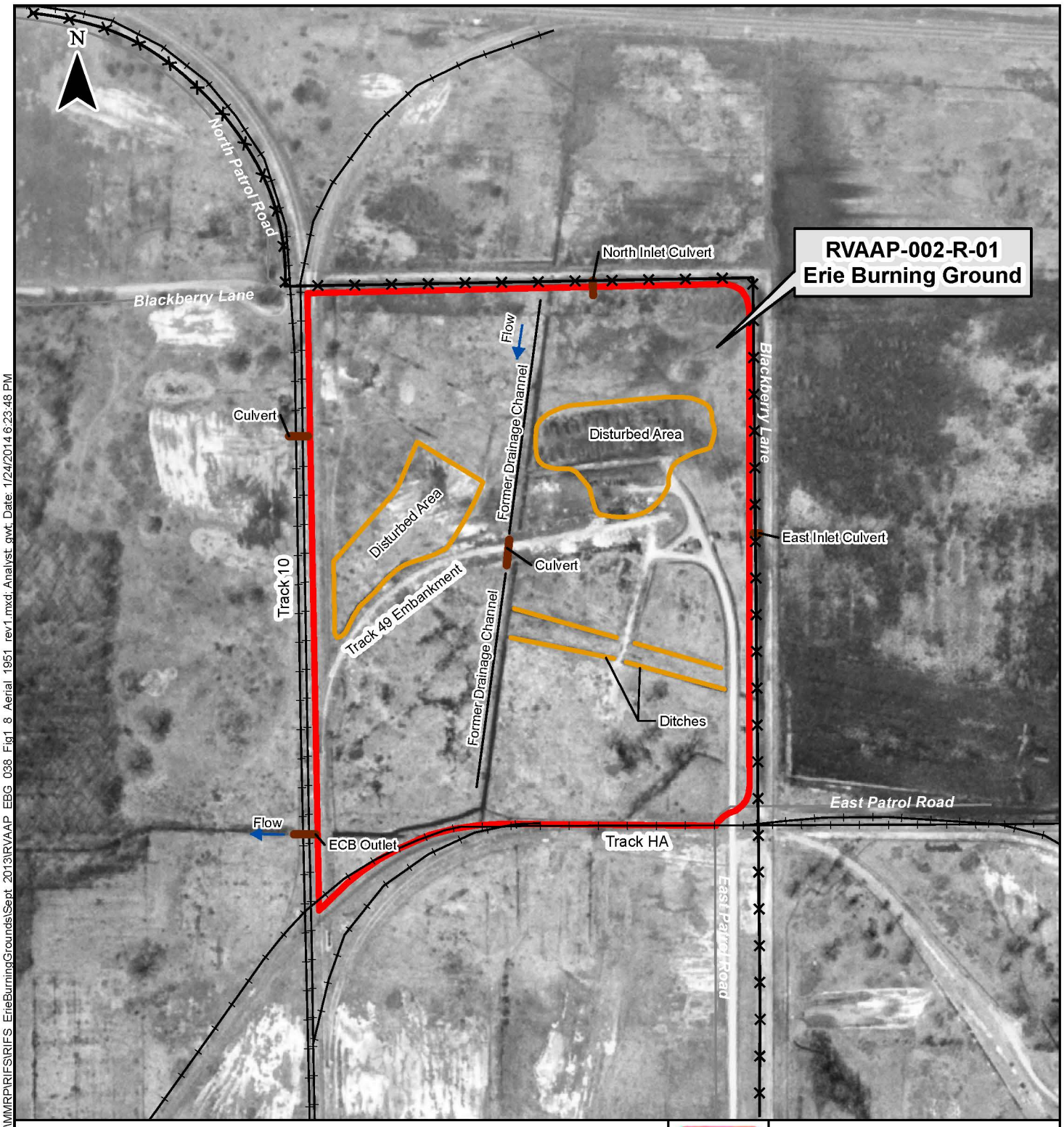


FIGURE 1-8 1951 AERIAL PHOTOGRAPH

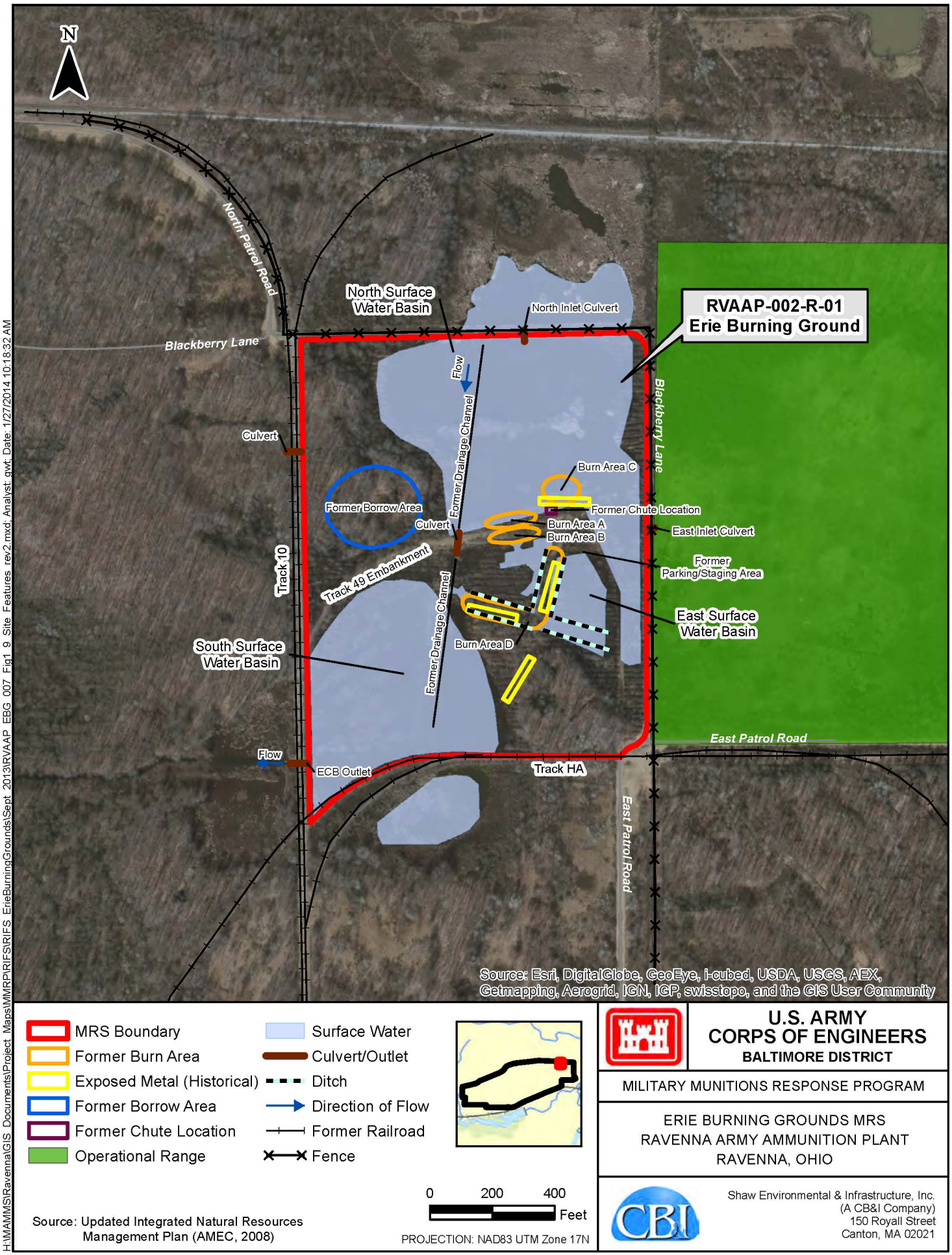


FIGURE 1-9 SITE FEATURES MAP

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 former RVAAP. 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 Erie Burning Grounds MRS was considered to have "potential explosives ordnance presence" (USACE, 2004).

1.5.2 2007 e^{2}M Final Historical Records Review

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

Of the 19 MMRP-eligible 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 and that resulted in the possible presence of MEC and/or MC, and where the releases occurred prior to September 2002 (e^{2}M, 2007). These 18 MRS identified during the HRR include the following:

- Ramsdell Quarry Landfill (RVAAP-001-R-01)
- Erie Burning Grounds (RVAAP-002-R-01)
- Open Demolition Area #2 (RVAAP-004-R-01)
- Load Line #1 (RVAAP-008-R-01)
- Load Line #12 (RVAAP-012-R-01)
- Fuze and Booster Quarry (RVAAP-016-R-01)
- Landfill North of Winklepeck (RVAAP-019-R-01)

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

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

The HRR identified several former burn areas at the Erie Burning Grounds: Burn Area A, Burn Area B, Burn Area C, and Burn Area D (also known as the T-Area). The Former Borrow Area, which is located in the western portion of the MRS, was also used for bomb-flashing activities. Partially buried debris (i.e., MD), tentatively identified by installation and USACE personnel as remnants of burned-out bombs (size and type not identified), have been observed across the MRS. The historical data did not provide adequate information to determine the presence of MEC, MEC density, and MC associated with the intentional disposal of explosives and related items that were anticipated throughout the MRS (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 further recommended for additional characterization under

the MMRP, which included the Erie Burning Grounds MRS (RVAAP-002-R-01). A summary of the SI Report (e^2M, 2008) recommendations for the MRS is presented in **Table 1-4**, and the recommendations are discussed below.

Table 1-4
Site Inspection Recommendation Summary

MRS	MRSPP Priority	Recommendation	Basis for Recommendation	
			MEC	MC
Erie Burning Grounds MRS (RVAAP-002-R-01)	3	Further characterize MEC and MC in wet sediments.	MEC possibly buried. MEC potentially present in submerged areas.	MC in wet sediments and surface water will require further characterization. All other media is addressed under IRP AOC RVAAP-02.

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 unexploded ordnance (UXO) survey that was conducted at all accessible dry areas of the MRS. The total area of the surveys covered approximately 14 acres. The survey instruments used included a Schonstedt handheld magnetic gradiometer and a White Matrix M6 metal detector. Subsurface anomalies were recorded in the northwest, central, and southwest portions of the MRS; however, no MEC was observed at these locations. Several subsurface anomalies were detected in the southwest portion of the MRS, and one possible MEC item was found partially buried northwest of the wooded area. The nature of anomalies was not determined, since an intrusive investigation was not performed as part of the SI. Based on the results of the SI field activities, further characterization for MEC was recommended for the entire MRS, including the inundated areas that were not investigated during the SI (e^2M, 2008). **Figure 1-10** presents the areas investigated and locations of significant findings that were identified during the SI field activities.

MC characterization was not performed at the MRS during the SI, since chemical contamination in soil, groundwater, surface water, and dry sediment was being addressed under the IRP at the same time as the SI field activities. The SI Report recommended further characterization for MC in the pond sediments under any future MMRP action, since this medium was not being evaluated under the IRP (e^2M, 2008).

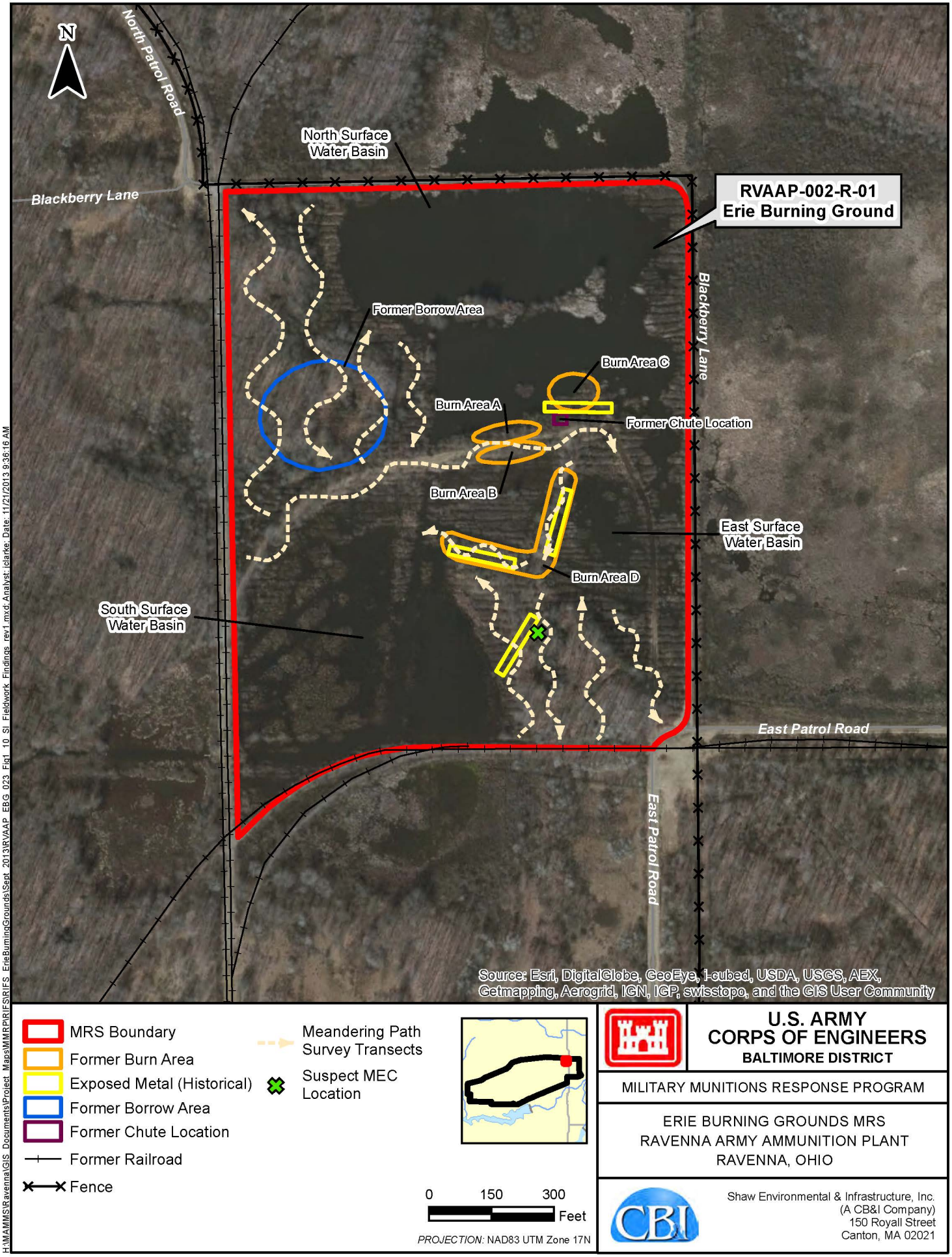


FIGURE 1-10 SI FIELD WORK AND FINDINGS

The Erie Burning Grounds MRS was assigned a Munitions Response Site Prioritization Protocol (MRSPP) priority of 3. 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 Erie Burning Grounds MRS was selected for inclusion for further characterization under the MMRP.

1.5.4 2007 SAIC Record of Decision for Soil and Dry Sediment

Six previous investigations have been performed at the Erie Burning Grounds AOC under the IRP. These investigations were performed to confirm whether chemical contamination was present at the AOC, define the nature and extent of contamination, and evaluate human and ecological risk associated with chemical contamination. Based on the results of the previous investigations, it was concluded that detected chemicals present in soil and dry sediment at the Erie Burning Grounds MRS do not pose a potential risk to human or environmental receptors including Unrestricted Land Use for the Resident Receptor (Adult and Child). As such, a ROD was issued that recommended no further action (NFA) for soil and dry sediment (SAIC, 2007) at the Erie Burning Grounds AOC that is inclusive of the boundaries of the collocated MRS.

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**—Field Documentation
- **Appendix C**—Data Evaluation Report
- **Appendix D**—Summary of Laboratory Analytical Results
- **Appendix E**—Investigation-Derived Waste Management Report
- **Appendix F**—Photograph Documentation Log
- **Appendix G**—Visual Survey and Intrusive Investigation Data Sheets
- **Appendix H**—Munitions Debris Waste Shipment and Disposal Records
- **Appendix I**—Ecological Screening Values
- **Appendix J**—Ecological Risk Assessment Worksheets
- **Appendix K**—Munitions Response Site Prioritization Protocol Worksheets
- **Appendix L**—Ohio EPA Correspondence
- **Appendix M**—Responses to Ohio EPA Comments
- **Appendix N**—Ohio EPA Approval Letter

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2.0 PROJECT OBJECTIVES

This section presents the preliminary CSM for MEC and MC at the Erie Burning Grounds 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 (e.g., lack of fencing) can facilitate trespassing at the MRS, either intentional or accidental.

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

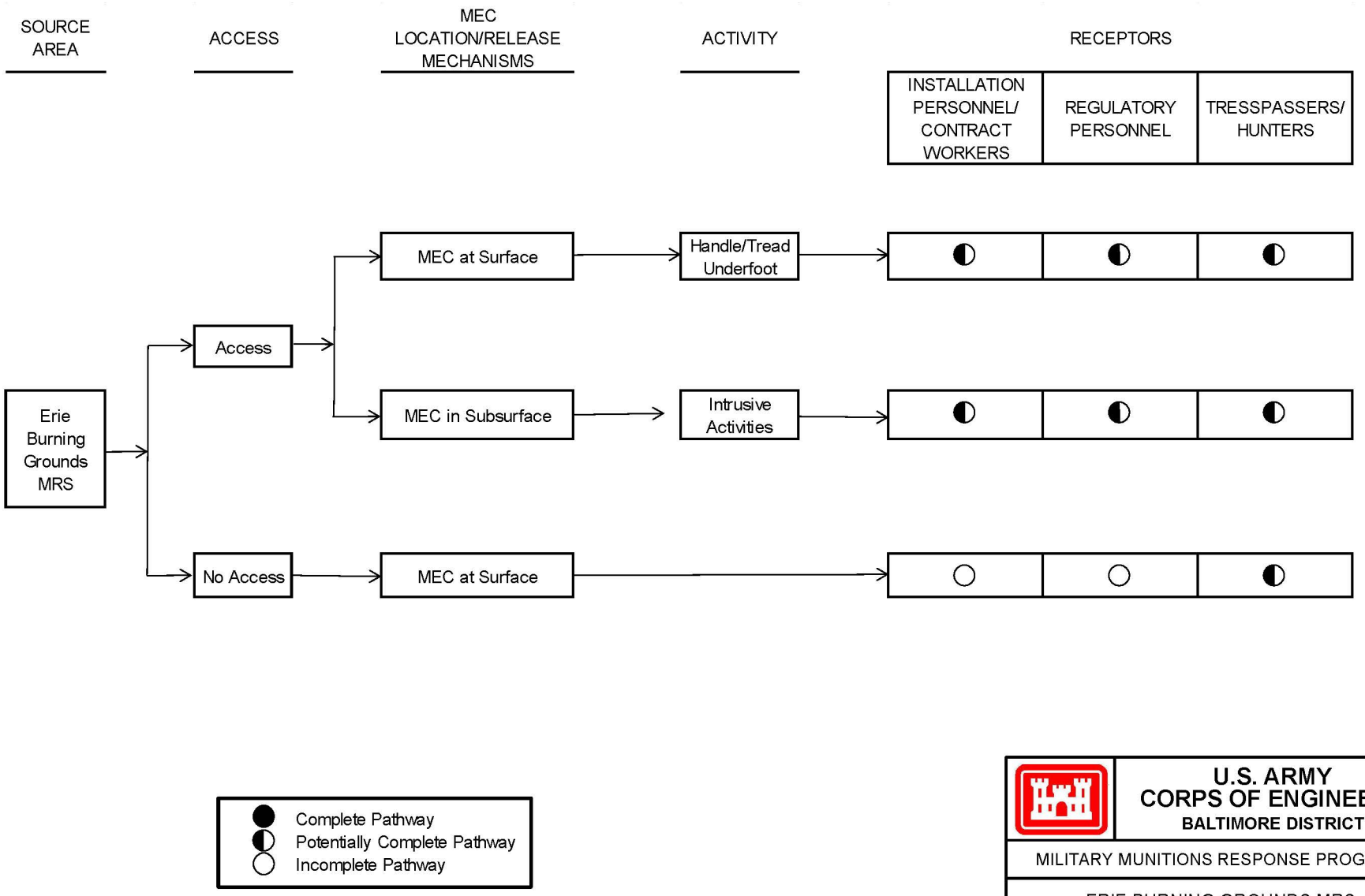
The preliminary CSM developed during the SI identified ecological receptors (biota) to be state-listed species identified as being present at the former RVAAP and listed in **Table 1-3**. For the purposes of the CSMs revised or created based on the RI, biota is identified as the listed and unlisted mammals, 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 Erie Burning Grounds 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 Erie Burning Grounds 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 as **Figures 2-1** and **2-2** for MEC and MC, respectively. A summary of each of the factors evaluated for the preliminary CSM is discussed below.

- **Sources—**Intentional disposal of explosives and related items is the primary source of MEC and MC at the Erie Burning Grounds MRS. Based on review of the archival records and available documentation, the principal sources of MEC and MC at the Erie Burning Grounds MRS are due to thermal treatment of explosives as well as flashing bomb bodies.



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

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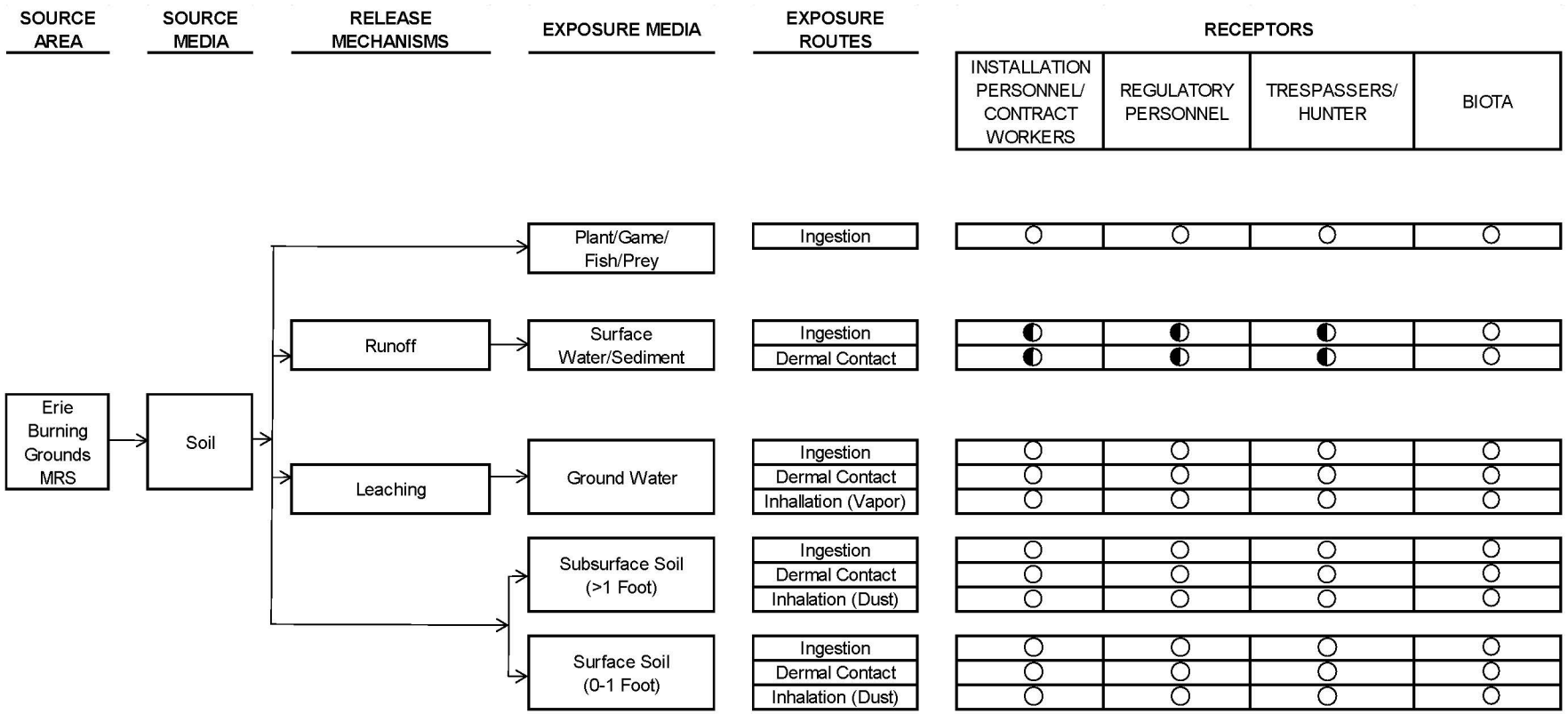
MILITARY MUNITIONS RESPONSE PROGRAM

ERIE BURNING GROUNDS MRS
RAVENNA ARMY AMMUNITION PLANT
RAVENNA, OHIO

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

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FIGURE 2-1 PRELIMINARY MEC CONCEPTUAL SITE MODEL



Note: No samples were collected during the site inspection. Surface/subsurface soil and groundwater were considered incomplete pathways in the Final Site Inspection Report since they were being addressed under the IRP at the time of the site inspection field activities.

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

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MILITARY MUNITIONS RESPONSE PROGRAM

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FIGURE 2-2 PRELIMINARY MC CONCEPTUAL SITE MODEL

- **Activity—**Human activities considered for the preliminary CSM included surveying, sampling, security, safety, maintenance, and natural resource management activities, which may result in moving or somehow disturbing MEC that could cause it to detonate.
- **Access—**Due to the high-quality wetlands and potential explosive hazard associated with MEC, current access to the Erie Burning Grounds MRS is restricted to authorized personnel only. However, no formal land use controls prevent access to the MRS. The preliminary CSM assumes that any MEC present at the MRS is submerged; therefore, transport and migration are not likely, unless disturbed. Receptors would have direct access to MEC lying on the ground surface during use of the MRS.
- **Receptors—**At the time of the SI, current and reasonably anticipated receptors included facility personnel, contract workers, regulatory personnel, trespassers, hunters, and biota (MC only). The ecological receptors (biota) identified in the SI Report (e^2M, 2008) were the state-listed species identified as being present at the facility and listed in **Table 1-3**. If present, MEC and/or MD and associated MC on the ground surface and near the surface could have been accessed by receptors.

In the early 1990s, the majority of the MRS became flooded due to a combination of sedimentation, vegetative growth, and beaver damming, leaving only the railroad embankment and a portion of the T-Area exposed. Within these areas, the primary exposure pathway for human receptors was considered to be contact with MEC lying on the ground surface. Periodically, the open water body north of the rail spur has drained on its own. During these episodes, contact with submerged MEC items could be possible. As such, the MEC exposure pathway for human receptors was considered potentially complete and included the disturbance of surface and subsurface soils or contact with submerged munitions in the water bodies. It was determined in the preliminary CSM that any MEC that was likely to be at the MRS was submerged, and transport and migration was not likely, unless disturbed. The preliminary CSM for MEC at the Erie Burning Grounds MRS, as presented in the SI Report (e^2M, 2008), is shown in **Figure 2-1**.

No MC sampling was conducted during the SI field work; however, the presence of explosives and metals in the surface and subsurface soil, surface water, and dry sediments had been established by investigations conducted under the IRP prior to the SI activities. These media were not addressed in the SI Report, since they were being addressed under the IRP. Additionally, the chemical contamination in soils and dry sediments has been addressed under the IRP with a risk assessment recommendation of NFA (i.e., Unrestricted Land Use was achieved for the Resident Receptor). A decision concerning MC in wet sediments had

not been made under the MMRP at the time of the SI Report, and it was determined for the preliminary CSM for MC that the exposure pathways, considered as dermal contact and ingestion, for wet sediment were potentially complete for human receptors. The exposure pathways for biota were considered incomplete for all media since no federally listed species or critical habitats were present at the facility at the time of the SI field activities. The preliminary CSM for MC at the Erie Burning Grounds 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 former RVAAP 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, TBC information, preliminary remediation goals, and remedial action objectives will be included in the FS 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 Addendum (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 at the RVAAP* (FWSAP) (SAIC, 2011b) and the U.S. Environmental Protection Agency (EPA) *Data Quality Objectives Process for Hazardous Waste Site Investigations*, EPA QA/G-4HW (2000). **Table 2-1** identifies the DQO process developed in the Work Plan Addendum (Shaw, 2011).

Table 2-1
Data Quality Objectives Process for the Erie Burning Grounds MRS

Step	Data Quality Objective
1. State the problem.	Munitions were thermally treated at the Erie Burning Grounds MRS. In addition, open burning of bulk, obsolete, off-specification propellants; conventional explosives; rags; and large, explosive-contaminated items was performed at the MRS. Based on the past activities, 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 Erie Burning Grounds MRS is to identify the areas impacted with MEC/MD. In addition, MC sampling will be performed in order to further characterize the type and amount 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 health and the environment.
3. Identify inputs to the decision.	• Historical information • DGM survey • Intrusive investigation • Surface water and incremental sediment sampling
4. Define the study boundaries.	The RI will be performed in the Erie Burning Grounds MRS boundaries as defined at the conclusion of the SI.
5. Develop a decision rule.	Although formal visual survey transects are not planned at Erie Burning Grounds, the presence of surface MEC/MD will be investigated during the DGM survey. A DGM survey and intrusive investigation will be performed at the Erie Burning Grounds MRS to assess the presence of buried MEC/MD. The DGM transects were placed using UXO Estimator®. CB&I and USACE agreed upon UXO Estimator® inputs of 95-percent confidence and 0.5 UXO/acre. 100 percent of the anomalies will be investigated to meet MRS-specific criteria. Land-based DGM will be performed in the dry areas at Erie Burning Grounds. At locations where water depth is less than 2 feet, float-mounted DGM will be performed. In areas with water depth greater than 2 feet, former U.S. Navy EOD divers will perform the DGM surveys. The extent of float-mounted DGM survey and former U.S. Navy EOD diver DGM surveys will be dependent on the MRS conditions at the time of the survey. In accordance with the recommendations in the SI Report (e^2M, 2008), MC sampling will be conducted for wet sediments and surface water at the MRS. A total of six ISM wet sediment samples will be collected from the wetland areas; three ISM sediment samples will be collected from the North Surface Water Basin (2.8 acres each), two ISM sediment samples will be collected from the South Surface Water Basin (3.2 acres each), and one ISM sediment sample will be collected from the East Surface Water Basin (1.5 acres). The rationale for the number of wet sediment samples is to develop an adequate conceptual site model and meet the project objects based on providing representative sized decisions units that are not underestimating (i.e. diluting) or missing contamination that may be present at a level of concern.

Table 2-1 (continued)
Data Quality Objectives Process for the Erie Burning Grounds MRS

Step	Data Quality Objective
5. Develop a decision rule (continued).	The sampling rationale was evaluated in accordance with the *Interim Guidance 09-02, Implementation of Incremental Sampling (IS) of Soil for the Military Munitions Response Program* (USACE, 2009a). A total of three surface water samples will be collected, one from each of the water basin areas. The samples will be analyzed for metals (aluminum, antimony, barium, cadmium, total and hexavalent chromium, copper, iron, lead, mercury, strontium, and zinc), explosives, semivolatile organic compounds, polychlorinated biphenyls, and nitrocellulose. The sediment and surface water samples will also be analyzed for geochemical metal parameters (calcium, magnesium, and manganese). No additional soil or dry sediment sampling is warranted at the MRS based on the ROD for soils and sediment performed under the IRP; however, additional MC sampling may be performed for these environmental media if source areas of MEC/MD are identified.
6. Specify limits of decision errors.	QC procedures are in place so that all fieldwork is performed in accordance with all applicable standards. Further details on the QC process implemented during the RI are located in Section 4.0 of the Work Plan Addendum (Shaw, 2011).
7. Optimize the design for obtaining data.	The information gathered as part of the field investigation at Erie Burning Grounds will be used to determine what risks or hazards, if any, are present. A MEC HA will be completed to identify the potential MEC hazards. In addition, a MRS-specific HHRA and ERA will be performed on the analytical results. If unacceptable risks or hazards to human health and the environment 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.
DGM denotes digital geophysical mapping.
EOD denotes explosive ordnance disposal.
ERA denotes ecological risk assessment.
HA denotes Hazard Assessment.
HHRA denotes human health risk assessment.
IRP denotes Installation Restoration Program.
ISM denotes incremental sampling methodology.
MC denotes munitions constituents.
MD denotes munitions debris.
MEC denotes munitions and explosives of concern.
MRS denotes Munitions Response Site.
QC denotes quality control.
RI denotes Remedial Investigation.
ROD denotes Record of Decision.
Shaw denotes Shaw Environmental & Infrastructure, Inc.
SI denotes Site Inspection.
USACE denotes United States Army Corps of Engineers.
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 human health 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 surface water, sediment, and other environmental media (surface and subsurface soil) 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 and Facility-Wide Surface Water/Sediment Data**—Data collected under the IRP and the 2003 *Facility-Wide Biological and Water Quality Study* (FWBWQS) (USACE, 2005b) at the Erie Burning Grounds include analytes considered to be MC associated with previous activities at the MRS, although it should be noted that not all analytes are considered as MC. Previously collected datasets may be incorporated with sampling data collected during the MMRP RI on a MRS-specific basis in order to close data gaps. For the Erie Burning Grounds MRS, the IRP data were reviewed and it was determined that

incorporation of soil and dry sediment data into the RI was not required, as it has been concluded under the IRP that detected chemicals in soil and dry sediment do not pose risks to likely human and environmental receptors (SAIC, 2007). Surface water samples collected for the IRP and the 2003 FWBWQS were not evaluated, since the surface water samples collected for this RI are considered to be more representative of current surface water conditions at the MRS. Wet sediment is one of the media of focus of the RI field activities, and the wet sediment samples for the RI were collected using the incremental sampling methodology (ISM). Wet sediment samples were also collected at the Erie Burning Grounds under the IRP and the 2003 FWBWQS. Evaluation of wet sediment under the IRP consisted primarily of discrete sampling methods and the sampling depth (0 to 3 inches bgs) and the sample equipment (Eckman sampler) used for the collection for wet sediment during the 2003 FWBWQS were different than for the RI field sampling event. In addition to providing results that are more representative of current conditions, the wet sediment samples collected during the RI using ISM provides for a more representative concentration over a spatial area in comparison to discrete sampling methods used during the IRP. The wet sediment samples collected during the RI were collected at 0 to 6 inches bgs that is the requisite exposure depth scenario in wet sediment at the facility (SAIC, 2010). Collection of the ISM samples using a step probe provides for an adequate volume (1 to 2 kilograms [kg]) and is the recommended equipment for ISM sample collection in accordance with the USACE guidance (2009a). Therefore, the results for the wet sediment samples collected under the IRP and the 2003 FWBWQS were not considered to be comparable to the wet sediment samples collected during the RI field activities and are not included for evaluation into this RI Report.

- **SI Data**—The MMRP SI conducted at the facility in 2007 (e^2M, 2008) provides visual survey data, which were used to preliminarily delineate areas where MEC and/or MD may have been disposed of by open burn activities. MC sampling was not performed during the SI at the Erie Burning Grounds MRS; therefore, no MC data was available from the SI field activities for inclusion in the RI.

3.0 CHARACTERIZATION OF MEC AND MC

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

3.1 MEC Characterization

The following sections summarize the geophysical, anomaly reacquisition, and subsequent intrusive investigation activities that were performed at the Erie Burning Grounds MRS during the RI field activities. Based on the historical open burn 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 Erie Burning Grounds MRS consisted of performing a digital geophysical mapping (DGM) investigation throughout the MRS as presented in the Work Plan Addendum (Shaw, 2011). Visual surveys of surface conditions were performed 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

In January and February of 2012, a DGM investigation was performed at the Erie Burning Grounds MRS to identify potential subsurface areas of MEC and/or MD. The approved sampling coverage presented in the Work Plan Addendum (Shaw, 2011) utilized the UXO Estimator® Version 2.2 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 5.2 acres of DGM data to be collected over the 33.93-acre MRS (15.4 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 (cm). Two EM61-MK2 deployment platforms were used at the Erie Burning Grounds MRS, depending on MRS conditions. For the survey over the terrestrial portion of

the MRS, the EM61-MK2 was deployed in the standard wheeled configuration with the lower coil positioned 16 inches (42 cm) above ground surface. For the remainder of the MRS that contained water/wetlands, it was necessary to use a floating platform. 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 two positioning systems: a Leica robotic total station (RTS) system and a Leica real-time kinematic (RTK) global positioning system (GPS). The RTK-GPS was used in areas that had a clear view of the sky, and the RTS was used in areas of heavy canopy. The team that performed the DGM survey consisted of two geophysicists and a UXO-qualified escort.

The *Digital Geophysical Mapping Report for RVAAP-002-R-01 Erie Burning Grounds MRS*, 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 Erie Burning Grounds MRS with regard to data acquisition, processing and analysis, and results of the DGM quality control (QC) program.

The DGM system used for the Erie Burning Grounds 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 report/technical memorandum is included as an attachment to the DGM Report in **Appendix A**.

Prior to the DGM survey at the Erie Burning Grounds MRS, a civil survey and vegetation clearance were performed to prepare the MRS for DGM activities.

3.1.1.1 Civil Survey

A Ohio Registered Land Surveyor established two survey monuments at the Erie Burning Grounds MRS. Each monument was established with third-order horizontal accuracy (residual error less than or equal to 1 part in 10,000). In areas where data could be acquired using the RTK-GPS, the survey monuments were used to provide positional data streamed directly to the EM61-MK2. In areas where the tree cover prohibited the use of RTK-GPS, the control monuments were used as a source to generate additional control points for the RTS. All of the survey data documenting MRS features and obstructions is referenced to the two established survey monuments.

For QC purposes, both the RTK-GPS and RTS positioning systems were used to reacquire a known, fixed location each time either system was set up to record data. Per the project metrics defined in the Work Plan Addendum (Shaw, 2011), static measurements for the positioning system were required not to exceed 0.5 feet. One hundred percent of location checks satisfied the metric. All mapping was developed in the Universal Transverse Mercator Zone 17 North Coordinate System, North American Datum 1983.

3.1.1.2 Vegetation Clearance and Inaccessible Areas

In recent years, the MRS has become inundated with water and the growth of wetland vegetation, primarily from beaver dam construction. Currently, approximately 80 percent of the MRS is covered by water that includes high-quality wetlands. The water level fluctuates seasonally and is strongly affected by local precipitation. At the time of the survey, the water depth ranged between 2 to 3 feet across most of the MRS. The majority of the terrestrial portions of the MRS are located along the perimeter road. The area between the perimeter road and the ponded areas has dense vegetation that consists of thick brush and trees with low-hanging limbs. Vegetation removal was required at the edges of the ponds in order to provide adequate ground clearance for the proposed transects as well as access for the DGM equipment into the ponds. 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.

3.1.1.3 Data Collection and Site Coverage

In order to meet the proposed investigation coverage requirement, DGM data were acquired in all accessible areas within the MRS boundaries on 81 transects spaced approximately 6 meters apart. The actual spatial coverage was calculated to be 6.8 acres, or 20 percent of the MRS, and exceeds the proposed sampling coverage of 5.2 acres presented in the Work Plan Addendum (Shaw, 2011). The 6.8 acres of actual DGM coverage equates to a total transect distance of 17 miles, as each transect is considered to have a 1-meter footprint based on the width of the EM61-MK2. The general DGM procedures performed for data acquisition at the Erie Burning Grounds 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 (RTK-GPS) or at a location determined by using a minimum of two known control points (RTS). The location control was verified by at least one “checkshot” at a different control point of known location.

- DGM system instrument functional checks were performed at the start and end of each day and the results were documented.
- DGM data were collected over the area in a systematic fashion with respect to the terrain, vegetation, and obstacles present. The acquisition protocol used navigation techniques proven at the IVS.
- Field logs were used to document 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 Shaw 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, 2009b).

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

3.1.1.4 Data Processing and Interpretation

The geophysical data were processed, analyzed, and interpreted using the methods and approach outlined in the Work Plan Addendum (Shaw, 2011). Using the EM61-MK2 to survey large areas covered by water is a relatively unique application, as the instrument was designed to be used on land where the lower coil is maintained at a constant, fixed distance of 16 inches (42 cm) above ground surface. Water depths that exceed approximately 3 inches result in a potential decrease in sensitivity for the EM61-MK2. Since the EM61-MK2 was deployed as a floating platform with the lower coil maintained approximately 13 inches above the surface of the water throughout much of the Erie Burning Grounds MRS, it was necessary to select a conservative target-picking threshold to compensate for the variable water depth at the MRS. An 8-millivolt (mV) threshold (Channel 2) was considered appropriate for anomaly selection in the terrestrial portions of the MRS. A 5-mV threshold (Channel 2) was considered appropriate for anomaly selection in the areas of the MRS covered by water and was used to pick targets across water-covered areas of the MRS. The 5-mV threshold (Channel 2) was found to be reasonable for the work being performed at the Erie Burning Grounds MRS based on: (1) the results of the IVS where smaller MEC items in the near-surface produced a response that exceeds 5 mV, and (2) the results of the Open Demolition Area #2 MRS and Ramsdell Quarry Landfill (Area 2) MRS, which are



FIGURE 3-1 PLANNED DGM TRANSECTS MAP

considered as similar sites to the Erie Burning Grounds MRS. At these MRSs, the excavation results indicated approximately 30 percent of the anomalies less than 5 mV were "no finds." In addition, for areas at the MRS that were identified as "background" noise level, the standard deviation on Channel 2 is approximately 0.4. The target selection threshold of 5 mV is 10 times the background noise value. Important factors that were considered during the interpretation process included the following:

- Data acquisition methods (one-dimensional, as is the case for the Erie Burning Grounds MRS)
- 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)
- Anomaly time constants
- Local background conditions
- Presence of surrounding anomalies (anomaly density)
- Presence of cultural features and sources of interference
- Anomaly characteristics of the IVS items

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

3.1.1.5 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 Addendum (Shaw, 2011). The performance metrics for the DGM system were derived from a combination of DID MMRP-09-004, *Geophysics* (USACE, 2009b) and the USACE Table *Performance Requirements for RI/FS using DGM Method*, which is presented in *Geophysics*, DID WERS-004.01 (USACE, 2010a). 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 part of the geophysics digital data deliverable in **Appendix A**.

3.1.2 Anomaly Investigation Activities

Following the completion of the DGM survey in February 2012, anomaly reacquisition was conducted for the locations identified as potentially containing subsurface MEC and/or MD in April and May 2012. These locations were identified as potentially containing subsurface MEC and/or MD based on the interpreted results of the DGM data review. Since complete DGM coverage was not performed at the MRS, the intrusive investigation activities required 100-percent reacquisition of individual non-culturally related anomalies that exceed the 8-mV threshold in the terrestrial portion of the MRS and the 5-mV threshold in the underwater portions of the MRS. The target locations were evaluated to determine if they were high-density anomaly areas that required excavation using mechanical equipment or were point-source anomalies that could be manually investigation (hand-dug). All anomaly investigation activities were performed by UXO-qualified personnel. Selection of investigation areas based on the DGM results is discussed further in Section 4.1, "MEC Investigation Results."

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 terrestrial 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. 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 Addendum (Shaw, 2011). Any items identified as MPPEH item were evaluated by the Senior UXO Supervisor (SUXOS) as to whether an explosive hazard was present. If no explosive hazard was identified, the item was considered material determined 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 MRS 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 Tactile Underwater Investigation Procedures

The maximum depth of water at the Erie Burning Grounds MRS was approximately 3 feet; however, the depths of the ponds were shallower at most locations. The clarity of the water at the MRS was very poor and these conditions limited the ability for the UXO technicians to move or jar any potential MEC or MPPEH that was buried in the sediment of the ponds. Therefore, no intrusive investigations using manual digging could be performed for underwater anomalies, and instead the UXO technicians used U.S. Navy tactile underwater investigation techniques.

The UXO technician reacquired the location of the anomaly using the Leica positioning system and verified the presence of a metallic item using a Diver Mag 1 underwater magnetometer. The underwater tactile investigations were performed by UXO technicians who were very familiar with the different ordnance categories/groups, and the arming and functioning of each item. After using the magnetometer to pinpoint the location of the object on the bottom (or in the sediment), the UXO technician 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 equals 1 foot, palm width equals 4 inches, etc.) the approximate size of the item was determined. The item was then to be evaluated if it contained a fuze (point detonating, mechanical time, proximity, etc.). If a MPPEH item was identified, the item was not to be moved or subjected to any sudden forces during the investigation.

3.1.2.3 High-Density Anomaly Area Reacquisition and Investigation Procedures

Trenching was performed at locations identified as having high-density areas 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; 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 Addendum (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 MRS 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.

3.1.2.4 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, 2009b). 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.

3.1.2.5 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 UXO QC Supervisor (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 size of the MRS (33.93 acres), the actual area investigated (6.8 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 4.2.4, "UXO Estimator® Analysis Results."

3.2 MC Characterization

The MC characterization activities and decision making process at the Erie Burning Grounds MRS are summarized in this section. Sampling for MC was predetermined during the DQO decision-making process to further characterize the nature and extent of contamination associated with previous activities at the MRS.

Predetermined sample locations for wet sediment and surface water were established for the Erie Burning Grounds MRS in the Work Plan Addendum (Shaw, 2011). The rationale for the number of wet sediment samples was to develop an adequate CSM for MC and meet the project DQOs by providing representative sized sampling units that are not underestimating (i.e. diluting) or missing contamination that may be present at a level of concern. The wet sediment samples were collected using ISM in order to achieve the DQOs. The surface water

samples were collected as discrete samples from the same surface water basins that the wet sediment samples were collected.

Soil samples were not predetermined for the RI field activities since soil and dry sediment at the Erie Burning Grounds did not require further characterization (e^2M, 2008). However, the Work Plan Addendum (Shaw, 2011) did specify that soil samples would be required at terrestrial areas with concentrated areas of MEC and MD and two soil samples were collected from the bottom of trenches where buried MD was found during the RI. The soil samples were collected from the bottoms of the trenches using the ISM similar to the procedures used at other MRSs at the former RVAAP under the MMRP, in particular the Group 8 MRS where soil samples were collected from the bottoms of burial trenches as well.

All MC samples 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) Addendum," which is included in Appendix A of the Work Plan Addendum (Shaw, 2011). The results of the MC sampling activities are presented in Section 4.4, "Nature and Extent of SRCs."

3.2.1 Sampling Approach

The grab surface water samples, ISM wet sediment samples, and ISM trench soil samples were collected at the Erie Burning Grounds MRS to evaluate for the nature and extent of contamination associated with historical activities at the MRS and to determine whether or not there is unacceptable risk. For the purposes of this RI and the sampling approach discussion for the ISM trench soil samples, subsurface soil is considered to be samples collected at depths greater than 1 foot bgs. These definitions of soil depths do not take into account the facility's definition of surface and subsurface soil for the receptors that are identified in the *Final Facility-Wide Human Health Cleanup Goals for the RVAAP* (SAIC, 2010), hereafter referred as the "Facility-Wide Cleanup Goal (FWCUG) guidance." Discussion regarding the ISM soil samples collected at depths in relation to the identified human receptors is presented in Section 7.0, "Human Health Risk Assessment." **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 Depth	Number of Samples[1]	Rationale
Surface Water	D	1.5 feet bws	3	To characterize the potential release of MC in surface water in each of the three surface water basins.

Table 3-1 (continued)
Summary and Rationale for MC Sample Collection

Medium	Sample Type	Sample Depth	Number of Samples[1]	Rationale
Wet Sediment	ISM	0–0.5 feet bss	6	To characterize the potential release of MC in sediment in each of the three surface water basins.
Subsurface Soil (Burial Trenches)	ISM	3.0–4.5 feet bgs	2	To characterize MC in soils at the base of two trenches; the RI identified concentrated MD in the trenches.

[1] *Number of samples does not include field duplicate or other quality control samples.*
bgs denotes below ground surface.
bss denotes below sediment surface.
bws denotes below water surface.
D denotes discrete (grab) sample.
ISM denotes incremental sampling methodology.
MC denotes munitions constituents.
MD denotes munitions debris.

The methods used in the collection of the grab surface water samples and the ISM sediment and soil samples during the RI field activities are summarized in the following sections.

3.2.1.1 Surface Water Sample Collection

The surface water samples (EBGsw-001D-0001-SW, EBGsw-002D-0001-SW, and EBGsw-003D-SW) were collected on May 7, 2012, from each of the main water basins at the MRS as predetermined in the SAP Addendum (Shaw, 2011). The surface water samples were collected using the hand-held bottle sample method. The sample collection procedure included lowering the sample bottle with the cap in place into the ponds to a depth of approximately 1 to 2 feet below the water surface. The sample bottle was then slowly filled using the cap to regulate the rate of sample entry into the container. The sample bottle was filled such that a minimum amount of bubbling occurred. For bottles containing preservative (i.e., metals analysis), a 1-liter amber bottle that did not contain preservative was used to collect the surface water sample from the pond for transfer into the bottle containing the preservative. Immediately following sample collection and completion of the bottle label information, each sample container was placed into a sealable plastic bag and then placed into an ice-filled cooler to ensure preservation.

The QC samples for surface water included a field duplicate and a matrix spike (MS)/matrix spike duplicate (MSD) sample. The field duplicate sample was collected at the same approximate location and depth as the original sample and required the same volume of water as the original sample. The field duplicate sample was labeled with a different sample number (EBGsw-004D-0001-SW) and was submitted to the contracted laboratory as a blind

field duplicate of surface water sample EBGsw-003D-0001-SW. Surface water sample EBGsw-001D-0001-SW was designated as the MS/MSD.

The grab surface water samples were collected in accordance with the SAP Addendum (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 surface water samples submitted to the contracted laboratory are included in **Appendix B**. **Figure 3-2** presents the surface water sample locations at the MRS.

3.2.1.2 Wet Sediment Sample Collection

The six ISM wet sediment samples (EBGsd-005M-0001-SD, EBGsd-006M-0001-SD, EBGsd-007M-0001-SD, EBGsd-008M-0001-SD, EBGsd-009M-0001-SD, and EBGsd-010M-0001-SD) were collected on May 8, 2012, from the main water basins at the Erie Burning Grounds MRS as predetermined in the SAP Addendum (Shaw, 2011). Each of the wet sediment samples were collected over an area that was designated as a sampling unit. Three ISM sediment samples were collected from sampling units at the North Surface Water Basin (2.8 acres each), two ISM sediment samples were collected at sampling units from the South Surface Water Basin (3.2 acres each), and one ISM sediment sample was collected at a sampling unit from the East Surface Water Basin (1.5 acres).

Each sampling unit consisted of 30 increments and each increment was collected at a sample depth of 0 to 0.5 feet beneath the sediment surface. The entire length of sediment collected at each of the 0-to-0.5–foot increments within a sampling unit was used to make up each of the ISM wet sediment samples. The six wet sediment sampling units were combined to make up the decision unit for wet sediment at the MRS.

The SAP Addendum (Shaw, 2011) did not specify the ISM collection designs for wet sediment, although it is expected that the collection of ISM wet sediment samples would closely follow the methods specified in the SAP Addendum for the ISM soil samples. The collection designs for ISM soil samples in the SAP Addendum consisted of the systematic and stratified random sampling methods. The conditions at the ponds that consisted of irregular shapes, the presence of thick vegetation, underwater obstacles, and small islands in the middle of the ponds, limited the ability to collect ISM wet sediment samples using either of the aforementioned methods and the simple random sample pattern was used instead. Use of the simple random sample pattern represents a slight deviation from the SAP Addendum (Shaw, 2011); however, this method is acceptable in accordance with the *Interim Guidance 09-02, Implementation of Incremental Sampling (IS) of Soil for the Military Munitions Response Program* (USACE, 2009a). The simple random pattern deviates from the systematic and stratified random sample patterns in that the increments for the simple random pattern are collected randomly with no established grids that are associated with the

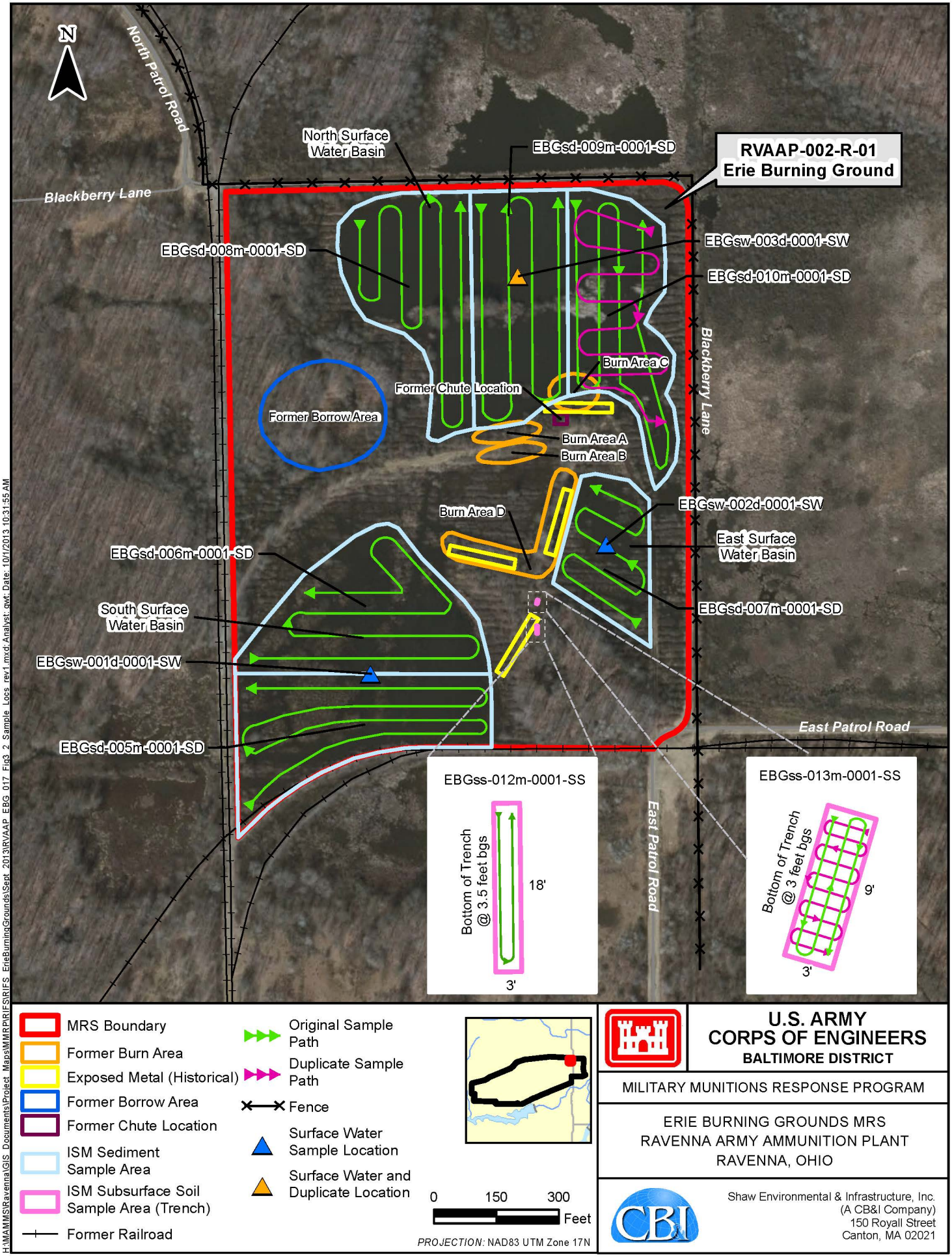


FIGURE 3-2 MC SAMPLE LOCATIONS

other two ISM sampling methods. Purely random sampling provides statistically uniform coverage and meets the requirement that every point within the sampling unit has an equal probability of being included in the ISM sample; however, random sampling does make it difficult to truly recreate the increment locations with the sampling units (USACE, 2009a).

Difficulty in recreating the original sample increment locations has the potential to impact any field duplicate samples that are collected and the ability to use these samples to determine sample heterogeneity and sampling methodology reproducibility. Taking this into consideration, there are other methods to help determine these criteria, such as the MS/MDS and laboratory duplicate samples associated with the original samples, and the uncertainties associated with implementation of the simple random pattern and the potential for impacting the data usability of the original sediment sample results using this pattern are considered minimal.

The wet sediment sampling units were established by a combination of terrain (i.e., edges of the ponds) and wood stakes along the edge of the pond. The ISM samples were collected from the predetermined number of increment sampling locations using a ⅞-inch stainless steel step probe sample collection device. The wet sediment increments were placed into a plastic sealable bag and combined to make a sample weighing between 1 to 2 kg.

The step probe sample collection device is similar to the hand core sampler with regards to the equipment technology and sampling methodology that was proposed in the Work Plan Addendum (Shaw, 2011). Due to the high clay content in the sediment, the step probe has a core tip that was able to collect the requisite 6 inches that is the considered the exposure depth in sediment to the facility receptors as discussed in Section 4.0. Extension rods were not required due to the relative shallow depth of the ponds. Based on the ability to collect the required increments for the ISM wet sediment samples at the applicable exposure depth, any uncertainties associated with using the stainless step probes in place of the originally proposed hand core samplers are considered minimal.

MEC avoidance activities were conducted prior to the collection of any increments for the ISM sediment samples. A UXO technician performed initial clearance at each increment sample location using a Diver Mag 1 underwater magnetometer. If an anomaly was detected, the sediment sample was moved until there was no reading on the magnetometer.

The QC samples included a field duplicate and a MS/MSD sample. The collection of the QC samples required similar increments of wet sediment as the original sample. Therefore, at the ISM sampling unit where a QC sample was required, an additional ISM sample was collected from within the same sampling unit consisting of 30 increments of wet sediment. The increments for the field duplicate were collected at randomly selected locations that

were different from the initial sample increments. The field duplicate was labeled with a different sample number (EBGsd-011M-0001-SD) and was submitted to the laboratory for processing as a blind field duplicate for wet sediment sample EBGsd-010M-0001-SD. Due to sufficient soil volume, additional collection of soil for the MS/MSD was not required and sample EBGsd-010M-0001-SD was analyzed as the MS/MSD by the contracted laboratory.

The sampling field logs where all data and observations at the sample locations were recorded and the chain-of-custody form for the wet sediment samples submitted to the contracted laboratory are included in **Appendix B**. **Figure 3-2** presents the wet sediment sample locations at the MRS.

3.2.1.3 Subsurface Soil Sample Collection

The ISM trench soil samples (EBGss-012M-0001-SS and EBGss-013M-0001-SS) were collected on May 9, 2012, at two locations (Trenches 6 and 8) where buried MD was encountered during the intrusive investigation activities. Each of the trenches was considered as separate sampling units that were combined to make up the subsurface decision unit for the terrestrial portions of the MRS. The surface areas for the ISM samples collected at Trenches 6 and 8 were 27 and 54 square feet, respectively.

Each sampling unit consisted of 30 increments collected from each of the two trenches. The ISM increments were collected at sample depths of 0 to 0.5 feet (6 inches) at the bottoms of the trenches. The increments were collected in a systematic random pattern from each designated sampling unit. The trench sample depths were 3.5 to 4 feet bgs at Trench 6 and 3 to 3.5 feet bgs at Trench 8.

The 0.5-foot (6-inch) bgs sample interval at the bottom of the trenches is considered appropriate in accordance with the *Munitions Response Remedial Investigation/Feasibility Study Guidance* (U.S. Army, 2009) and is the maximum depth that MC released from buried MEC or MD would be expected to vertically migrate. The entire length of the soil collected at each of the 0-to-0.5–foot increments within a sampling unit (i.e., each trench location) was used to make up each of the ISM samples.

The collection of ISM samples from beneath concentrated areas of MEC/MD is considered a deviation from the SAP Addendum (Shaw, 2011) since discrete samples were originally proposed; however, the ISM is considered the more applicable approach for providing an estimate of the mean analyte concentration over a sampling unit when possible.

Each ISM subsurface soil sample consisted of 30 increments collected from locations selected in a systematic random pattern throughout the designated grid area (i.e., sampling unit). The three key steps for collection of a systematic increment were: (1) subdivide the

sampling unit into a uniform grid (i.e., pace out the area and divide into at least 30 grids for a 30-increment sample), (2) randomly select a single increment location in the first grid, and (3) collect increments from the same relative location within each of the other grids.

The ISM trench soil samples were collected from the predetermined number of increment sample locations using a $^{7}/_{8}$-inch–diameter stainless steel step probe sample collection device. The increments of soil were placed into a plastic sealable baggie and combined to make a single sample weighing between 1 to 2 kg.

The QC samples included a field duplicate sample and a MS/MSD sample. The collection of the QC samples required similar increments of soil as the original sample. Therefore, at the ISM sampling unit where a QC sample was required, an additional ISM sample was collected from within the same sampling unit consisting of 30 increments of soil. The field duplicate was labeled with a different sample number (EBGss-014M-0001-SS) and was submitted to the laboratory for processing as a blind field duplicate for soil sample EBGss-013M-0001-SS. Due to sufficient sediment volume, additional collection of sediment for the MS/MSD was not required and sample EBGss-012M-0001-SO was analyzed as the MS/MSD by the contracted laboratory.

The sampling field logs where all data and observations at the sample locations were recorded and the chain-of-custody form for the ISM soil samples submitted to the contracted laboratory are included in **Appendix B**. **Figure 3-2** presents the locations at the MRS where the ISM soil samples were collected during the RI field activities.

3.2.2 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 *Resource Conservation and Recovery Act* (RCRA). These methods are accepted by the 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 Erie Burning Grounds MRS was based on the historical use of the MRS (thermal treatment of explosives and bomb bodies), the

types of munitions historically identified at the MRS, and the potential MC associated with those munitions. Partially buried and burned-out bombs and projectiles have been historically identified at the MRS and were verified during the RI field activities; however, any munitions items used or disposed at the former RVAAP may be present at the MRS. Based on this information, the proposed SW846 analytical suites and methods were presented in the MC Sampling Rationale in the SAP Addendum (Shaw, 2011) and included the following:

- Metals (aluminum, antimony, barium, cadmium, total chromium, Cr^{+6}, copper, iron, lead, mercury, strontium, and zinc)—Method EPA SW846 6010C/7470A/7471A/7196A
- Explosives—Method EPA SW846 8330B
- Nitrocellulose—Method EPA SW846 9056
- Polychlorinated biphenyls (PCBs)—Method EPA SW846 8082A (soil and sediment only)
- Semivolatile organic compounds (SVOCs)—Method EPA SW846 8270C
- Total organic carbon (TOC)—9060A/Lloyd Kahn Method
- pH—Method EPA SW846 9040C/9045D

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

For the ISM soil and wet sediment 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, PCBs, 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 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 Addendum (Shaw, 2011). A separate signed custody record with sample numbers and locations listed

was enclosed with each shipment. When transferring the possession of samples, the individuals relinquishing and receiving signed, dated, and noted the time on the record. All shipments were in compliance with applicable U.S. Department of Transportation regulations for environmental samples.

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

Sample Name	Sample Type	Sample Area	Depth	Analytical Parameters	No. of Samples	Field Duplicate
Surface Water						
EBGsw-001D-0001-SW	D	NA	1.5 ft bws	Metals[1] Geochemical metals[2] Explosives Nitrocellulose SVOCs TOC pH	1	
EBGsw-002D-0001-SW					1	
EBGsw-003D-0001-SW					1	1
Wet Sediment						
EBGsd-005M-0001-SD	ISM	1.5 acres	0–0.5 ft bss	Metals[1] Geochemical metals[2] Explosives Nitrocellulose SVOCs PCBs TOC pH	1	
EBGsd-006M-0001-SD		3.2 acres			1	
EBGsd-007M-0001-SD		3.2 acres			1	
EBGsd-008M-0001-SD		2.8 acres			1	
EBGsd-009M-0001-SD		2.8 acres			1	
EBGsd-010M-0001-SD		2.8 acres			1	1
Subsurface Soil (Burial Trenches)						
EBGss-012M-0001-SS	ISM	27 sq ft	3.5–4.0 ft bgs	Metals[1] Geochemical metals[2] Explosives Nitrocellulose SVOCs PCBs TOC pH	1	
EBGss-013M-0001-SS		54 sq ft	4–4.5 ft bgs		1	1

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

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

bgs denotes below ground surface.
bss denotes below sediment surface.
bws denotes below water surface.
D denotes discrete (grab) sample.
ft denotes foot/feet.
ISM denotes incremental sampling methodology.
NA denotes not applicable/available.
PCB denotes polychlorinated biphenyl.
sq ft denotes square feet.
SVOC denotes semivolatile organic compound.
TOC denotes total organic carbon.

3.2.3 Laboratory Analysis

The samples were collected and analyzed according to the FWSAP (SAIC, 2011b) and the SAP Addendum (Shaw, 2011). The FWSAP and associated addenda were prepared in accordance with USACE and EPA guidance, and outline the organization, objectives, intended data uses, and quality assurance (QA)/QC activities to achieve the desired DQOs and to maintain the defensibility of the data. Project DQOs were established in accordance with the guidance contained in *Data Quality Objectives Process for Hazardous Waste Site Investigations* (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 Addendum (Shaw, 2011) was required of the analytical laboratory so that conditions adverse to quality would not arise. The laboratory was required to perform all analyses in compliance with the *DoD Quality Systems Manual for Environmental Laboratories*, Version 4.2 (QSM) (DoD, 2010); EPA SW-846, *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, Analytical Protocols* (EPA, 2007); or as specified in the FWSAP (SAIC, 2011b). The EPA SW-846 chemical analytical procedures were followed for the analyses of all metals, explosives, nitrocellulose, pH, TOC, SVOCs, and PCBs. The contracted laboratory, CT Laboratories, 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), laboratory duplicates, and MS/MSDs 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 Erie Burning Grounds 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/Matrix Spike Duplicate	

CB&I is the custodian of the project file and will maintain the contents of the files for this investigation, including all relevant records, reports, logs, field notebooks, pictures, subcontractor reports, correspondence, and chain-of-custody forms. These files will remain in a secure area under the custody of CB&I until they are transferred to the USACE, Baltimore District and the former RVAAP. 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 are considered "unacceptable" or required caution on the part of the data user in terms of its reliability. Data were reduced, reviewed, and reported as described in the laboratory QA manual and the laboratory standard operation procedures (SOPs) in the SAP Addendum (Shaw, 2011). Data reduction, review, and reporting by the laboratory were conducted as follows:

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

Data were then delivered to CB&I for data validation. CT Laboratories prepared and retained full analytical and QC documentation for the project in electronic storage media (i.e.,

compact disc), as directed by the analytical methods employed. CT Laboratories provided the following information to CB&I in each analytical data package submitted:

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

3.2.4 Data Validation

Following receipt of the analytical data packages, CB&I performed data validation on all subsurface soil, wet sediment, and surface water samples collected from the Erie Burning Grounds 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) 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 Addendum (Shaw, 2011), FWSAP (SAIC, 2011b), and the QSM (DoD, 2010). Data use qualifiers were assigned to each result based on laboratory QA review and verification criteria. Results were qualified as follows:

- "U"—Analyte was not detected or reported less than the LOD.
- "J"—The reported result is an estimated value.
- "UJ"—Analyte was estimated and not detected or reported less than the LOD.

In addition to assigning qualifiers, the validation process also selected the appropriate result to use when reanalyses or dilutions were performed. Where laboratory surrogate recovery data or laboratory QC samples were outside of analytical method specifications, the validation chemist determined whether laboratory 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 are contained in the Data Evaluation Report in **Appendix C**.

3.2.5 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 Addendum (Shaw, 2011), FWSAP (SAIC, 2011b), the QSM (DoD, 2010), and the laboratory's QA manual. Laboratory reports included documentation verifying analytical holding time compliance. The DQOs were developed concurrently with the SAP Addendum (Shaw, 2011) to ensure the following:

- The reliability of field sampling, chemical analyses, and physical analyses
- The sufficiency of collected data
- The applicability of data for intended use
- The 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
- QC results reported on summary forms as applicable to the analysis performed (i.e., initial and continuing calibrations; method, calibration, equipment, and trip

blanks; LCS/MS/MSD; performance and interference check samples and instrument tunes; surrogates; internal standards; and serial dilutions)

- Detection and reporting limits
- Other contractual items

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

Data were qualified during the validation process from predetermined criteria for QC nonconformances. The quality of data collected in support of the RI sampling activities as noted in data tables is considered acceptable with qualifications during the validation process. Results were assessed for precision, accuracy, representativeness, comparability, and sensitivity 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 *Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual (Part A)* (EPA, 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" (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 analytical column confirmation or accuracy recoveries outside criteria. There was no data rejections (i.e., R-flagged results) resultant from the data validation reviews.
- **Precision—**Laboratory duplicate pairs and/or laboratory spiked duplicate pairs were analyzed as per method requirements for each parameter and/or compound on a batch- and matrix-specific basis. Field duplicates were collected on the basis of 10 percent frequency per matrix to identify the cumulative precision of the sampling and analytical process and were sent on a blind basis to the laboratory. Field duplicates are evaluated at less than or equal to a 50 percent relative percent difference (RPD) for organic parameters and less than or equal to a 25 percent RPD for inorganic parameters. Serial dilutions are evaluated at less than or equal to a 10 percent difference (%D). Field duplicate pairs, laboratory duplicate pairs,

and/or laboratory MSDs and serial dilutions were evaluated for the surface water, wet sediment, and subsurface soil samples.

For sample EBGsw-001D-0001-SW, aluminum, chromium, and lead were outside laboratory duplicate RPD criteria and were qualified estimated "J" based upon these outliers. For the serial dilution, calcium and magnesium exceeded the %D criterion; therefore, were qualified estimated "J" based upon these outliers. For sample EBGss-012M-0001-SS, Cr^{+6} was outside laboratory duplicate RPD criteria and was qualified estimated "J" based upon this outlier. For the serial dilution, calcium exceeded the %D criterion; therefore, was qualified estimated "J" based upon this outlier. For sample EBGsd-010M-0001-SD, the results for antimony, cadmium, copper, iron, magnesium, manganese, aluminum, barium, mercury, and TOC were outside laboratory duplicate RPD criteria and were qualified estimated "J" based upon these outliers. For the serial dilution, chromium, copper, iron, lead, magnesium, manganese, strontium, and zinc exceeded the %D criterion; therefore, were qualified estimated "J" based upon these outliers. For sample EBGsd-RB-001, barium and chromium were outside laboratory duplicate RPD criteria and were qualified estimated "J" based upon these outliers. All other laboratory duplicate pairs were within RPD criteria limits, and serial dilutions were within %D criterion; therefore, did not warrant further qualification.

The MS/MSD pair was outside RPD criteria for target compounds copper, lead, and zinc for the spiked sample EBGsd-010M-0001-SD; therefore, the spiked sample was qualified estimated "J" based upon this outlier. The MS/MSD pair was outside RPD criteria for the following organic target compounds: Explosives batch 40979 for pentaerythritol tetranitrate; SVOC batch 40892 for 3,3'-dichlorobenzidine, 3-nitroaniline, 4,6-dinitro-2-methylphenol, 4-nitroaniline, and hexachloroethane; and SVOC batch 40959 for 3,3'-dichlorobenzidine and 4-chloroaniline. Per organic validation guidance, no qualifiers were applied based upon these outliers alone. All other laboratory MSD pairs were within RPD criteria limits; therefore, did not warrant further qualification.

A blind subsurface soil field duplicate sample pair EBGss-013M-0001-SS/EBGss-014M-0001-SS was collected for all parameter groups. The results for cadmium and TOC were outside criteria and qualified estimated "J" for the field duplicate pair based upon the high RPDs. A blind surface water field duplicate sample pair EBGsw-003D-0001-SW/EBGsw-004D-0001-SW was collected for all parameter groups. Aluminum, copper, and zinc were outside criteria and qualified estimated "J" for the field duplicate pair based upon the high RPDs. A blind sediment field duplicate sample pair EBGsd-010M-0001-SD/EBGsd-011M-

0001-SD was collected for all parameter groups. The results for aluminum, antimony, barium, cadmium, calcium, iron, magnesium, manganese, strontium, Cr^{+6}, and TOC were outside criteria and qualified estimated "J" for the field duplicate pair based upon the high RPDs. For all other parameter groups for each matrix, all criteria were met for the field duplicate. Generally, poor field precision data is resultant from each or a combination of each of the following with the EPA methodology performed: sample in-homogeneity, sample matrix interferences, and/or dilution effects. Any impacted field duplicate pairs were qualified as estimated. 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 C**.

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

  The LCS for QC batch 40893 for hexachlorocyclopentadiene (43 percent) was less than the laboratory acceptance criteria; however, it did not impact any reported samples. All other LCS recoveries were within criteria limits for all parameter groups; therefore, did not warrant qualification.

  The MS/MSD recoveries for SVOC batch 40892 exceeded recovery limits for 3,3'-dichlorobenzidine, 3-nitroaniline, 4,6-dinitro-2-methylphenol, 4-chloroaniline, 4-nitroaniline, benzo(g,h,i)perylene, hexachlorocyclopentadiene, and hexachloroethane. The MS/MSD recoveries for SVOC batch 40959 exceeded recovery limits for 2,4-dinitrophenol, 3,3'-dichlorobenzidine, 4,6-dinitro-2-methylphenol, 4-chloroaniline, benzo(g,h,i)perylene, hexachlorocyclopentadiene, and indeno(1,2,3-cd)pyrene. Per organic validation guidance, no qualifiers were applied based upon these outliers alone. For sample EBGsw-001D-0001-SW, the MS/MSD recoveries exceeded recovery limits for aluminum and iron; therefore, the spiked sample was qualified estimated "J" based upon these outliers. The recoveries for the post-digestion spike (PDS) exceeded recovery limits for iron, lead, and manganese; therefore, the spiked sample was qualified estimated "J" based upon these outliers. The MS/MSD recoveries for spiked sample EBGsd-010M-0001-SD exceeded recovery limits for aluminum, antimony, barium, cadmium, calcium, chromium, copper, iron, lead, magnesium, manganese, mercury, strontium, and zinc; therefore, the spiked sample was qualified estimated "J" based upon these outliers. The recoveries for the PDS sample for

EBGsd-010M-0001-SD exceeded recovery limits for aluminum, iron, manganese, mercury, and zinc; therefore, the spiked sample was qualified estimated "J" based upon these outliers. The MS/MSD recoveries for spiked sample EBGss-012M-0001-SS exceeded recovery limits for aluminum, antimony, iron, and Cr^{+6}; therefore, the spiked sample was qualified estimated "J" for detection and "UJ" for nondetections based upon these outliers. The recoveries for the PDS sample for EBGss-012M-0001-SS exceeded recovery limits for aluminum, copper, iron, and Cr^{+6}; therefore, the spiked sample was qualified estimated "J" based upon these outliers. All other laboratory MS/MSD recoveries were within criteria limits; therefore, did not warrant further qualification.

The samples EBGsw-002D-0001-SW and EBGsw-003D-0001-SW had one SVOC base/neutral surrogate recovery outside limits. All other surrogates were within criteria; therefore, no qualifiers were applied based upon these outliers. As a result, NFAs 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 C**.

- **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.

  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. The nature of the sediment consists primarily of very poorly drained soil (primarily the Sebring variant) with a thin (less than 1-inch thick) organic layer. Although, the $^{7}/_{8}$-inch

stainless steel step probes that were used did not have self-closing valves and/or core catchers as specified in the SAP Addendum (Shaw, 2011), the clayey content and stiffness of the sediment types allowed for the step probes to maintain the integrity of the ISM sediment samples that required a minimum sample depth of 6 inches and a total minimum sample volume of 1 to 2 kg. Sample identification and integrity were maintained (i.e., chain-of-custody forms) during this sampling event as determined during data validation.

Field sample duplicates were collected for each of the environmental media sampled as the Erie Burning Grounds MRS that included surface water, wet sediment and subsurface soil. The wet sediment samples were collected using the simple random sampling method and it is difficult to reproduce the sampling pattern for duplicate samples using this sampling method in comparison to the systematic or stratified random methods that utilize grid placement for the increments. Thus, there is uncertainty associated with the use of the simple random sampling method regarding the representativeness of the results of the field duplicate sample (EBGsd-011m-0001SD) in comparison to the original sample location. However, the use of the simple random sampling method does have a valid statistical basis and is an acceptable incremental sampling method in accordance with the *Interim Guidance 09-02, Implementation of Incremental Sampling (IS) of Soil for the Military Munitions Response Program* (USACE, 2009a).

In review of the analytical data, data validation reports, and field records, no significant nonconformances were noted for holding times, QC blanks, accuracy, precision, and completeness evaluations. All analytical data were deemed representative in accordance with the applicable guidance (EPA, 1989), with no sample or data rejections for the compounds of concern.

QC field inspections were conducted for field sampling activities at the facility in accordance with the Work Plan Addendum (Shaw, 2011). A QC field inspection for ISM soil sampling activities was conducted at the Group 8 MRS in February 2012 and in August 2013, a QC field inspection was completed for underwater sediment sampling activities that were conducted at the Fuze and Booster Quarry MRS. Although these inspections were not conducted at the Erie Burning Grounds MRS, they are considered applicable to the representativeness of the ISM wet sediment and subsurface soil samples collected at the MRS. The basis being that the inspections were activity-based, the same sample methods and equipment were used at both MRSs, and most of the same sample personnel were present for both sampling events. The quality surveillance summary reports that were prepared for each of the sampling events at the Group 8 MRS and the Fuze

and Booster Quarry MRS for ISM soil and ISM wet sediment, respectively, are presented along with the field documentation in **Appendix B**.

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

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

No nonconformances were observed during the QA field inspection by the UXOQCS at the Fuze and Booster Quarry MRS that is also representative of the ISM wet sediment sampling activities conducted at the Erie Burning Grounds MRS. Results of the rinsate blank (FBQ-RB-01) for the sampling equipment step probes used for the ISM sediment sampling event at the Fuze and Booster Quarry MRS support the evidence that equipment was properly decontaminated during field activities.

- **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 90 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.

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. Four discrete surface water samples, seven ISM wet sediment samples, and three ISM subsurface soil samples were collected and sent to the laboratory for analysis. The sample numbers include a field duplicate sample for each matrix. Rinsate blanks were also collected for ISM subsurface soil and wet sediment samples.

Four discrete surface water samples and seven ISM wet sediment samples, including field duplicate samples, were proposed in the Work Plan Addendum (Shaw, 2011) for this sampling event. Additionally, three ISM subsurface soil samples, including a field duplicate sample, were collected based on the findings in the field. 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 subsurface soil, surface water, and sediment samples resulted in 1,796 useable data points of possible 1,796 data points, resulting in an overall analytical completeness quotient of 100 percent for all parameter groups. The completeness statistics were computed as follows:

– 1,796 represents the number of accepted analytes as usable data points (no analytes were rejected)

– 1,796 represents the number of analyzed inputs, which is equal to the number of analytes for all field samples

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

- **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. The laboratory chemical analyses were performed by CT Laboratories, an ELAP-accredited laboratory, in

accordance with the approved SAP Addendum (Shaw, 2011) using cited EPA methodology. Where applicable, the EPA-approved methods and the QSM (DoD, 2010) provided the QC criteria guidelines for the analytical methods and the ELAP accrediting body provided the QA oversight. The laboratory adapted its processes accordingly into an applicable working SOP specific to their laboratory capabilities (i.e., instrumentation, prep method, sample volumes, etc.) in applying the EPA methods. The SOPs were followed throughout the process by the laboratory, as reviewed by the ELAP accrediting body. Furthermore, laboratory data were validated in accordance with established SOPs, and the validation qualifiers were applied when QC nonconformances were identified (as applicable). The consistent use of the laboratory SOPs provides confidence with which one data set can be compared to another previous data set.

Established field SOPs that were preapproved in the SAP Addendum (Shaw, 2011) for the RI program were applied to work at the MRS during this sampling round with the exception that $^{7}/_{8}$-inch step probe samplers were used for wet sediment sampling in place of a hand core sampler. Based on the nature of the sediment as identified in the field to consist of high clay content, use of the step probe was considered more applicable. This instrument is similar to the hand core sampler in its coring abilities and the nature of the sediment enabled the step probe to collect and retain each increment at the requisite depth interval (6 inches). Additionally, the step probe provides a recommended sample volume (1 to 2 kg) in accordance with the *Interim Guidance 09-02, Implementation of Incremental Sampling (IS) of Soil for the Military Munitions Response Program* (USACE, 2009a), whereas the hand core sampler would provide a much larger volume, creating a potential to "dilute" the sample.

Taking into account the noted exception, the field SOPs were followed, as established in the SAP Addendum (Shaw, 2011) to ensure that protocols meet project DQOs. The recorded field documentation provided verification 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 ISM soil samples (EBGss-012M-0001-SS and EBGss-013M-0001-SS) that were collected from the bottom of the burial trenches were evaluated for comparability, specifically to determine if the differences in sample depths (3.5 to 4 feet bgs at Trench 6 and 3 to 3.5 feet bgs at Trench 8) and surface areas (27 square feet for Trench 6 and 54 square feet for Trench 8) affected the ability to compare the data sets. The surface areas and depths of the samples depended on the horizontal and vertical extent of the buried MD and the nature of sampling

of burial areas for MC under the MMRP does not necessarily allow for the comparison of the same ISM surface areas or exact sample depths. Both sets of data were collected and analyzed in accordance with the approved SAP Addendum (Shaw, 2011) and established field SOPs. The purpose of the ISM samples was to evaluate for the nature and extent of contamination associated with historical activities at the MRS and to determine whether or not there is unacceptable risk to receptors. The evaluation for the potential release of MC at each of the sampling units included the collection of 30 increments beneath concentrated areas of buried MD that are considered as areas of equally probable use (i.e., disposal areas). The collection of 30 increments for each of the ISM sampling units was presented in the approved SAP Addendum (Shaw, 2011) and is not expected to over or underestimate the contaminant concentrations at each location. Both ISM soil samples were collected from the bottoms of trenches at the approximate same sample depths with a deviation of 6 inches bgs between the two samples and are considered similar exposure depths for receptors that may perform intrusive activities at the MRS. Since both sampling units are considered as similar likely contaminant release areas and are at similar exposure depths for receptors, the data sets for the two ISM soil samples are considered comparable.

- **Sensitivity—**The sensitivities are dependent on the analytical method, the sample volumes, and percent moistures (solid matrix) used in laboratory determinative analysis. For each analyte, the method sensitivities (i.e., MDLs, method reporting limits [MRLs], LODs, etc.) and analyte detections presented in the analytical data were compared to the screening criteria for each of the samples collected. The analytical laboratory updated their sensitivity reporting convention from MDLs/MRLs to MDLs/LODs/MRLs during the sampling and analysis phase for this RI. The screening criteria are presented in Attachment F, *Table 12 Proposed Human Health and Ecological Screening Levels for Ravenna AAP MRSs,* of the SAP Addendum (Shaw, 2011). Upon comparing the sample results to the minimum project screening criteria, the method sensitivity requirements were met. All MDLs, MRLs, and LODs were less than the project screening criteria. A complete summary of the project data against the minimum screening criteria is presented in the data summary tables in **Appendix D**.

- **QC Blanks—**Method blanks, calibration blanks, and rinsate blanks were evaluated to identify potential non-MRS–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 the guidance (EPA, 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 EBGsd-RB-001 had concentrations of benzyl alcohol at 0.84 micrograms per liter (µg/L), octagen explosives at 1.0 µg/L, research department explosives (RDX) at 0.48 µg/L, and chromium at 0.85 µg/L. All other parameters and target analytes were nondetect. Benzyl alcohol, octagen explosives, RDX, and chromium were either not detected or had concentrations greater than 5 times the blank sample concentrations for all of the associated environmental samples collected on the same day as rinsate blank sample EBGsd-RB-001 (May 8, 2012); therefore, no qualifiers were applied based upon these outliers.

Field equipment rinsate blank sample EBGss-RB-002 had detected concentrations of bis(2-ethylhexly)phthalate at 0.77 µg/L, benzyl alcohol at 0.76 µg/L, calcium at 107 µg/L, and magnesium at 55.5 µg/L. All other parameters and target analytes were nondetect. Benzyl alcohol, bis(2-ethylhexyl)phthalate, calcium, and magnesium were either not detected or had concentrations greater than 5 times the blank sample concentrations for all of the associated environmental samples collected on the same day as rinsate blank sample EBGss-RB-002 (May 9, 2012); therefore, no qualifiers were applied based upon these outliers.

Laboratory method blank samples for SVOC QC batch 84505 contained bis(2-ethylhexyl)phthalate (4.83 µg/L). Associated samples EBGsw-001D-0001-SW, EBGsw-002D-0001-SW, EBGsw-003D-0001-SW, EBGsw-004D-0001-SW, and EBGsd-RB-001 were qualified UJ based upon this outlier. Cr^{+6} was detected in the laboratory method blank. Associated sample EBGss-012M-0001-SS was qualified UJ based upon this outlier. Laboratory method blank samples for metals QC batch 40839 contained calcium (86.9 µg/L), magnesium (6.37 µg/L), manganese (7.60 µg/L); for metals QC batch 40947 contained barium (0.37 µg/L), calcium (34.0 µg/L), chromium (0.046 µg/L), magnesium (9.90 µg/L), manganese (0.082 µg/L), strontium (0.014 µg/L), and zinc

(0.10 µg/L); and for metals QC batch 40953 contained aluminum (0.51 µg/L), calcium (1.6 µg/L), iron (1.8 µg/L), magnesium (0.81 µg/L), manganese (0.10 µg/L), and zinc (0.11 µg/L). All other parameters and target analytes were nondetect for their associated laboratory method blank. All associated environmental samples were either not detected or had concentrations greater than 5 times the blank sample concentrations; therefore, no qualifiers were applied based upon these outliers.

Trace amounts of barium and manganese were detected in the laboratory calibration blanks; however, these concentrations were well below detected sample concentrations and did not warrant qualification. As a result, NFAs were required. Further discussion of the QC sample blanks is provided in the Data Evaluation Report in **Appendix C**.

The Erie Burning Grounds MRS data were determined to be of sufficient quality to make informed decisions for the surface water, wet sediment, and subsurface soil samples that were collected during the RI field activities. Further discussions of data qualifications are provided in the Data Evaluation Report in **Appendix C**.

3.3 Decontamination Procedures

Decontamination of dedicated sampling equipment was performed in accordance with the procedures presented in the SAP Addendum (Shaw, 2011) with the exception that the hydrochloric acid step was eliminated due to previous observations of surface corrosion on the sampling equipment when applied. The sampling equipment consisted of individual $^{7}/_{8}$-inch–diameter stainless steel step probes used to collect each of the ISM and the field duplicate wet sediment and subsurface soil samples. Each step probe was decontaminated after the collection of each ISM soil and wet sediment 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 (EBGsd-RB-001 and EBGss-RB-002) 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.

Evaluation of the equipment rinsate samples analytical data is discussed in Section 3.2.5, "Data Review and Quality Assessment." The results of the equipment blank analyses identified low level contamination in both rinsate blank samples. The analytes detected in the rinsate blanks were not detected nor had concentrations greater than 5 times the blank sample concentrations for all of the associated environmental samples collected on the same day as the rinsate blank samples. As such, no qualifiers were applied based upon these outliers and the detected levels of contaminants in the rinsate blanks do not affect data usability. A summary of results of the equipment rinsate samples is presented in **Appendix D**.

3.4 Investigation-Derived Waste

The investigation-derived waste (IDW) generated during the field activities at the Erie Burning Grounds 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 Addendum (Shaw, 2011). The IDW generated was containerized separately along with similar materials generated from other MRSs and were staged at Building 1036 in accordance with the FWSAP (SAIC, 2011b). IDW Management, which describes the waste characterization analyses performed, waste characterization screening, and IDW transport and disposal, is presented in **Appendix E**.

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4.0 REMEDIAL INVESTIGATION RESULTS

This section presents a discussion of the results of the RI data that were collected for MEC and MC at the Erie Burning Grounds 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 health and the environment. 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 F**.

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 Erie Burning Grounds MRS. These efforts included a combination of visual and DGM surveys and intrusive investigations that were conducted in accordance with the Work Plan Addendum (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 Erie Burning Grounds MRS to provide performance criteria that were agreed upon among the stakeholders (0.5 MEC per 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, UXO Estimator® was 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 Erie Burning Grounds MRS, the potential presence of MEC and/or MD on the ground surface was investigated during the geophysical investigation. Visual survey surface coverage of the MRS was conducted during the DGM field activities and no MEC or MD was identified on the ground surface.

4.1.2 Geophysical Survey Results

The DGM data were acquired over transects spaced approximately 6 meters (20 feet) apart across all accessible areas of the MRS, which resulted in a spatial coverage of approximately 6.8 acres of the 33.9-acre MRS. This equates to approximately 20 percent DGM coverage. Thick vegetation and various underwater obstructions consisting primarily of construction

debris or remnants of the former burning grounds (i.e., railroad ties, steel rails, etc.) redirected transects from the proposed paths in some areas. Removal of smaller vegetation was required at areas along transects in order to provide adequate ground clearance and access for the DGM equipment. Vegetation removal was minimized to the extent possible to allow for the execution of work. The 6.8 acres surveyed exceeds the proposed DGM coverage of 5.2 acres that was originally determined using the UXO Estimator® module (Shaw, 2011). The DGM data were processed and interpreted in accordance with the Work Plan Addendum (Shaw, 2011). **Figure 4-1** illustrates the actual DGM survey transects for the RI field activities.

In general, the geophysical data indicates that the anomaly density at the Erie Burning Grounds MRS is relatively low, with the exception of the land on either side of the railroad embankment and near Burn Area D, which contain regions of high anomaly densities. Except for a general reduction in anomaly density moving away from the high-density anomaly area, no significant pattern of anomaly distribution is observed. **Table 4-1** presents the areas where anomalies were identified, the suspected distribution of anomalies (i.e., segregated or high-density areas), the rationale for the individual point anomaly or combined investigation due to high-density areas, and the recommended method of investigation.

Table 4-1
Summary of Proposed Intrusive Investigation Activities

Area at MRS	Anomalies Identified	Proposed Investigation Area	Investigation Method
Single point-source anomalies at the terrestrial portions of the MRS	190 single point-source anomalies above 8 mV	190 single point-source anomalies above 8 mV	Hand-digging at all 190 single point-source anomaly locations
Single point-source anomalies at the underwater portions of the MRS	862 single point-source anomalies above 5 mV	862 single point-source anomalies above 5 mV	Underwater Navy tactile technique at all 862 single point-source anomaly locations
High-density anomaly areas of varying size and shape distributed throughout the terrestrial portions of the MRS	1,719 clusters of anomalies that represent aggregates of subsurface metal above 5 mV	1,719 clusters of anomalies that represent aggregates of subsurface metal above 5 mV	1,719 clusters of anomalies to be mechanically excavated at 15 trenches

MRS denotes Munitions Response Site.
mV denotes millivolt(s).

Figure 4-2 presents the distribution of anomalies at the Erie Burning Grounds MRS based on the DGM survey results. The selected intrusive and underwater tactile investigation locations are presented in **Figures 4-3a** and **4-3b**.

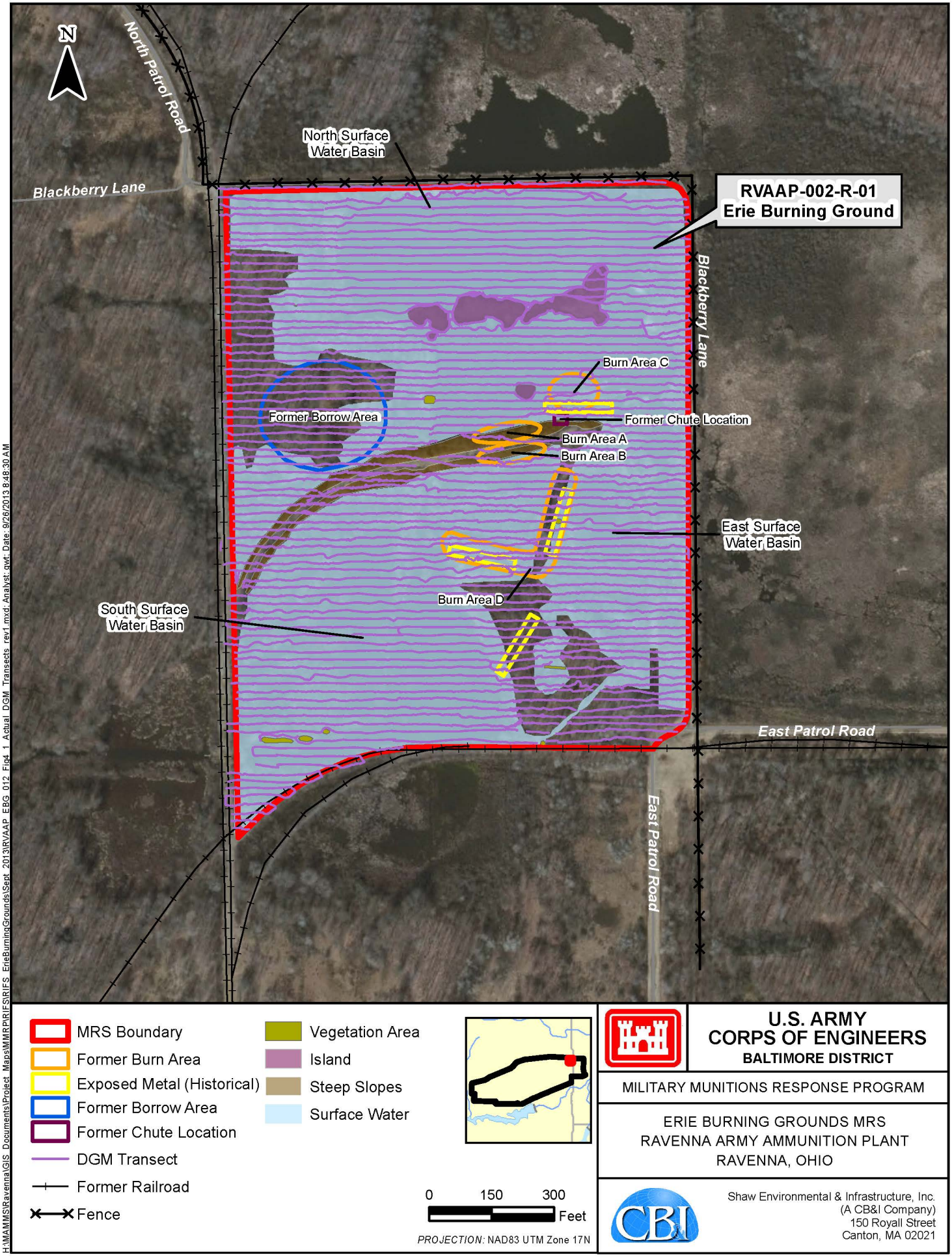


FIGURE 4-1 ACTUAL DGM TRANSECTS MAP

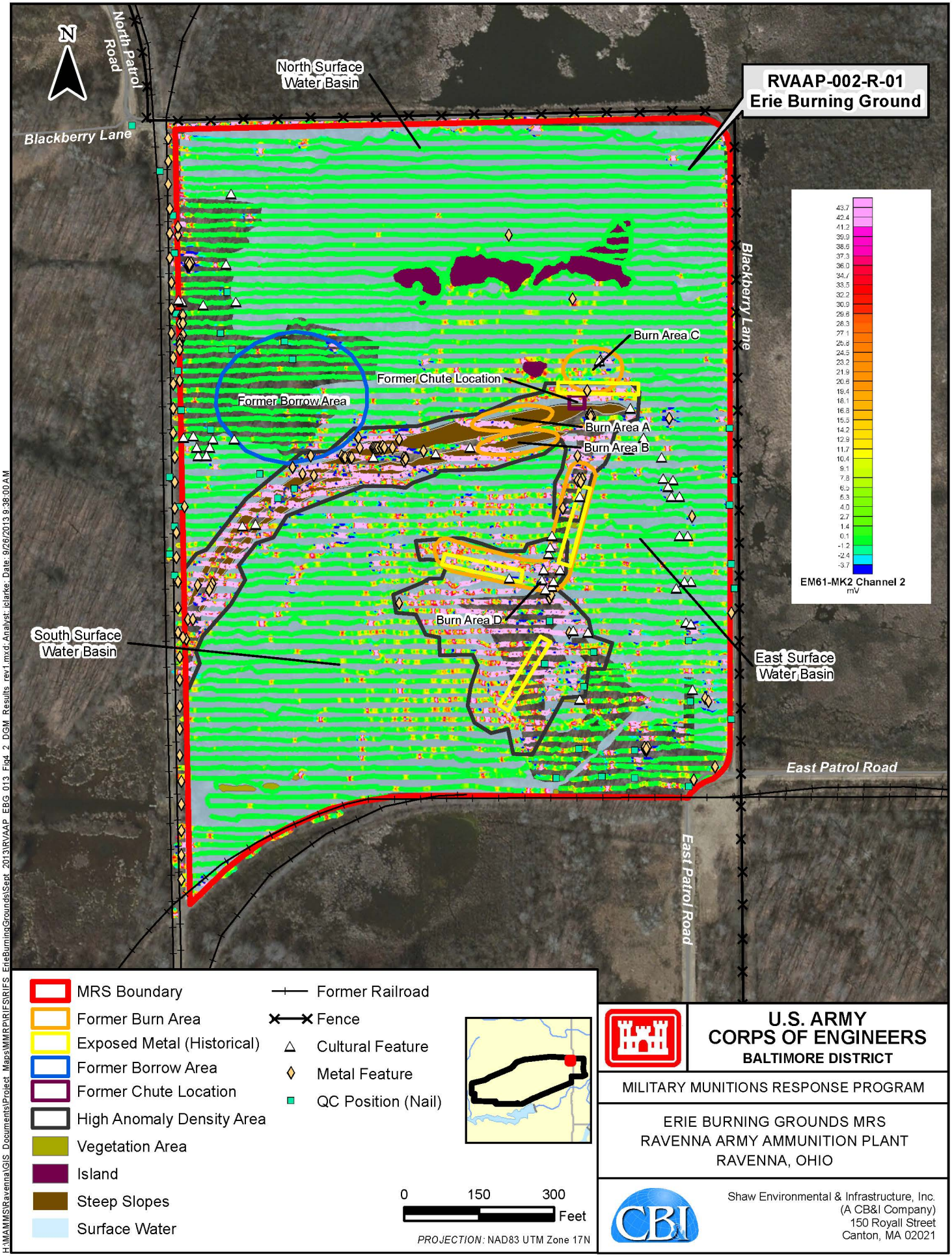


FIGURE 4-2 DGM SURVEY RESULTS

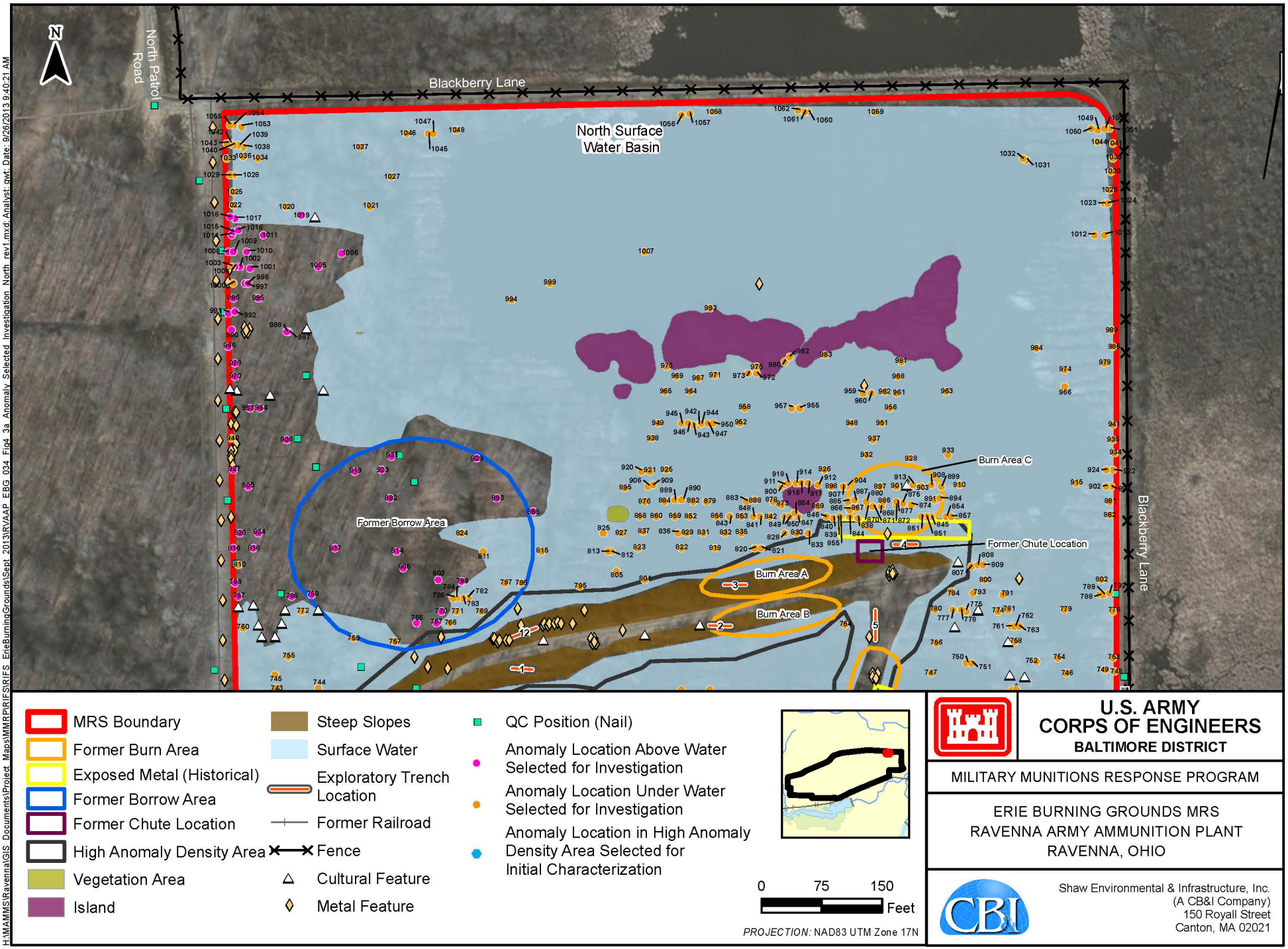


FIGURE 4-3A ANOMALIES SELECTED FOR INVESTIGATION - NORTH SECTION

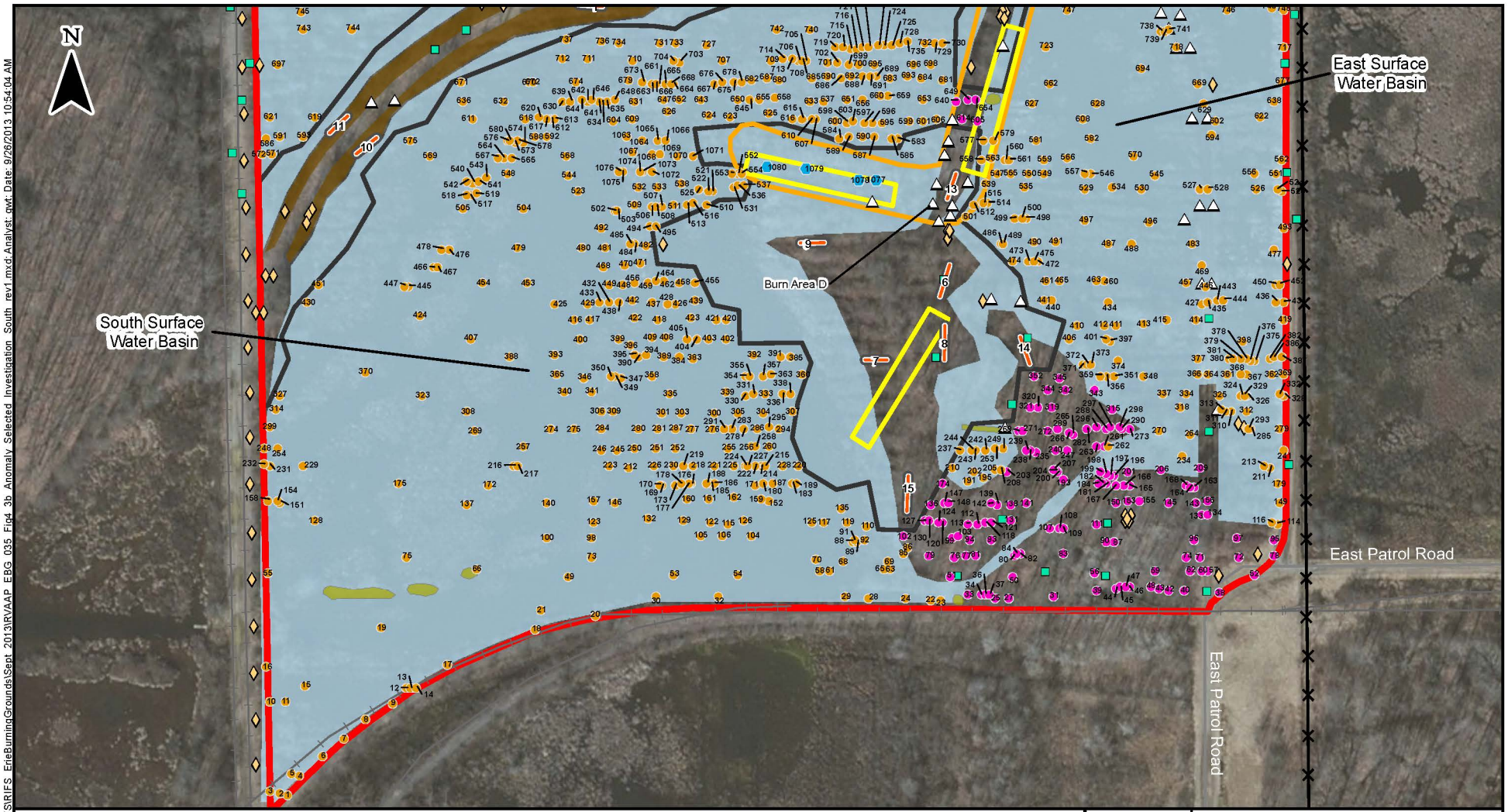


FIGURE 4-3B ANOMALIES SELECTED FOR INVESTIGATION - SOUTH SECTION

4.1.2.1 High-Density Anomaly Areas

A total of 3,824 anomalies were identified at the portions of the MRS that were surveyed as part of the DGM process. The intensities of the anomalies ranged from 5 to 11,401 mV (Channel 2). A high-density anomaly area that consisted of 2,233 clusters of anomalies above 5 mV was found at the terrestrial portions of the MRS that included the former Track 49 embankment; Former Burn Areas A, B, and D; and the former chute location. Former Burn Area C is now inundated with water. Two hundred anomaly clusters were within approximately 3 feet of one another and were merged together to form one target location south of Burn Area D. Forty-nine anomaly clusters were located outside of the high-density anomaly area and were found to be either related to cultural features identified by the DGM team during field operations or nails placed by the DGM team for QC purposes for the DGM activities. Another 266 anomaly clusters were identified to be slightly outside areas of the MRS boundary.

Approximately 25 to 30 percent of the 266 anomaly clusters were on one transect along the portion of Blackberry Lane that bounds the northern side of the MRS. Blackberry Lane forms both the north and east boundaries of the MRS that is itself bound by a fence that has existed since the MRS was in operation. Surface water and wetland areas are present to the north of the Blackberry Lane fence line and an operational range is situated to the east of the fence line adjacent to the east of Blackberry Lane. The south and west portions of the MRS are bound by former elevated railroad beds in relation to the MRS that are covered with ballast material. A majority of the remaining portions of the 266 anomaly clusters were identified at the southwest and western edges of the MRS along the slopes of the former railroad beds. Based on the distinct boundaries that are presented by Blackberry Lane and the former elevated railroad beds, the extent of the DGM survey along the edges of the MRS are considered to be adequately characterized.

As discussed in Section 3.1.2, “Anomaly Investigation Activities,” an 8-mV threshold (Channel 2) was considered appropriate for anomaly selection in the terrestrial portions of the MRS; however, for the purposes of this RI, the high-density anomaly areas were identified based on the more stringent 5-mV threshold. In all, a total of 1,719 clusters of anomalies above 5 mV were identified for intrusive investigation in the high-density anomaly areas.

The Work Plan Addendum (Shaw, 2011) specified that 100 percent of anomalies identified during the DGM survey at the Erie Burning Grounds MRS were to be investigated, since less than 100 percent of the MRS was covered by DGM. However, since the anomalous locations detected were indicative of burial areas, the recommended investigation method at the high-density anomaly areas was mechanical trenching. A total of 15 trenches were proposed in the *Final DGM Survey Results and Proposed Dig Locations for the Erie Burning Grounds MRS*

(RVAAP-002-R-01) technical memorandum that was submitted to the USACE and the Ohio EPA for review and approval (**Appendix A**). The proposed length of the trenches in the high-density anomaly areas was 20 feet to adequately investigate the detected subsurface anomalies; however, some of the trenches were shorter in length where the DGM survey identified areas of density that were not as large.

4.1.2.2 Terrestrial and Underwater Point-Source Anomalies

Outside of the high-density anomaly areas, a total of 1,076 point-source anomalies remained at the terrestrial and underwater portions of the MRS that were detected at intensities greater than 5 mV. Since complete DGM coverage was not performed at the MRS, the intrusive investigation activities require 100-percent reacquisition of individual non-culturally related anomalies that exceed the 8-mV threshold in the terrestrial portion of the MRS and the 5-mV threshold in the underwater portions of the MRS. Following the evaluation of the DGM survey results, 186 of 214 targets within the terrestrial zone were greater than 8 mV and were recommended for intrusive investigation. Within the underwater areas, 862 targets greater than 5 mV were recommended for investigation. Following review of the *Final DGM Survey Results and Proposed Dig Locations for the Erie Burning Grounds MRS (RVAAP-002-R-01)* technical memorandum, four additional point-source anomalies that were located in a high-density anomaly area west of Burn Area D were recommended for investigation by the USACE geophysicists. The rationale for the intrusive investigation by USACE at these four additional locations was: (1) to provide some characterization information for the underwater high-density anomaly area, and (2) to provide additional information in the immediate area of exposed metal west of Burn Area D. In all, a total of 1,052 point-source anomalies were identified as requiring intrusive investigation at both the terrestrial and underwater areas of the MRS.

4.1.3 Geophysical Quality Control Results

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

4.2 Intrusive and Underwater Investigation Results

The section presents the results of the intrusive and underwater investigation activities performed at the Erie Burning Grounds MRS. A total of 190 point-source anomalies were identified for intrusive investigation using manual hand-digging. A total of 862 point-source anomalies were identified for intrusive investigation using U.S. Navy tactile underwater investigation techniques. High-density anomaly areas were proposed for intrusive

investigation using mechanical excavation at 15 trench locations. The results of the intrusive investigation are presented in **Figures 4-4a** and **4-4b**. The MEC investigation data results are presented in **Appendix G**.

4.2.1 Trench Investigation Results

In all, 14 of the 15 high-density anomaly trench locations were successfully investigated during the RI field work. Trench 4 was underwater at the time of the intrusive investigation activities and was not accessible. No MEC was uncovered during the excavations conducted at the 14 accessible trench locations. A total of 33 MD items that were parts associated with the AN-M64A1 series 500-lb general purpose (GP) bomb were encountered at 5 of the trenches at a maximum depth of 48 inches bgs. The trenches were 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.

The total weight of the MD items was approximately 910 lbs and the most MD (750 lbs) was found between Trenches 6 and 8. The locations of these two trenches are in the immediate vicinity of the most southern location where partially buried MD was historically observed. A total of 2,720 lbs of "Other Debris" items that consisted primarily of road base slag, metal rods, hinges, steel rails, cans, and miscellaneous scrap metal, were identified at the nine other trench locations. All "Other Debris" items were left in place and the trenches were backfilled with excavated material. All MD was managed and disposed in accordance with the Work Plan Addendum (Shaw, 2011) and as discussed in Section 4.2.5. **Table 4-2** summarizes the results and includes each trench, the maximum depth attained, a description of the items uncovered, and the estimated weight of the debris.

Table 4-2
Trench Investigation Results

Trench Number	Maximum Depth (inches bgs)	Munitions Debris Description	Approximate Weight (lbs)	Other Debris	Approximate Weight (lbs)
EBG-01	24	NA	0	Trash Pit	500
EBG-02	36	NA	0	Scrap Metal	400
EBG-03	12	NA	0	Scrap Metal	45
EBG-04	Underwater and not accessible for intrusive investigation				
EBG-05	36	NA	0	Trash Pit	500

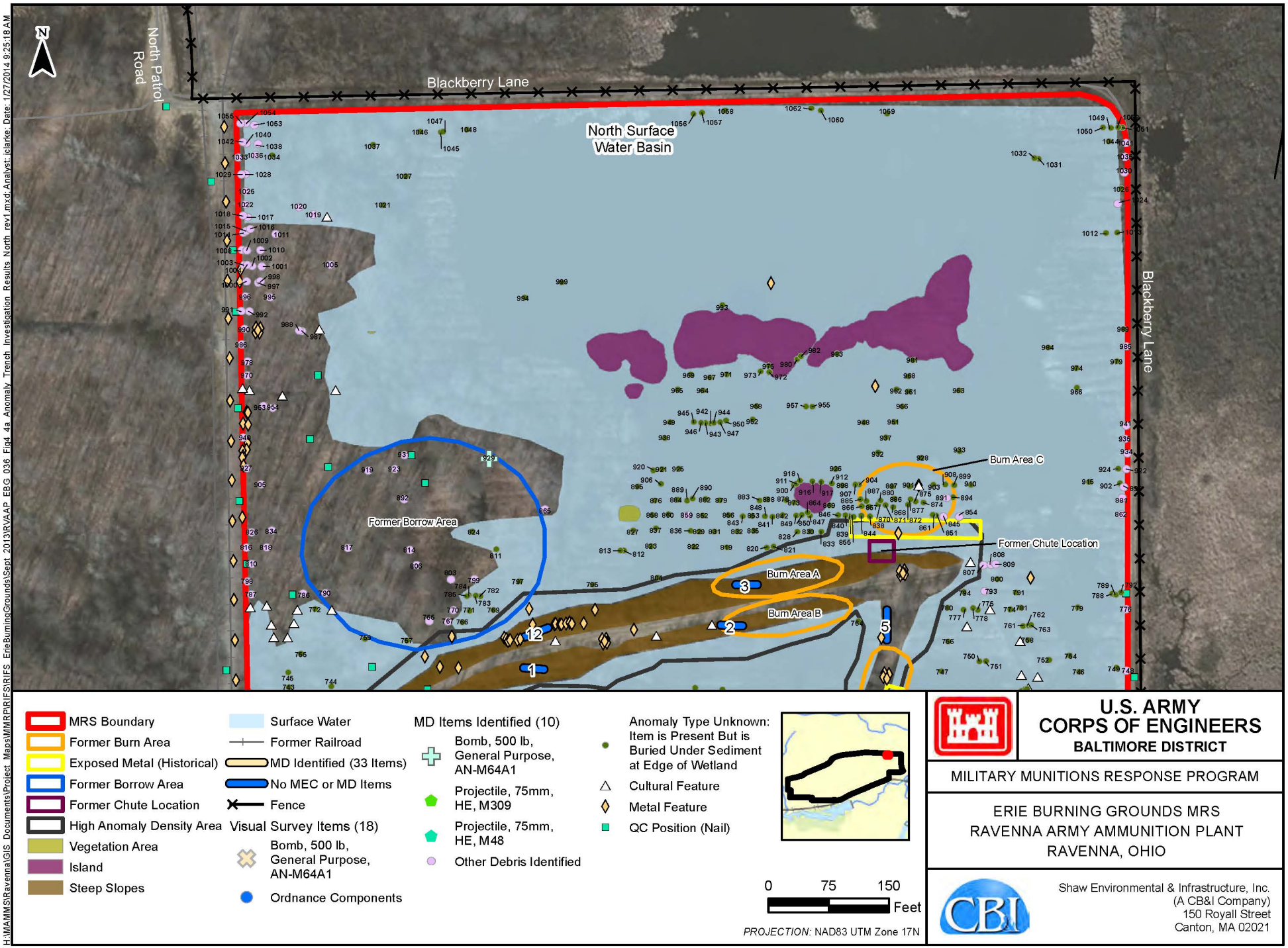
Table 4-2 (continued)
Trench Investigation Results

Trench Number	Maximum Depth (inches bgs)	Munitions Debris Description	Approximate Weight (lbs)	Other Debris	Approximate Weight (lbs)
EBG-06	36	GP Bomb, 500 lb, AN-M64A1 series	400	NA	0
EBG-07	24	GP Bomb, 500 lb, AN-M64A1 series	75	NA	0
EBG-08	48	GP Bomb, 500 lb, AN-M64A1 series	350	NA	0
EBG-09	36	GP Bomb, 500 lb, AN-M64A1 series	45	NA	0
EBG-10	36	NA	0	Trash Pit	500
EBG-11	24	NA	0	Scrap Metal	500
EBG-12	36	NA	0	Scrap Metal	25
EBG-13	24	NA	0	Slag road base	200
EBG-14	36	GP Bomb, 500 lb, AN-M64A1 series	40	NA	0
EBG-15	24	NA	0	Trash Pit	50
		Total:	**910**	**---**	**2,720**

bgs denotes below ground surface.
GP denotes general purpose.
lb denotes pound.
NA denotes not applicable/available.

4.2.2 Terrestrial and Underwater Point-Source Anomaly Investigation Results

A total of 1,052 terrestrial and underwater point-source anomalies were identified for reacquisition following the DGM survey and 1,049 of the point-source anomaly locations were successfully required. The three point-source anomalies that were not successfully located were Targets 241, 419, and 936. Targets 241 and 419 were underwater locations, and Target 936 was a terrestrial anomaly. All three of these targets had low initial detection responses (less than 10 mV) during the DGM survey, which can often be difficult for reacquisition, in particular at water-covered locations. Two other target locations, 1039 and 1043, were found to be associated with other detected anomalies that were successfully investigated. Although 1,049 point-source anomaly locations were successfully reacquired, only 350 (33 percent) of the point-source anomalies were successfully investigated and identified. The majority of the point-source anomalies that could not be identified were buried in the sediment in the underwater portions of the MRS at depths greater than 10 inches. The reason as to why the submerged anomalies could not be investigated is that



U.S. ARMY CORPS OF ENGINEERS
BALTIMORE DISTRICT

MILITARY MUNITIONS RESPONSE PROGRAM

ERIE BURNING GROUNDS MRS
RAVENNA ARMY AMMUNITION PLANT
RAVENNA, OHIO

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

FIGURE 4-4A INTRUSIVE INVESTIGATION RESULTS - NORTH SECTION

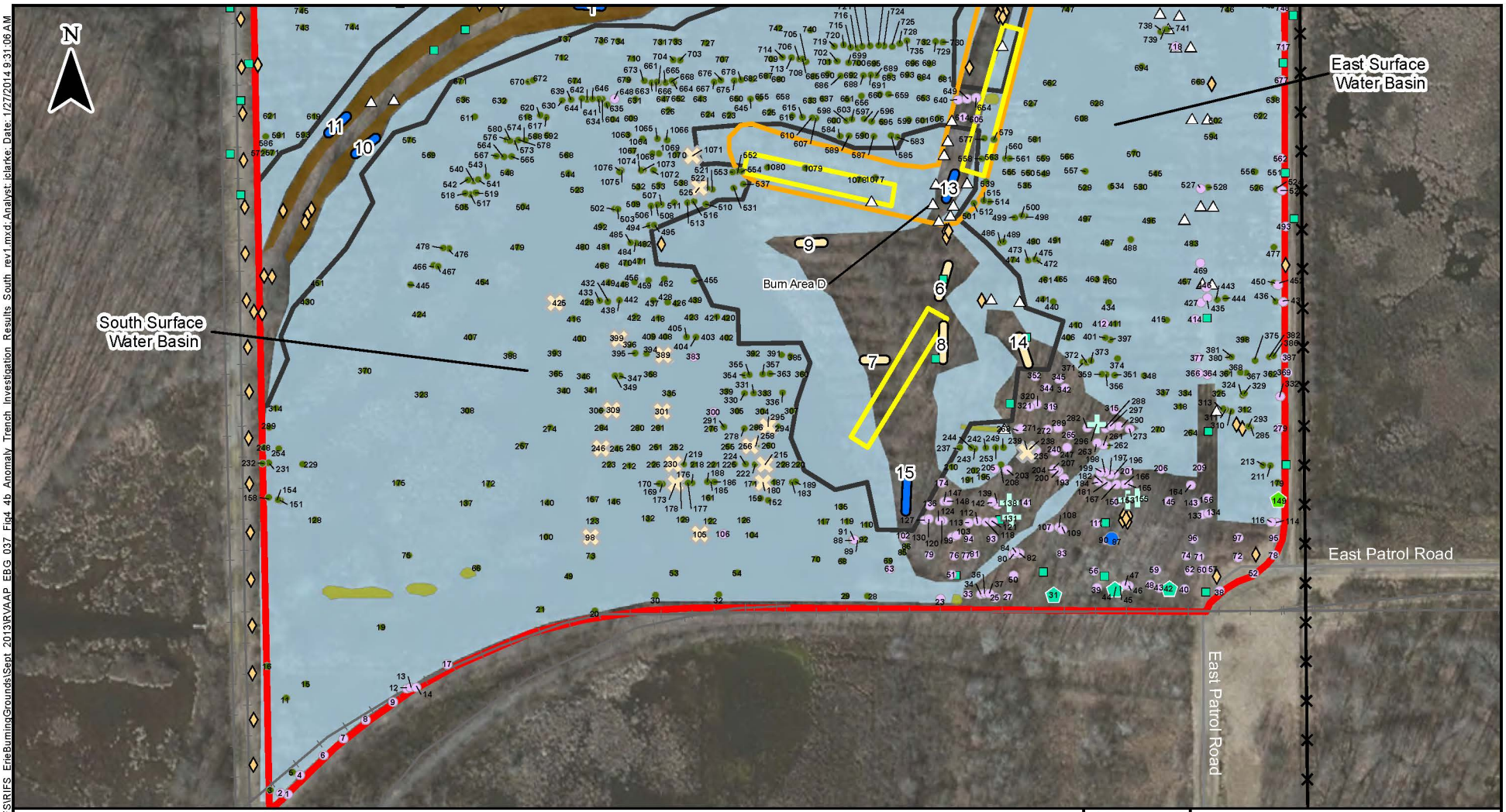


FIGURE 4-4B INTRUSIVE INVESTIGATION RESULTS - SOUTH SECTION

underwater investigation of anomalies in sediment and the poor underwater visibility conditions that existed at the MRS presented safety concerns for the UXO technicians.

No MEC was identified at any of the point-source anomaly locations that were able to be identified; however, 385 lbs of MD were recovered at 29 of the point-source anomaly locations. The MD items found at 19 of the 29 point-source anomaly locations were directly on the ground surface, and the maximum depth of MD found during the intrusive investigation was 6 inches bgs. The MD items observed were primarily associated with AN-M64A1-series 500-lb GP bombs that were found at 24 point-source anomaly locations. Other MD items found included parts associated with the M309-series 75-millimeter (mm) high-explosive (HE) projectile and the M48-series 75mm HE projectile and a bomb skin associated with a bomb of unknown size. **Table 4-3** summarizes the results of the point-source anomaly investigation and includes each MD item, the item depth, and the estimated weight of the MD item.

Table 4-3
Point-Source Anomaly Investigation Results

Target Anomaly ID	Item Depth (inches bgs)	Description of Munitions Debris	Approximate Weight (lbs)
31	4	Projectile, 75 mm, HE, M48 series	5
42	3	Projectile, 75 mm, HE, M48 series	5
44	3	Projectile, 75 mm, HE, M48 series	5
87	0	Bomb Skin	-
98	0	GP Bomb, 500 lb, AN-M64A1series	25
105	0	GP Bomb, 500 lb, AN-M64A1series	10
131	2	GP Bomb, 500 lb, AN-M64A1series	5
138	2	GP Bomb, 500 lb, AN-M64A1series	3
149	6	Projectile, 75 mm, HE, M309 series	5
153	1	GP Bomb, 500 lb, AN-M64A1series	10
155	3	GP Bomb, 500 lb, AN-M64A1series	5
173	0	GP Bomb, 500 lb, AN-M64A1series	9
180	0	GP Bomb, 500 lb, AN-M64A1series	25
215	0	GP Bomb, 500 lb, AN-M64A1series	8
230	0	GP Bomb, 500 lb, AN-M64A1series	25
238	0	GP Bomb, 500 lb, AN-M64A1series	10

Table 4-3 (continued)
Point-Source Anomaly Investigation Results

Target Anomaly ID	Item Depth (inches bgs)	Description of Munitions Debris	Approximate Weight (lbs)
239	0	GP Bomb, 500 lb, AN-M64A1series	10
246	0	GP Bomb, 500 lb, AN-M64A1series	15
256	0	GP Bomb, 500 lb, AN-M64A1series	25
295	0	GP Bomb, 500 lb, AN-M64A1series	15
296	1	GP Bomb, 500 lb, AN-M64A1series	5
301	0	GP Bomb, 500 lb, AN-M64A1series	25
309	0	GP Bomb, 500 lb, AN-M64A1series	25
389	0	GP Bomb, 500 lb, AN-M64A1series	15
399	0	GP Bomb, 500 lb, AN-M64A1series	15
425	0	GP Bomb, 500 lb, AN-M64A1series	20
525	0	GP Bomb, 500 lb, AN-M64A1series	25
929	2	GP Bomb, 500 lb, AN-M64A1series	25
1071	0	GP Bomb, 500 lb, AN-M64A1series	10
		Total:	**385**

bgs denotes below ground surface.
GP denotes general purpose.
HE denotes high-explosive.
ID denotes identification.
lb denotes pound.
mm denotes millimeter(s).

During the intrusive investigation, the majority of MD items were identified in burial trenches at the southern portion of the MRS. Several individual MD items were found just below the ground surface near the southeast MRS boundary. The southern portions of the MRS are bounded by former railroad beds to the north (Track 49) and south (Track HA) and Blackberry Lane to the east and were features that existed when the MRS was in operation. Evidence of the Burn Area D trenches were identified at the southern portion of the MRS during review of historical aerial photographs that were taken near the end of operations at the MRS. An aerial photograph that depicts the MRS near the end of the operations in 1951 is presented in **Figure 1-8**.

The historical aerial photographs identify the major areas of disturbance at the MRS were present north of Track 49 and to date, no MEC/MD has been reported or observed outside of the defined boundaries of the MRS. A fence is present on the east side of Blackberry Lane

that separates the MRS from an existing operational range. The operational range first became active in the 1970s; however, the fence existed when the MRS was active to meet the explosive storage requirements for the adjacent Group 7 area that contained bunkers. No areas with significant disturbance that indicate the potential for buried MEC or MD is noted to the south of the MRS in the historical aerial photographs.

Additionally, instrument-assisted visual surveys were conducted along the former rail beds at the west and south MRS boundaries in order verify that there were no indications of former MRS activities in these directions. These activities were not tracked with a GPS since they were for verification purposes only and no MEC or MD was found outside of the MRS.

A total of 416 "Other Debris" items were identified at 296 point-source anomaly locations during the intrusive investigation activities. The "Other Debris" items consisted mainly of scrap metal, rebar, wire, and pipes. All quantities of both MD and "Other Debris" 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 it came. All MD was managed and disposed in accordance with the Work Plan Addendum (Shaw, 2011) and as discussed in Section 4.2.5.

4.2.3 Post-Excavation Quality Control

Seventy-seven of the 1,052 anomalies selected for investigation were randomly selected for post-excavation QC checks with the EM61-MK2 following intrusive investigation. The post-excavation QC checks were conducted in accordance with the *USACE Table Performance Requirements for RI/FS using DGM Method* in Geophysics, DID WERS-004.01 (USACE, 2010a). The purpose of the post-excavation QC activities were to perform intrusive anomaly verification to ensure that at 90-percent confidence, less than 5 percent of the remaining anomalies are "unresolved" (i.e., there is a low probability that a significant item related to MEC is present within the dig locations that were not checked post-excavation). The 77 anomalies were selected from the population of anomalies located in terrestrial areas of the MRS. QC checks were not performed for anomalies located in the underwater portions of the MRS because the majority of these items were determined during the underwater investigation activities to be located deep within the pond sediment (greater than 10 inches) and were left in place.

At 69 of the 77 locations, the post-excavation response measured by the EM61-MK2 was less than 4 mV. The remaining eight locations were checked with a Schonstedt because the locations were inaccessible to the EM61-MK2. The MRS conditions, especially at the margins of the wetland areas, changed significantly throughout the course of the field operations. Consequently, several locations that were initially dry and accessible with the EM61-MK2 on the wheeled platform during data acquisition were no longer dry for the post-

excavation QC activities. Anomalies at these eight locations had been left in place during the intrusive investigation phase because the holes rapidly filled with water and the items were determined to be located deep in the soil. Based on the results of the post-excavation QC, the measured responses were all well below 8 mV (the investigation threshold for the terrestrial point-source anomalies) and it was not necessary to investigate additional excavation locations.

4.2.4 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 Erie Burning Grounds MRS. The actual investigation area of 6.8 acres exceeds the proposed investigation area of 5.2 acres, and since no MEC was found during the RI field activities, the UXO Estimator® module calculates the statistical upper bound density of MEC to be 0.442 MEC per acre at a 95-percent confidence level. The calculated density is below the target density of 0.5 MEC per acre and indicates that the performance criteria have been met; however, UXO Estimator® does not take into account whether all of the proposed anomalies were actually investigated. Therefore, it is possible that MEC may be present at the MRS even though confirmed discoveries have not been made to date and there are uncertainties as whether the DQOs have been achieved. The uncertainties are discussed further in Section 9.3.

4.2.5 Management and Disposal of MD

This section presents the management and disposal practices for MD items that were encountered during the RI field activities at the Erie Burning Grounds MRS. In all, a total of 1,300 lbs of MD were generated during the intrusive investigation activities at the MRS. All MD items were managed and disposed in accordance with Section 5.0 of the Work Plan Addendum (Shaw, 2011).

Once an item was verified as MD, it was placed into a 55-gallon drum for disposal off of the facility. Each drum was documented as MDAS and was transported for temporary storage at Building 1501 at the Open Demolition Area #2 site at the former RVAAP. Each of the drums was labeled as “Scrap Steel” for demilitarization disposal at Demil Metals, Inc. in Glencoe, Illinois. On May 11, 2012, seven drums that were inclusive of all MD that was generated under the MMRP at the Erie Burning Grounds MRS and the other MRSs investigated between September 8, 2011 and May 10, 2012, were shipped off site for disposal at Demil Metals, Inc. The waste shipment documentation for the MD disposal is presented in **Appendix H**.

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 Erie Burning Grounds 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 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 (subsurface soil, wet sediment and surface water) established for this RI Report are also presented below. A summary of the complete laboratory analytical results for the data collected during the RI field work is presented in **Appendix D**.

4.3.1 Data Evaluation Method

The data evaluation methods discussed herein are consistent with those established in the FWCUG guidance (SAIC, 2010). 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

Samples collected at the Erie Burning Grounds MRS were grouped (aggregated) based on the type of sample and consistency in sample type, area, and depth. The data aggregates identified for the MRS included the following:

- **Surface Water—**This data aggregate consists of three surface water samples. One surface water sample was collected at each of the three main water basins at the MRS. The surface water samples were collected at a depth of approximately 1 to 2 feet below the water surface at each location. This medium is evaluated as an MRS-wide aggregate since the ponds are considered areas of equally probable anticipated use by likely human and ecological receptors. For consideration of this MC exposure analysis, the defined exposure unit (EU) for surface water will be the combined areas of the ponds.
- **Wet Sediment (0 to 0.5 feet)—**This data aggregate consists of six wet sediment samples that were collected using ISM. The ISM sediment samples were collected at approximate same sized sampling units (2.8 to 3.2 acres) with the exception of the ISM sediment sample collected at the East Water Basin (1.5 acres). USACE

guidance (2009) recommends that ISM units be of similar size; however, this medium is evaluated as an MRS-wide aggregate since the combined sediment samples from all six sampling units cover the majority of the inundated areas at the MRS and the sampling units are considered as areas of equally probably anticipated use by likely human and ecological receptors. For consideration of this MC exposure analysis, the defined EU for wet sediment will be the entire area beneath the surface water at the MRS at a sample depth of 0 to 0.5 feet (6 inches) beneath the sediment surface.

- **Subsurface Soil—**This data aggregate consists of two subsurface soil samples that were collected using ISM from the bottom of two trench locations where buried MD were encountered during the RI field activities. Additional sampling for MC at areas of concentrated areas of MD is in accordance with the Work Plan Addendum (Shaw, 2011). The samples were collected at the two trenches where nearly 90 percent of the MD was found during the RI field activities. The trenches were approximately same size (between 27 and 54 square feet), were excavated to similar depths (3.5 to 4.0 feet bgs), and are considered comparable as discussed in Section 3.2.5. The subsurface soil samples are evaluated as an MRS-wide aggregate for depths greater than 1 foot bgs. The ISM subsurface samples were collected at 0.5-foot (6-inch) intervals at the bottoms of the trenches beneath the depths where the MD items were buried and were not collected continuously through the subsurface strata. The EU sample depths of 0.5 feet (6-inch) for the subsurface samples were selected based on the anticipated maximum depth that MC from MEC or MD would be expected to vertically migrate through the soil column.

For risk assessment purposes and consideration of MC exposure analysis, the surface water, and wet sediment aggregates will be used to define human health and ecological exposure in the risk assessments as discussed in Section 7.0, "Human Health Risk Assessment," and Section 8.0, "Ecological Risk Assessment." Evaluation for ecological risk in soil is typically performed for samples collected within the 0-to-1–foot soil interval; therefore, the subsurface soil aggregate will be used to evaluate for potential risk for human receptors only in Section 7.0.

4.3.1.2 Data Validation

Data validation was performed on all surface water, wet sediment, and subsurface soil samples collected from the Erie Burning Grounds MRS (including field duplicates and QC samples) during the RI field activities to ensure the precision, accuracy, representativeness, comparability, and sensitivity of the analytical data were adequate for their intended use. The

review constituted comprehensive validation of 100 percent of the primary data set, as discussed in Section 3.2.4, "Data Validation."

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 4-5** shows the facility data screening process 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.

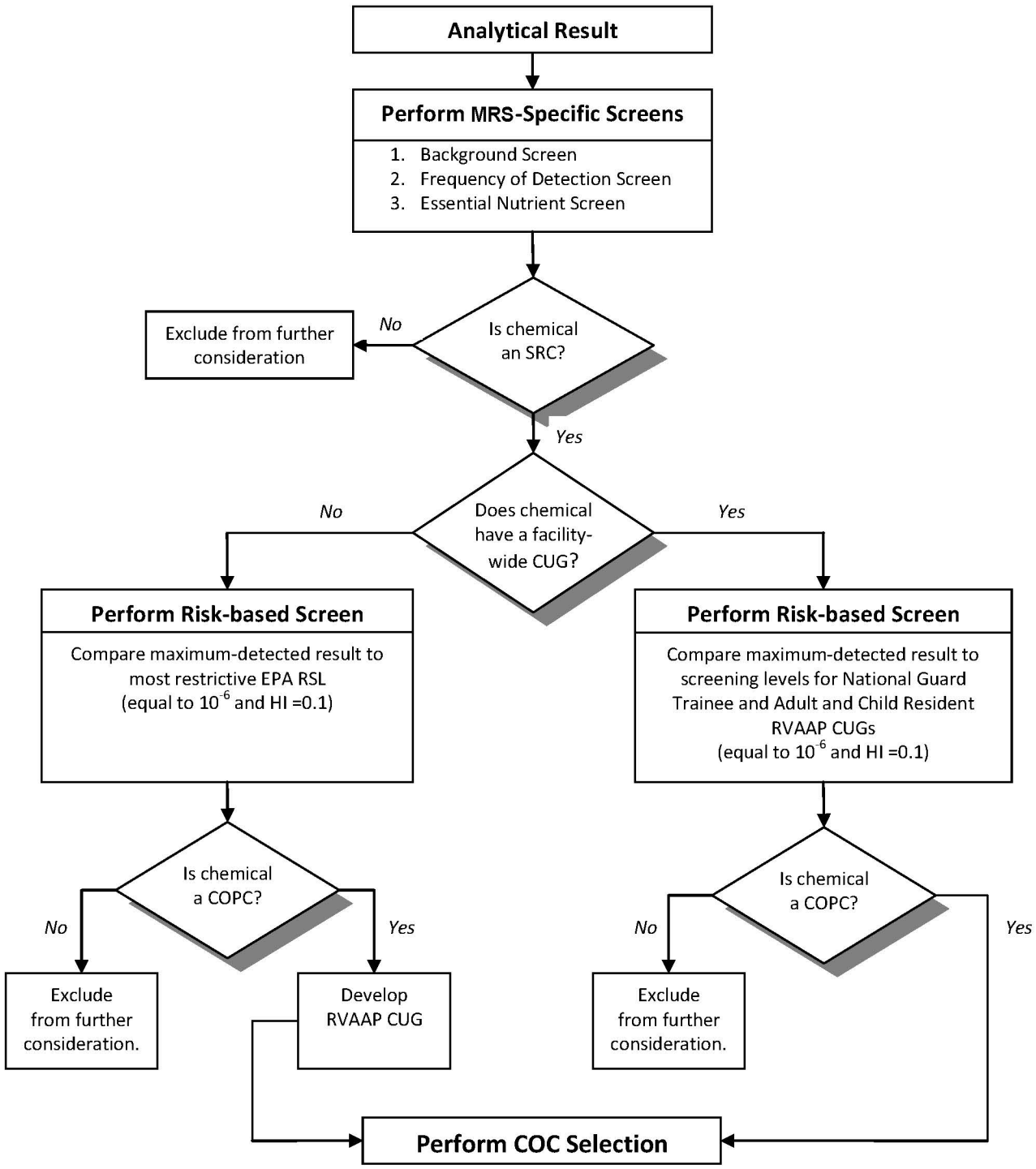
Frequency of Detection

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 approach may be used to determine if the chemical is MRS related. Since the total number of samples collected at the Erie Burning Grounds MRS was less than 20, frequency of detection was not utilized to support a weight of evidence approach for the MRS 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 MRSs being investigated under the MMRP, analyses were conducted for calcium, magnesium, and manganese to be potentially used for geochemical



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 COPCs is for human health evaluation only.

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H:\MAMMS\Ravenna\GIS_Documents\Project_Maps\MMRP\RIFS\RIFS_FuzeBoosterQuarry\RVAAP_FBQ_019_Fig4_4_Process_Chem_of_Concern.mxd; Analyst: jclarke; Date: 12/13/2013 12:35:27 PM

FIGURE 4-5 RVAAP DATA SCREENING PROCESS

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 Erie Burning Grounds 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 Erie Burning Grounds MRS based on the evaluation of the metal results in Section 4.0 and the HHRA and ERA conclusions in Sections 7.0 and 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, 2005a). For the RI field effort, analyses were conducted for calcium, magnesium, and manganese to be used for geochemical analysis, should one be required. These three constituents were eliminated as SRCs in the environmental medium, since they are not considered as an MC associated with the Erie Burning Grounds MRS.

4.3.1.4 Data Presentation

Data summary statistics for SRCs in surface water, wet sediment, and subsurface soil collected at the Erie Burning Grounds MRS are presented for each media in the following sections. The designated use and sample collection rationale for the Erie Burning Grounds MRS samples is presented in **Table 4-4**. The summary of results for the surface water, wet sediment, and subsurface samples are presented in **Tables 4-5**, **4-7**, and **4-9**, respectively. The SRCs identified in surface water, wet sediment, and subsurface soil following the facility data evaluation process are presented in **Tables 4-6**, **4-8**, and **4-10**, respectively. The SRCs for surface water, wet sediment, and subsurface soil are shown on **Figures 4-6**, **4-7**, and **4-8**, respectively. A summary of the complete laboratory analytical results for the data collected during the RI field work is presented in **Appendix D**.

Table 4-4
Data Use Summary and Sample Collection Rationale

Sample Location ID	Sample Date	Sample Area	Depth	Sample Type	Data Use Type	Sample Collection Rationale
Surface Water						
EBGsw-0001M-0001-SW	5/7/12	NA	1.5 ft bws	D	N&E, F&T, RA	Collected to characterize for MC in surface water at the South Surface Water Basin that may have been impacted from historical OB/thermal treatment activities at the MRS.
EBGsw-0002M-0001-SW						Collected to characterize for MC in surface water at the East Surface Water Basin that may have been impacted from historical OB/thermal treatment activities at the MRS.
EBGsw-0003M-0001-SW						Collected to characterize for MC in surface water at the North Surface Water Basin that may have been impacted from historical OB/thermal treatment activities at the MRS
Wet Sediment						
EBGsd-005M-0001-SD	5/8/12	1.5 acres	0–0.5 ft bss	ISM	N&E, F&T, RA	Collected to characterize for MC in sediment at the south portion of the South Surface Water Basin that may have been impacted from historical OB/thermal treatment activities at the MRS.
EBGsd-006M-0001-SD		3.2 acres				Collected to characterize for MC in sediment at the north portion of the South Surface Water Basin that may have been impacted from historical OB/thermal treatment activities at the MRS.
EBGsd-007M-0001-SD		3.2 acres				Collected to characterize for MC in sediment at the East Surface Water Basin that may have been impacted from historical OB/thermal treatment activities at the MRS.

Table 4-4 (continued)
Data Use Summary and Sample Collection Rationale

Sample Location ID	Sample Date	Sample Area	Depth	Sample Type	Data Use Type	Sample Collection Rationale
Wet Sediment (continued)						
EBGsd-008M-0001-SD	5/8/12	2.8 acres	0–0.5 ft bss	ISM	N&E, F&T, RA	Collected to characterize for MC in sediment at the North Surface Water Basin that may have been impacted from historical OB/thermal treatment activities at the MRS.
EBGsd-009M-0001-SD		2.8 acres				Collected to characterize for MC in sediment at the North Surface Water Basin that may have been impacted from historical OB/thermal treatment activities at the MRS.
EBGsd-0010M-0001-SD		2.8 acres				Collected to characterize for MC in sediment at the North Surface Water Basin that may have been impacted from historical OB/thermal treatment activities at the MRS.
Subsurface Soil						
EBGss-012M-0001-SS	5/9/12	54 sq ft	3.5–4.0 ft bgs	ISM	N&E, F&T, RA	Collected to characterize for MC associated with buried MD at the bottom of Trench 8.
EBGss-013M-0001-SS		27 sq ft	3.0–3.5 ft bgs			Collected to characterize for MC associated with buried MD at the bottom of Trench 6.

bgs denotes below ground surface.
bss denotes below sediment surface.
bws denotes below water surface.
D denotes discrete (grab) sample.
F&T denotes fate and transport evaluation.
ft denotes foot/feet.
ID denotes identification.
ISM denotes incremental sampling methodology.
MC denotes munitions constituents.
MD denotes munitions debris.
MRS denotes Munitions Response Site.
N&E denotes nature and extent evaluation.
OB denotes open burning.
RA denotes risk assessment evaluation.
sq ft denotes square feet.

Table 4-5
Summary of Surface Water Results

Analyte	Location ID:	EBGsw-001		EBGsw-002		EBGsw-003	
	Sample ID:	EBGsw-001D-0001-SW		EBGsw-002D-0001-SW		EBGsw-003D-0001-SW	
	Sample Date:	5/7/2012		5/7/2012		5/7/2012	
	Depth (feet bws):	1.5		1.5		1.5	
	BSV[1] (µg/L)	Result (µg/L)	VQ	Result (µg/L)	VQ	Result (µg/L)	VQ
Metals							
Aluminum	*3,370*	506	J	639	J	452	J
Antimony	*0*	<6	U	<6	U	<6	U
Barium	*47.5*	35.6	J	**54.8**	**J**	24.9	J
Cadmium	*0*	<1	U	<1	U	<1	U
Chromium (as Cr^{+3})	*0*	**2**	**J**	**2.4**	**J**	**1.2**	**J**
Copper	*7.9*	4.7	J	17.1		3.7	J
Iron	*2,560*	**4,580**	**J**	**8,690**	**J**	**3,170**	**J**
Lead	*0*	**2**	**J**	**6.1**		**2**	**J**
Mercury	*0*	<0.06	U	<0.06	U	<0.06	U
Strontium	*0*	**63.7**		**83.4**		**54.1**	
Zinc	*42*	15.1		**42.8**		25.4	
Geochemical Metals[2]							
Calcium	*41,400*	19,700	J	25,500	J	16,500	J
Magnesium	*10,800*	6,430	J	7,300	J	4,130	J
Manganese	*391*	149	J	**1,210**	**J**	108	J

Table 4-5 (continued)
Summary of Surface Water Results

	Location ID:	EBGsw-001		EBGsw-002		EBGsw-003	
	Sample ID:	EBGsw-001D-0001-SW		EBGsw-002D-0001-SW		EBGsw-003D-0001-SW	
	Sample Date:	5/7/2012		5/7/2012		5/7/2012	
	Depth (feet bws):	1.5		1.5		1.5	
Analyte	BSV[1] (µg/L)	Result (µg/L)	VQ	Result (µg/L)	VQ	Result (µg/L)	VQ
Explosives and Propellants							
1,3,5-Trinitrobenzene	*NA*	<0.4	U	<0.4	U	<0.4	U
1,3-Dinitrobenzene	*NA*	<0.5	U	<0.5	U	<0.5	U
2,4,6-Trinitrotoluene	*NA*	<0.5	U	<0.5	U	<0.5	U
2,4-Dinitrotoluene	*NA*	<1	U	<1	U	<1	U
2,6-Dinitrotoluene	*NA*	<0.5	U	<0.5	U	<0.5	U
2-Amino-4,6-Dinitrotoluene	*NA*	<0.5	U	<0.5	U	<0.5	U
3,5-Dinitroaniline	*NA*	<0.5	U	<0.5	U	<0.5	U
4-Amino-2,6-Dinitrotoluene	*NA*	<0.5	U	<0.5	U	<0.5	U
HMX	*NA*	<0.5	U	<0.5	U	<0.5	U
m-Nitrotoluene	*NA*	<0.4	U	<0.4	U	<0.4	U
Nitrobenzene	*NA*	<0.4	U	<0.4	U	<0.4	U
Nitroglycerin	*NA*	<4	U	<4	U	<4	U
Nitroguanidine	*NA*	<60	U	<60	U	<60	U
o-Nitrotoluene	*NA*	<1	U	<1	U	<1	U

Table 4-5 (continued)
Summary of Surface Water Results

Analyte	Location ID:	EBGsw-001		EBGsw-002		EBGsw-003	
	Sample ID:	EBGsw-001D-0001-SW		EBGsw-002D-0001-SW		EBGsw-003D-0001-SW	
	Sample Date:	5/7/2012		5/7/2012		5/7/2012	
	Depth (feet bws):	1.5		1.5		1.5	
	BSV[1] (µg/L)	Result (µg/L)	VQ	Result (µg/L)	VQ	Result (µg/L)	VQ
PETN	*NA*	<6	U	<6	U	<6	U
p-Nitrotoluene	*NA*	<0.5	U	<0.5	U	<0.5	U
RDX	*NA*	<0.4	U	<0.4	U	<0.4	U
Tetryl	*NA*	<0.5	U	<0.5	U	<0.5	U
Semivolatile Organic Compounds							
1,2,4-Trichlorobenzene	*NA*	<0.55	U	<0.5	U	<0.55	U
1,2-Dichlorobenzene	*NA*	<0.55	U	<0.5	U	<0.55	U
1,3-Dichlorobenzene	*NA*	<0.55	U	<0.5	U	<0.55	U
1,4-Dichlorobenzene	*NA*	<0.55	U	<0.5	U	<0.55	U
2,4,5-Trichlorophenol	*NA*	<2.8	U	<2.55	U	<26.5	U
2,4,6-Trichlorophenol	*NA*	<2.8	U	<2.55	U	<26.5	U
2,4-Dichlorophenol	*NA*	<2.8	U	<2.55	U	<26.5	U
2,4-Dimethylphenol	*NA*	<2.8	U	<2.55	U	<26.5	U
2,4-Dinitrophenol	*NA*	<2.8	U	<2.55	U	<26.5	U
2-Chloronaphthalene	*NA*	<0.55	U	<0.5	U	<26.5	U

Table 4-5 (continued)
Summary of Surface Water Results

	Location ID:	EBGsw-001		EBGsw-002		EBGsw-003	
	Sample ID:	EBGsw-001D-0001-SW		EBGsw-002D-0001-SW		EBGsw-003D-0001-SW	
	Sample Date:	5/7/2012		5/7/2012		5/7/2012	
	Depth (feet bws):	1.5		1.5		1.5	
Analyte	BSV[1] (µg/L)	Result (µg/L)	VQ	Result (µg/L)	VQ	Result (µg/L)	VQ
2-Chlorophenol	*NA*	<2.8	U	<2.55	U	<26.5	U
2-Methylnaphthalene	*NA*	<0.55	U	<0.5	U	<0.55	U
2-Nitroaniline	*NA*	<0.55	U	<0.5	U	<0.55	U
2-Nitrophenol	*NA*	<2.8	U	<2.55	U	<26.5	U
3,3'-Dichlorobenzidine	*NA*	<1.65	U	<1.55	U	<1.6	U
3-Nitroaniline	*NA*	<0.55	U	<0.5	U	<0.55	U
4,6-Dinitro-2-Methylphenol	*NA*	<3.35	U	<3.05	U	<3.2	U
4-Bromophenyl Phenyl Ether	*NA*	<0.55	U	<0.5	U	<0.55	U
4-Chloro-3-Methylphenol	*NA*	<2.8	U	<2.55	U	<26.5	U
4-Chloroaniline	*NA*	<0.55	U	<0.5	U	<0.55	U
4-Chlorophenyl Phenyl Ether	*NA*	<0.55	U	<0.5	U	<0.55	U
4-Nitrobenzenamine	*NA*	<0.55	U	<0.5	U	<0.55	U
4-Nitrophenol	*NA*	<2.8	U	<2.55	U	<26.5	U
Acenaphthene	*NA*	<0.55	U	<0.5	U	<0.55	U
Acenaphthylene	*NA*	<0.55	U	<0.5	U	<0.55	U

Table 4-5 (continued)
Summary of Surface Water Results

	Location ID:	EBGsw-001		EBGsw-002		EBGsw-003	
	Sample ID:	EBGsw-001D-0001-SW		EBGsw-002D-0001-SW		EBGsw-003D-0001-SW	
	Sample Date:	5/7/2012		5/7/2012		5/7/2012	
	Depth (feet bws):	1.5		1.5		1.5	
Analyte	BSV[1] (µg/L)	Result (µg/L)	VQ	Result (µg/L)	VQ	Result (µg/L)	VQ
Anthracene	*NA*	<0.55	U	<0.5	U	<0.55	U
Benzo(a)anthracene	*NA*	<0.55	U	<0.5	U	<0.55	U
Benzo(a)pyrene	*NA*	<0.55	U	<0.5	U	<0.55	U
Benzo(b)fluoranthene	*NA*	<0.55	U	<0.5	U	<0.55	U
Benzo(ghi)perylene	*NA*	<0.55	U	<0.5	U	<0.55	U
Benzo(k)fluoranthene	*NA*	<0.55	U	<0.5	U	<0.55	U
Benzoic Acid	*NA*	<28	U	<25.5	U	<26.5	U
Benzyl Alcohol	*NA*	<1.65	U	<1.55	U	<1.6	U
Bis(2-Chloroethoxy)methane	*NA*	<0.55	U	<0.5	U	<0.55	U
Bis(2-Chloroethyl)ether	*NA*	<0.55	U	<0.5	U	<0.55	U
Bis(2-Chloroisopropyl)ether	*NA*	<0.55	U	<0.5	U	<0.55	U
Bis(2-Ethylhexyl)phthalate	*NA*	<0.7	UJ	<0.56	UJ	<0.62	UJ
Butyl Benzyl Phthalate	*NA*	<1.65	U	<1.55	U	<1.6	U
Carbazole	*NA*	<0.55	U	<0.5	U	<0.55	U
Chrysene	*NA*	<0.55	U	<0.5	U	<0.55	U

Table 4-5 (continued)
Summary of Surface Water Results

	Location ID:	EBGsw-001		EBGsw-002		EBGsw-003	
	Sample ID:	EBGsw-001D-0001-SW		EBGsw-002D-0001-SW		EBGsw-003D-0001-SW	
	Sample Date:	5/7/2012		5/7/2012		5/7/2012	
	Depth (feet bws):	1.5		1.5		1.5	
Analyte	BSV[1] (µg/L)	Result (µg/L)	VQ	Result (µg/L)	VQ	Result (µg/L)	VQ
Cresols (Total)	*NA*	<5	U	<4.6	U	<4.8	U
Dibenzo(a,h)anthracene	*NA*	<0.55	U	<0.5	U	<0.55	U
Dibenzofuran	*NA*	<0.55	U	<0.5	U	<0.55	U
Diethyl Phthalate	*NA*	<1.65	U	<1.55	U	<1.6	U
Dimethyl Phthalate	*NA*	<1.65	U	<1.55	U	<1.6	U
Di-n-Butyl Phthalate	*NA*	<1.65	U	<1.55	U	<1.6	U
Di-n-Octyl Phthalate	*NA*	<1.65	U	<1.55	U	<1.6	U
Fluoranthene	*NA*	<0.55	U	<0.5	U	<0.55	U
Fluorene	*NA*	<0.55	U	<0.5	U	<0.55	U
Hexachlorobenzene	*NA*	<0.55	U	<0.5	U	<0.55	U
Hexachlorobutadiene	*NA*	<0.55	U	<0.5	U	<0.55	U
Hexachlorocyclopentadiene	*NA*	<0.55	U	<0.5	U	<0.55	U
Hexachloroethane	*NA*	<0.55	U	<0.5	U	<0.55	U
Indeno(1,2,3-cd)pyrene	*NA*	<0.55	U	<0.5	U	<0.55	U
Isophorone	*NA*	<0.55	U	<0.5	U	<0.55	U

Table 4-5 (continued)
Summary of Surface Water Results

	Location ID:	EBGsw-001		EBGsw-002		EBGsw-003	
	Sample ID:	EBGsw-001D-0001-SW		EBGsw-002D-0001-SW		EBGsw-003D-0001-SW	
	Sample Date:	5/7/2012		5/7/2012		5/7/2012	
	Depth (feet bws):	1.5		1.5		1.5	
Analyte	BSV[1] (µg/L)	Result (µg/L)	VQ	Result (µg/L)	VQ	Result (µg/L)	VQ
Naphthalene	*NA*	<0.55	U	<0.5	U	<0.55	U
N-Nitroso-di-n-Propylamine	*NA*	<0.55	U	<0.5	U	<0.55	U
N-Nitrosodiphenylamine	*NA*	<1.1	U	<1	U	<1.05	U
o-Cresol	*NA*	<2.8	U	<2.55	U	<2.65	U
Phenanthrene	*NA*	<0.55	U	<0.5	U	<0.55	U
Pyrene	*NA*	<0.55	U	<0.5	U	<0.55	U
General Chemistry							
Hexavalent Chromium	*NA*	<12	U	<12	U	<12	U
Nitrocellulose	*NA*	<1,700	U	<1,700	U	<1,650	U
pH (SU)	*NA*	7.29		6.84		7.02	

Table 4-5 (continued)
Summary of Surface Water Results

[1] *Background values as presented in the* Final Facility-Wide Human Health Cleanup Goals at the RVAAP, Ravenna, Ohio *(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 RVAAP background value. For organics, bold numbering indicates a detected value.

< denotes less than.

µg/L denotes micrograms per liter.

bws denotes below water surface.

BSV denotes background screening value.

Cr^{+3} denotes trivalent chromium.

HMX denotes octogen explosives.

ID denotes identification.

MC denotes munitions constituents.

NA denotes not applicable/available.

PETN denotes pentaerythritol tetranitrate.

RDX denotes research department explosives.

RVAAP denotes Ravenna Army Ammunition Plant.

SU denotes standard unit.

VQ denotes validation qualifier.

Validation Qualifiers:

J denotes that the result is reported as an estimated value.

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

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

Table 4-6
SRC Screening Summary for Surface Water

Analyte	CAS Number	Frequency of Detection	Minimum Detect		Maximum Detect		Mean Result (µg/L)	BSV (µg/L)	SRC?	SRC Justification
			Results (µg/L)	VQ	Result (µg/L)	VQ				
Metals										
Aluminum	7429-90-5	3/3	452	J	639	J	532	3,370	No	Below BSV
Barium	7440-39-3	3/3	24.9	J	54.8	J	38.4	47.5	Yes	Above BSV
Chromium (as Cr^{+3})	7440-47-3	3/3	1.2	J	2.4	J	1.9	0	Yes	No BSV
Copper	7440-50-6	3/3	3.7	J	17.1	J	8.5	7.9	Yes	Above BSV
Iron	7439-89-6	3/3	3,170	J	8,690	J	5,580	2,560	Yes	Above BSV
Lead	7439-92-1	3/3	2	J	6.1		3.3	0	Yes	No BSV
Strontium	7440-24-6	3/3	54.1		83.4		67	0	Yes	No BSV
Zinc	7440-36-0	3/3	15.1		42.8		27.8	42	Yes	Above BSV

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

µg/L denotes micrograms per liter.

BSV denotes background screening value.

CAS denotes Chemical Abstracts Service.

Cr^{+3} denotes trivalent chromium.

J denotes that the result is reported as an estimated value.

RVAAP denotes Ravenna Army Ammunition Plant.

SRC denotes site-related chemical.

VQ denotes validation qualifier.

Table 4-7
Summary of Wet Sediment Results

	Location ID:	EBGsd-005		EBGsd-006		EBGsd-007		EBGsd-008	
	Sample ID:	EBGsd-005M-0001-SD		EBGsd-006M-0001-SD		EBGsd-007M-0001-SD		EBGsd-008M-0001-SD	
	Sample Date:	5/8/2012		5/8/2012		5/8/2012		5/8/2012	
	Depth (feet bss):	0–0.5		0–0.5		0–0.5		0–0.5	
Analyte	**BSV[1] (mg/kg)**	**Result (mg/kg)**	**VQ**	**Result (mg/kg)**	**VQ**	**Result (mg/kg)**	**VQ**	**Result (mg/kg)**	**VQ**
Metals									
Aluminum	*13,900*	13,900	J	**14,200**	**J**	**20,200**	**J**	**25,300**	J
Antimony	*0*	<0.55	U	**0.92**	**J**	<0.65	U	<0.85	U
Barium	*123*	**235**	**J**	**207**	**J**	**226**	**J**	**271**	**J**
Cadmium	*0*	**0.61**		**0.64**		**1.5**		**2.5**	
Chromium (as Cr^{+3})	*18.1*	11.9		<8.5	U	2	J	**20.2**	
Copper	*27.6*	**30.9**		**56.2**		**36.8**		**88.4**	
Iron	*28,200*	8,740	J	14,900	J	12,000	J	12,400	J
Lead	*27.4*	14.7		27		17.5		22.9	
Mercury	*0.059*	0.04		**0.092**		0.048		**0.08**	
Strontium	*0*	**18.6**		**19.8**		**22.9**		**29.6**	
Zinc	*532*	46.6		83.9		68.7		116	
Geochemical Metals[2]									
Calcium	*5,510*	4,020	J	**5,880**	**J**	5,450	J	**6,860**	**J**
Magnesium	*2,760*	2,240	J	**8,210**	**J**	2,680	J	2,010	J
Manganese	*1,950*	96	J	207	J	133	J	192	J

Table 4-7 (continued)
Summary of Wet Sediment Results

	Location ID:	EBGsd-005		EBGsd-006		EBGsd-007		EBGsd-008	
	Sample ID:	EBGsd-005M-0001-SD		EBGsd-006M-0001-SD		EBGsd-007M-0001-SD		EBGsd-008M-0001-SD	
	Sample Date:	5/8/2012		5/8/2012		5/8/2012		5/8/2012	
	Depth (feet bss):	0–0.5		0–0.5		0–0.5		0–0.5	
Analyte	BSV[1] (mg/kg)	Result (mg/kg)	VQ	Result (mg/kg)	VQ	Result (mg/kg)	VQ	Result (mg/kg)	VQ
Explosives and Propellants									
1,3,5-Trinitrobenzene	*NA*	<0.25	U	<0.25	U	<0.25	U	<0.25	U
1,3-Dinitrobenzene	*NA*	<0.15	U	<0.15	U	<0.15	U	<0.15	U
2,4,6-Trinitrotoluene	*NA*	<0.25	U	<0.25	U	<0.25	U	<0.25	U
2,4-Dinitrotoluene	*NA*	<0.15	U	<0.15	U	<0.15	U	<0.15	U
2,6-Dinitrotoluene	*NA*	<0.15	U	<0.15	U	<0.15	U	<0.15	U
2-Amino-4,6-Dinitrotoluene	*NA*	<0.15	U	<0.15	U	<0.15	U	<0.15	U
3,5-Dinitroaniline	*NA*	<0.15	U	<0.15	U	<0.15	U	<0.15	U
4-Amino-2,6-Dinitrotoluene	*NA*	<0.15	U	<0.15	U	<0.15	U	<0.15	U
HMX	*NA*	<0.25	U	<0.25	U	<0.25	U	<0.25	U
m-Nitrotoluene	*NA*	<0.25	U	<0.25	U	<0.25	U	<0.25	U
Nitrobenzene	*NA*	<0.25	U	<0.25	U	<0.25	U	<0.25	U
Nitroglycerin	*NA*	<1	U	<1	U	<1	U	<1	U
Nitroguanidine	*NA*	<0.125	U	<0.125	U	<0.125	U	<0.125	U

Table 4-7 (continued)
Summary of Wet Sediment Results

	Location ID:	**EBGsd-005**		**EBGsd-006**		**EBGsd-007**		**EBGsd-008**	
	Sample ID:	**EBGsd-005M-0001-SD**		**EBGsd-006M-0001-SD**		**EBGsd-007M-0001-SD**		**EBGsd-008M-0001-SD**	
	Sample Date:	**5/8/2012**		**5/8/2012**		**5/8/2012**		**5/8/2012**	
	Depth (feet bss):	**0–0.5**		**0–0.5**		**0–0.5**		**0–0.5**	
Analyte	**BSV[1] (mg/kg)**	**Result (mg/kg)**	**VQ**	**Result (mg/kg)**	**VQ**	**Result (mg/kg)**	**VQ**	**Result (mg/kg)**	**VQ**
o-Nitrotoluene	*NA*	<0.15	U	<0.15	U	<0.15	U	<0.15	U
PETN	*NA*	<1	U	<1	U	<1	U	<1	U
p-Nitrotoluene	*NA*	<0.25	U	<0.25	U	<0.25	U	<0.25	U
RDX	*NA*	<0.25	U	<0.25	U	<0.25	U	<0.25	U
Tetryl	*NA*	<0.15	U	<0.15	U	<0.15	U	<0.15	U
Semivolatile Organic Compounds									
1,2,4-Trichlorobenzene	*NA*	<0.085	U	<0.1	U	0.095	U	0.125	U
1,2-Dichlorobenzene	*NA*	<0.085	U	<0.1	U	<0.095	U	<0.125	U
1,3-Dichlorobenzene	*NA*	<0.085	U	<0.1	U	<0.095	U	<0.125	U
1,4-Dichlorobenzene	*NA*	<0.085	U	<0.1	U	<0.095	U	<0.125	U
2,4,5-Trichlorophenol	*NA*	<0.435	U	<0.5	U	<0.475	U	<0.65	U
2,4,6-Trichlorophenol	*NA*	<0.435	U	<0.5	U	<0.475	U	<0.65	U
2,4-Dichlorophenol	*NA*	<0.435	U	<0.5	U	<0.475	U	<0.65	U
2,4-Dimethylphenol	*NA*	<0.435	U	<0.5	U	<0.475	U	<0.65	U

Table 4-7 (continued)
Summary of Wet Sediment Results

	Location ID:	EBGsd-005		EBGsd-006		EBGsd-007		EBGsd-008	
	Sample ID:	EBGsd-005M-0001-SD		EBGsd-006M-0001-SD		EBGsd-007M-0001-SD		EBGsd-008M-0001-SD	
	Sample Date:	5/8/2012		5/8/2012		5/8/2012		5/8/2012	
	Depth (feet bss):	0–0.5		0–0.5		0–0.5		0–0.5	
Analyte	BSV[1] (mg/kg)	Result (mg/kg)	VQ	Result (mg/kg)	VQ	Result (mg/kg)	VQ	Result (mg/kg)	VQ
2,4-Dinitrophenol	*NA*	<0.7	U	<0.85	U	<0.8	U	<1.05	U
2-Chloronaphthalene	*NA*	<0.085	U	<0.1	U	<0.095	U	<0.125	U
2-Chlorophenol	*NA*	<1.45	U	<1.7	U	<1.6	U	<2.1	U
2-Methylnaphthalene	*NA*	<0.085	U	<0.1	U	<0.095	U	<0.125	U
2-Nitroaniline	*NA*	<0.085	U	<0.1	U	<0.095	U	<0.125	U
2-Nitrophenol	*NA*	<0.7	U	<0.85	U	<0.8	U	<1.05	U
3,3'-Dichlorobenzidine	*NA*	<0.36	U	<0.425	U	<0.4	U	<0.5	U
3-Nitroaniline	*NA*	<0.085	U	<0.1	U	<0.095	U	<0.125	U
4,6-Dinitro-2-Methylphenol	*NA*	<0.7	U	<0.85	U	<0.8	U	<1.05	U
4-Bromophenyl Phenyl Ether	*NA*	<0.085	U	<0.1	U	<0.095	U	<0.125	U
4-Chloro-3-Methylphenol	*NA*	<1.45	U	<1.7	U	<1.6	U	<2.1	U
4-Chloroaniline	*NA*	<0.145	U	<0.17	U	<0.16	U	<0.21	U
4-Chlorophenyl Phenyl Ether	*NA*	<0.085	U	<0.1	U	<0.095	U	<0.125	U
4-Nitrobenzenamine	*NA*	<0.085	U	<0.1	U	<0.095	U	<0.125	U

Table 4-7 (continued)
Summary of Wet Sediment Results

	Location ID:	EBGsd-005		EBGsd-006		EBGsd-007		EBGsd-008	
	Sample ID:	EBGsd-005M-0001-SD		EBGsd-006M-0001-SD		EBGsd-007M-0001-SD		EBGsd-008M-0001-SD	
	Sample Date:	5/8/2012		5/8/2012		5/8/2012		5/8/2012	
	Depth (feet bss):	0–0.5		0–0.5		0–0.5		0–0.5	
Analyte	BSV[1] (mg/kg)	Result (mg/kg)	VQ	Result (mg/kg)	VQ	Result (mg/kg)	VQ	Result (mg/kg)	VQ
4-Nitrophenol	*NA*	<1.45	U	>1.7	U	<1.6	U	<2.1	U
Acenaphthene	*NA*	<0.085	U	<0.1	U	<0.095	U	<0.125	U
Acenaphthylene	*NA*	<0.085	U	<0.1	U	<0.095	U	<0.125	U
Anthracene	*NA*	<0.085	U	<0.1	U	<0.095	U	<0.125	U
Benzo(a)anthracene	*NA*	<0.085	U	<0.1	U	<0.095	U	<0.125	U
Benzo(a)pyrene	*NA*	<0.085	U	<0.1	U	<0.095	U	<0.125	U
Benzo(b)fluoranthene	*NA*	<0.085	U	<0.1	U	<0.095	U	<0.125	U
Benzo(ghi)perylene	*NA*	<0.085	U	<0.1	U	<0.095	U	<0.125	U
Benzo(k)fluoranthene	*NA*	<0.085	U	<0.1	U	<0.095	U	<0.125	U
Benzoic Acid	NA	0.61	J	0.63	J	0.61	J	0.82	J
Benzyl Alcohol	*NA*	<0.29	U	<0.34	U	<0.32	U	<0.42	U
Bis(2-Chloroethoxy)methane	*NA*	<0.085	U	<0.1	U	<0.095	U	<0.125	U
Bis(2-Chloroethyl)ether	*NA*	<0.085	U	<0.1	U	<0.095	U	<0.125	U
Bis(2-Chloroisopropyl)ether	*NA*	<0.085	U	<0.1	U	<0.095	U	<0.125	U

Table 4-7 (continued)
Summary of Wet Sediment Results

	Location ID:	EBGsd-005		EBGsd-006		EBGsd-007		EBGsd-008	
	Sample ID:	EBGsd-005M-0001-SD		EBGsd-006M-0001-SD		EBGsd-007M-0001-SD		EBGsd-008M-0001-SD	
	Sample Date:	5/8/2012		5/8/2012		5/8/2012		5/8/2012	
	Depth (feet bss):	0–0.5		0–0.5		0–0.5		0–0.5	
Analyte	BSV[1] (mg/kg)	Result (mg/kg)	VQ	Result (mg/kg)	VQ	Result (mg/kg)	VQ	Result (mg/kg)	VQ
Bis(2-Ethylhexyl)phthalate	*NA*	<0.29	U	<0.34	U	<0.32	U	<0.42	U
Butyl Benzyl Phthalate	*NA*	<0.29	U	<0.34	U	<0.32	U	<0.42	U
Carbazole	*NA*	<0.085	U	<0.1	U	<0.095	U	<0.125	U
Chrysene	*NA*	<0.085	U	<0.1	U	<0.095	U	<0.125	U
Cresols (Total)	*NA*	<2.6	U	<3.05	U	<2.85	U	<3.75	U
Dibenzo(a,h)anthracene	*NA*	<0.085	U	<0.1	U	<0.095	U	<0.125	U
Dibenzofuran	*NA*	<0.085	U	<0.1	U	**0.049**	**J**	<0.125	U
Diethyl Phthalate	*NA*	<0.29	U	<0.34	U	<0.32	U	<0.42	U
Dimethyl Phthalate	*NA*	<0.29	U	<0.34	U	<0.32	U	<0.42	U
Di-n-Butyl Phthalate	*NA*	<0.29	U	<0.34	U	<0.32	U	<0.42	U
Di-n-Octyl Phthalate	*NA*	<0.145	U	<0.17	U	<0.16	U	<0.21	U
Fluoranthene	*NA*	<0.085	U	<0.1	U	<0.095	U	<0.125	U
Fluorene	*NA*	<0.085	U	<0.1	U	<0.095	U	<0.125	U
Hexachlorobenzene	*NA*	<0.085	U	<0.1	U	<0.095	U	<0.125	U

Table 4-7 (continued)
Summary of Wet Sediment Results

	Location ID:	**EBGsd-005**		**EBGsd-006**		**EBGsd-007**		**EBGsd-008**	
	Sample ID:	**EBGsd-005M-0001-SD**		**EBGsd-006M-0001-SD**		**EBGsd-007M-0001-SD**		**EBGsd-008M-0001-SD**	
	Sample Date:	**5/8/2012**		**5/8/2012**		**5/8/2012**		**5/8/2012**	
	Depth (feet bss):	**0–0.5**		**0–0.5**		**0–0.5**		**0–0.5**	
Analyte	**BSV[1] (mg/kg)**	**Result (mg/kg)**	**VQ**	**Result (mg/kg)**	**VQ**	**Result (mg/kg)**	**VQ**	**Result (mg/kg)**	**VQ**
Hexachlorobutadiene	*NA*	<0.29	U	<0.34	U	<0.32	U	<0.42	U
Hexachlorocyclopentadiene	*NA*	<0.145	U	<0.17	U	<0.16	U	<0.21	U
Hexachloroethane	*NA*	<0.085	U	<0.1	U	<0.095	U	<0.125	U
Indeno(1,2,3-cd)pyrene	*NA*	<0.085	U	<0.1	U	<0.095	U	<0.125	U
Isophorone	*NA*	<0.145	U	<0.17	U	<0.16	U	<0.21	U
Naphthalene	*NA*	<0.085	U	<0.1	U	<0.095	U	<0.125	U
N-Nitroso-di-n-Propylamine	*NA*	<0.29	U	<0.34	U	<0.32	U	<0.42	U
N-Nitrosodiphenylamine	*NA*	<0.175	U	<0.205	U	<0.19	U	<0.25	U
o-Cresol	*NA*	<1.45	U	<1.7	U	<1.6	U	<2.1	U
Phenanthrene	*NA*	<0.085	U	<0.1	U	**0.056**	**J**	<0.125	U
Pyrene	*NA*	<0.085	U	<0.1	U	<0.095	U	<0.125	U
Polychlorinated Biphenyls									
Aroclor-1016	*NA*	<0.075	U	<0.085	U	<0.08	U	<0.105	U
Aroclor-1221	*NA*	<0.075	U	<0.085	U	<0.08	U	<0.105	U

Table 4-7 (continued)
Summary of Wet Sediment Results

	Location ID:	**EBGsd-005**		**EBGsd-006**		**EBGsd-007**		**EBGsd-008**	
	Sample ID:	**EBGsd-005M-0001-SD**		**EBGsd-006M-0001-SD**		**EBGsd-007M-0001-SD**		**EBGsd-008M-0001-SD**	
	Sample Date:	**5/8/2012**		**5/8/2012**		**5/8/2012**		**5/8/2012**	
	Depth (feet bss):	**0–0.5**		**0–0.5**		**0–0.5**		**0–0.5**	
Analyte	**BSV[1] (mg/kg)**	**Result (mg/kg)**	**VQ**	**Result (mg/kg)**	**VQ**	**Result (mg/kg)**	**VQ**	**Result (mg/kg)**	**VQ**
Aroclor-1232	*NA*	<0.075	U	<0.085	U	<0.08	U	<0.105	U
Aroclor-1242	*NA*	<0.075	U	<0.085	U	<0.08	U	<0.105	U
Aroclor-1248	*NA*	<0.075	U	<0.085	U	<0.08	U	<0.105	U
Aroclor-1254	*NA*	<0.075	U	<0.085	U	<0.08	U	<0.105	U
Aroclor-1260	*NA*	<0.075	U	<0.085	U	<0.08	U	<0.105	U
General Chemistry									
Hexavalent Chromium	*NA*	<7	U	**16**	**J**	**14**	**J**	<9.5	U
Nitrocellulose	*NA*	<100	U	<100	U	<100	U	<100	U
Total organic carbon	*NA*	11,000		42,000		51,000		56,000	
pH (SU)	*NA*	68.3		59		62.5		47.6	

Table 4-7 (continued)
Summary of Wet Sediment Results

Analyte	Location ID:	EBGsd-009		EBGsd-010	
	Sample ID:	EBGsd-009M-0001-SD		EBGsd-010M-0001-SD	
	Sample Date:	5/8/2012		5/8/2012	
	Depth (feet bss):	0–0.5		0–0.5	
	BSV[1] (mg/kg)	Result (mg/kg)	VQ	Result (mg/kg)	VQ
Metals					
Aluminum	*13,900*	**18,200**	**J**	37,300	J
Antimony	*0*	**6.5**		**6.4**	**J**
Barium	*123*	**128**	**J**	**418**	**J**
Cadmium	*0*	**0.72**		**1.1**	**J**
Chromium (as Cr^{+3})	*18.1*	10.8		<10	U
Copper	*27.6*	**301**		**91.5**	**J**
Iron	*28,200*	10,600	J	**33,000**	**J**
Lead	*27.4*	**67.3**		**72**	**J**
Mercury	*0.059*	0.025		0.055	J
Strontium	*0*	**18.4**		**27.6**	**J**
Zinc	*532*	241		315	J
Geochemical Metals[2]					
Calcium	5,510	3,470	J	**11,600**	**J**
Magnesium	2,760	2,290	J	**7,350**	J
Manganese	1,950	130	J	324	J

Table 4-7 (continued)
Summary of Wet Sediment Results

	Location ID:	EBGsd-009		EBGsd-010	
	Sample ID:	EBGsd-009M-0001-SD		EBGsd-010M-0001-SD	
	Sample Date:	5/8/2012		5/8/2012	
	Depth (feet bss):	0–0.5		0–0.5	
Analyte	BSV[1] (mg/kg)	Result (mg/kg)	VQ	Result (mg/kg)	VQ
Explosives and Propellants					
1,3,5-Trinitrobenzene	*NA*	<0.25	U	<0.25	U
1,3-Dinitrobenzene	*NA*	<0.15	U	<0.15	U
2,4,6-Trinitrotoluene	*NA*	**0.63**		<0.25	U
2,4-Dinitrotoluene	*NA*	<0.15	U	<0.15	U
2,6-Dinitrotoluene	*NA*	<0.15	U	<0.15	U
2-Amino-4,6-Dinitrotoluene	*NA*	<0.15	U	<0.15	U
3,5-Dinitroaniline	*NA*	<0.15	U	<0.15	U
4-Amino-2,6-Dinitrotoluene	*NA*	**0.13**	**J**	<0.15	U
HMX	*NA*	<0.25	U	<0.25	U
m-Nitrotoluene	*NA*	<0.25	U	<0.25	U
Nitrobenzene	*NA*	<0.25	U	<0.25	U
Nitroglycerin	*NA*	<1	U	<1	U
Nitroguanidine	*NA*	<0.125	U	<0.125	U
o-Nitrotoluene	*NA*	<0.15	U	<0.15	U

Table 4-7 (continued)
Summary of Wet Sediment Results

	Location ID:	EBGsd-009		EBGsd-010	
	Sample ID:	EBGsd-009M-0001-SD		EBGsd-010M-0001-SD	
	Sample Date:	5/8/2012		5/8/2012	
	Depth (feet bss):	0–0.5		0–0.5	
Analyte	BSV[1] (mg/kg)	Result (mg/kg)	VQ	Result (mg/kg)	VQ
PETN	*NA*	<1	U	<1	U
p-Nitrotoluene	*NA*	<0.25	U	<0.25	U
RDX	*NA*	<0.25	U	<0.25	U
Tetryl	*NA*	<0.15	U	<0.15	U
Semivolatile Organic Compounds					
1,2,4-Trichlorobenzene	*NA*	<0.095	U	<0.12	U
1,2-Dichlorobenzene	*NA*	<0.095	U	<0.12	U
1,3-Dichlorobenzene	*NA*	<0.095	U	<0.12	U
1,4-Dichlorobenzene	*NA*	<0.095	U	<0.12	U
2,4,5-Trichlorophenol	*NA*	<0.47	U	<0.6	U
2,4,6-Trichlorophenol	*NA*	<0.47	U	<0.6	U
2,4-Dichlorophenol	*NA*	<0.47	U	<0.6	U
2,4-Dimethylphenol	*NA*	<0.47	U	<0.6	U
2,4-Dinitrophenol	*NA*	<0.8	U	<1	U
2-Chloronaphthalene	*NA*	<0.095	U	<0.12	U

Table 4-7 (continued)
Summary of Wet Sediment Results

	Location ID:	EBGsd-009		EBGsd-010	
	Sample ID:	EBGsd-009M-0001-SD		EBGsd-010M-0001-SD	
	Sample Date:	5/8/2012		5/8/2012	
	Depth (feet bss):	0–0.5		0–0.5	
Analyte	BSV[1] (mg/kg)	Result (mg/kg)	VQ	Result (mg/kg)	VQ
2-Chlorophenol	*NA*	<1.55	U	<2	U
2-Methylnaphthalene	*NA*	<0.095	U	<0.12	U
2-Nitroaniline	*NA*	<0.095	U	<0.12	U
2-Nitrophenol	*NA*	<0.8	U	<1	U
3,3'-Dichlorobenzidine	*NA*	<0.39	U	<0.5	U
3-Nitroaniline	*NA*	<0.095	U	<0.12	U
4,6-Dinitro-2-Methylphenol	*NA*	<0.8	U	<1	U
4-Bromophenyl Phenyl Ether	*NA*	<0.095	U	<0.12	U
4-Chloro-3-Methylphenol	*NA*	<1.55	U	<2	U
4-Chloroaniline	*NA*	<0.155	U	<0.2	U
4-Chlorophenyl Phenyl Ether	*NA*	<0.095	U	<0.12	U
4-Nitrobenzenamine	*NA*	<0.095	U	<0.12	U
4-Nitrophenol	*NA*	<1.55	U	<2	U
Acenaphthene	*NA*	<0.095	U	<0.12	U
Acenaphthylene	*NA*	<0.095	U	<0.12	U

Table 4-7 (continued)
Summary of Wet Sediment Results

	Location ID:	**EBGsd-009**		**EBGsd-010**	
	Sample ID:	**EBGsd-009M-0001-SD**		**EBGsd-010M-0001-SD**	
	Sample Date:	**5/8/2012**		**5/8/2012**	
	Depth (feet bss):	**0–0.5**		**0–0.5**	
Analyte	**BSV[1] (mg/kg)**	**Result (mg/kg)**	**VQ**	**Result (mg/kg)**	**VQ**
Anthracene	*NA*	<0.095	U	<0.12	U
Benzo(a)anthracene	*NA*	<0.095	U	<0.12	U
Benzo(a)pyrene	*NA*	<0.095	U	<0.12	U
Benzo(b)fluoranthene	*NA*	**0.07**	**J**	<0.12	U
Benzo(ghi)perylene	*NA*	<0.095	U	<0.12	U
Benzo(k)fluoranthene	*NA*	<0.095	U	<0.12	U
Benzoic Acid	*NA*	**0.7**	**J**	**0.78**	**J**
Benzyl Alcohol	*NA*	<0.315	U	<0.4	U
Bis(2-Chloroethoxy)methane	*NA*	<0.095	U	<0.12	U
Bis(2-Chloroethyl)ether	*NA*	<0.095	U	<0.12	U
Bis(2-Chloroisopropyl)ether	*NA*	<0.095	U	<0.12	U
Bis(2-Ethylhexyl)phthalate	*NA*	<0.315	U	<0.4	U
Butyl Benzyl Phthalate	*NA*	<0.315	U	<0.4	U
Carbazole	*NA*	<0.095	U	<0.12	U
Chrysene	*NA*	**0.039**	**J**	<0.12	U

Table 4-7 (continued)
Summary of Wet Sediment Results

	Location ID:	EBGsd-009		EBGsd-010	
	Sample ID:	EBGsd-009M-0001-SD		EBGsd-010M-0001-SD	
	Sample Date:	5/8/2012		5/8/2012	
	Depth (feet bss):	0–0.5		0–0.5	
Analyte	BSV[1] (mg/kg)	Result (mg/kg)	VQ	Result (mg/kg)	VQ
Cresols (Total)	*NA*	<2.8	U	<3.6	U
Dibenzo(a,h)anthracene	*NA*	<0.095	U	<0.12	U
Dibenzofuran	*NA*	<0.095	U	<0.12	U
Diethyl Phthalate	*NA*	<0.315	U	<0.4	U
Dimethyl Phthalate	*NA*	<0.315	U	<0.4	U
Di-n-Butyl Phthalate	*NA*	<0.315	U	<0.4	U
Di-n-Octyl Phthalate	*NA*	<0.155	U	<0.2	U
Fluoranthene	*NA*	**0.067**	**J**	<0.12	U
Fluorene	*NA*	<0.095	U	<0.12	U
Hexachlorobenzene	*NA*	<0.095	U	<0.12	U
Hexachlorobutadiene	*NA*	<0.315	U	<0.4	U
Hexachlorocyclopentadiene	*NA*	<0.155	U	<0.2	U
Hexachloroethane	*NA*	<0.095	U	<0.12	U
Indeno(1,2,3-cd)pyrene	*NA*	<0.095	U	<0.12	U
Isophorone	*NA*	<0.155	U	<0.2	U

Table 4-7 (continued)
Summary of Wet Sediment Results

	Location ID:	**EBGsd-009**		**EBGsd-010**	
	Sample ID:	**EBGsd-009M-0001-SD**		**EBGsd-010M-0001-SD**	
	Sample Date:	**5/8/2012**		**5/8/2012**	
	Depth (feet bss):	**0–0.5**		**0–0.5**	
Analyte	**BSV[1] (mg/kg)**	**Result (mg/kg)**	**VQ**	**Result (mg/kg)**	**VQ**
Naphthalene	*NA*	<0.095	U	<0.12	U
N-Nitroso-di-n-Propylamine	*NA*	<0.315	U	<0.4	U
N-Nitrosodiphenylamine	*NA*	<0.19	U	<0.24	U
o-Cresol	*NA*	<1.55	U	<2	U
Phenanthrene	*NA*	**0.053**	**J**	<0.12	U
Pyrene	*NA*	**0.042**	**J**	<0.12	U
Polychlorinated Biphenyls					
Aroclor-1016	*NA*	<0.08	U	<0.095	U
Aroclor-1221	*NA*	<0.08	U	<0.095	U
Aroclor-1232	*NA*	<0.08	U	<0.095	U
Aroclor-1242	*NA*	<0.08	U	<0.095	U
Aroclor-1248	*NA*	<0.08	U	<0.095	U
Aroclor-1254	*NA*	<0.08	U	**0.052**	**J**
Aroclor-1260	*NA*	<0.08	U	<0.095	U

Table 4-7 (continued)
Summary of Wet Sediment Results

Analyte	Location ID:	EBGsd-009		EBGsd-010	
	Sample ID:	EBGsd-009M-0001-SD		EBGsd-010M-0001-SD	
	Sample Date:	5/8/2012		5/8/2012	
	Depth (feet bss):	0–0.5		0–0.5	
	BSV[1] (mg/kg)	Result (mg/kg)	VQ	Result (mg/kg)	VQ
General Chemistry					
Hexavalent Chromium	*NA*	**4.2**	**J**	**22**	
Nitrocellulose	*NA*	<100	U	**100**	**J**
Total organic carbon	*NA*	47,000		110,000	J
pH (SU)	*NA*	6.59		6.3	
Total Solids (%)	*NA*	63.4		50.5	

[1] Background values as presented in the Final Facility-Wide Human Health Cleanup Goals at the RVAAP, Ravenna, Ohio *(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 RVAAP background value. For organics, bold numbering indicates a detected value.
> denotes greater than.
< denotes less than.
bss denotes below sediment surface.
BSV denotes background screening value.
Cr^{+3} denotes trivalent chromium.
HMX denotes octogen explosives.
ID denotes identification.
MC denotes munitions constituents.
mg/kg denotes milligrams per kilogram.
NA denotes not applicable/available.
PETN denotes pentaerythritol tetranitrate.
RDX denotes research department explosives.
RVAAP denotes Ravenna Army Ammunition Plant.
SU denotes standard unit.
VQ denotes validation qualifier.

Validation Qualifiers:
J denotes that the result is reported as an estimated value.
U denotes result is not detected or the concentration is below the detection limit.

Table 4-8
SRC Screening Summary for Wet Sediment

Analyte	CAS Number	Frequency of Detection	Minimum Detect		Maximum Detect		Mean Result (mg/kg)	BSV[1] (mg/kg)	SRC?	SRC Justification
			Result (mg/kg)	VQ	Result (mg/kg)	VQ				
Metals										
Aluminum	7429-90-5	6/6	13,900	J	37,300	J	21,517	13,900	Yes	Above BSV
Antimony	7440-36-0	3/6	0.92	J	6.5		2.65	0	Yes	No BSV
Barium	7440-39-3	6/6	128	J	418	J	247.5	123	Yes	Above BSV
Cadmium	7440-43-9	6/6	0.61		2.5		1.18	0	Yes	No BSV
Chromium (as Cr^{+3})	7440-47-3	3/6	11.9		20.2		15.97	18.1	Yes	Above BSV
Copper	7440-50-6	6/6	30.9		301		100.8	27.6	Yes	Above BSV
Iron	7439-89-6	6/6	8,740	J	33,000	J	15,273	28,200	Yes	Above BSV
Lead	7439-92-1	6/6	14.7		72	J	36.9	27.4	Yes	Above BSV
Mercury	7439-97-6	6/6	0.025		0.092		0.057	0.059	Yes	Above BSV
Strontium	7440-24-6	6/6	18.4		29.6		22.82	0	Yes	No BSV
Zinc	7440-36-0	6/6	46.6		315	J	145.2	532	No	Below BSV
Explosives and Propellants										
2,4,6-Trinitrotoluene	118-96-7	1/6	0.38	J	0.63		0.313	NA	Yes	Detected organic
4-Amino-2,6-Dinitrotoluene	19406-51-0	1/6	0.13	J	0.13	J	0.147	NA	Yes	Detected organic
Semivolatile Organic Compounds										
Benzo(b)fluoranthene	205-99-2	1/6	0.07	J	0.07	J	0.0992	NA	Yes	Detected organic
Benzoic Acid	65-85-0	6/6	0.61	J	0.82	J	0.692	NA	Yes	Detected organic

Table 4-8 (continued)
SRC Screening Summary for Wet Sediment

Analyte	CAS Number	Frequency of Detection	Minimum Detect		Maximum Detect		Mean Result (mg/kg)	BSV[1] (mg/kg)	SRC?	SRC Justification
			Result (mg/kg)	VQ	Result (mg/kg)	VQ				
Chrysene	218-01-9	1/6	0.039	J	0.039	J	0.094	NA	Yes	Detected organic
Dibenzofuran	132-64-9	1/6	0.049	J	0.049	J	0.0957	NA	Yes	Detected organic
Fluoranthene	206-44-0	1/6	0.067	J	0.067	J	0.0987	NA	Yes	Detected organic
Phenanthrene	85-01-8	2/6	0.053	J	0.056	J	0.0898	NA	Yes	Detected organic
Pyrene	129-00-0	1/6	0.042	J	0.042	J	0.0945	NA	Yes	Detected organic
Polychlorinated Biphenyls										
Aroclor-1254	11097-69-1	1/6	0.052	J	0.052	J	0.0795	NA	Yes	Detected organic
General Chemistry										
Hexavalent Chromium	18540-29-9	4/6	4.2	J	22		12.12	0	Yes	No BSV
Nitrocellulose	9004-70-0	1/6	100	J	100	J	100	NA	Yes	Detected organic

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

BSV denotes background screening value.

CAS denotes Chemical Abstracts Service.

Cr^{+3} denotes trivalent chromium.

J denotes that the result is reported as an estimated value.

mg/kg denotes milligrams per kilogram.

NA denotes not applicable/available.

RVAAP denotes Ravenna Army Ammunition Plant.

SRC denotes site-related chemical.

VQ denotes validation qualifier.

Table 4-9
Summary of Subsurface Soil Results

Analyte	Location ID:	EBGss-012		EBGss-013	
	Sample ID:	EBGss-012M-0001-SS		EBGss-013M-0001-SS	
	Sample Date:	5/9/2012		5/9/2012	
	Depth (feet bgs):	3.5–4.0		3–3.5	
	BSV[1] (mg/kg)	Result (mg/kg)	VQ	Result (mg/kg)	VQ
Metals					
Aluminum	*19,500*	5,110	J	6,830	
Antimony	*0.96*	0.56	J	0.15	J
Barium	*124*	35.5		49	
Cadmium	*0*	**0.054**		**0.036**	**J**
Chromium (as Cr^{+3})	*27.2*	6.6	J	8.6	J
Copper	*32.3*	10.7	J	9.4	
Iron	*35,200*	11,000	J	8,030	
Lead	*19.1*	9.6		14.1	
Mercury	*0.044*	0.014		0.027	
Strontium	*0*	**3.6**		**5**	
Zinc	*93.3*	41.7		42	
Geochemical Metals[2]					
Calcium	*35,500*	543	J	598	
Magnesium	*8,790*	2,330		2,230	
Manganese	*3,030*	92.1		58.3	

Table 4-9 (continued)
Summary of Subsurface Soil Results

Analyte	Location ID:	EBGss-012		EBGss-013	
	Sample ID:	EBGss-012M-0001-SS		EBGss-013M-0001-SS	
	Sample Date:	5/9/2012		5/9/2012	
	Depth (feet bgs):	3.5–4.0		3–3.5	
	BSV[1] (mg/kg)	Result (mg/kg)	VQ	Result (mg/kg)	VQ
Explosives and Propellants					
1,3,5-Trinitrobenzene	*NA*	<0.25	U	<0.25	U
1,3-Dinitrobenzene	*NA*	<0.15	U	<0.15	U
2,4,6-Trinitrotoluene	*NA*	<0.25	U	<0.25	U
2,4-Dinitrotoluene	*NA*	<0.15	U	<0.15	U
2,6-Dinitrotoluene	*NA*	<0.15	U	<0.15	U
2-Amino-4,6-Dinitrotoluene	*NA*	<0.15	U	<0.15	U
3,5-Dinitroaniline	*NA*	<0.15	U	<0.15	U
4-Amino-2,6-Dinitrotoluene	*NA*	<0.15	U	<0.15	U
HMX	*NA*	<0.25	U	<0.25	U
m-Nitrotoluene	*NA*	<0.25	U	<0.25	U
Nitrobenzene	*NA*	<0.25	U	<0.25	U
Nitroglycerin	*NA*	<1	U	<1	U
Nitroguanidine	*NA*	<0.125	U	<0.125	U
o-Nitrotoluene	*NA*	<0.15	U	<0.15	U

Table 4-9 (continued)
Summary of Subsurface Soil Results

Analyte	Location ID:	EBGss-012		EBGss-013	
	Sample ID:	EBGss-012M-0001-SS		EBGss-013M-0001-SS	
	Sample Date:	5/9/2012		5/9/2012	
	Depth (feet bgs):	3.5–4.0		3–3.5	
	BSV[1] (mg/kg)	Result (mg/kg)	VQ	Result (mg/kg)	VQ
PETN	*NA*	<1	U	<1	U
p-Nitrotoluene	*NA*	<0.25	U	<0.25	U
RDX	*NA*	<0.25	U	<0.25	U
Tetryl	*NA*	<0.15	U	<0.15	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*	<0.3	U	<0.3	U
2,4,6-Trichlorophenol	*NA*	<0.3	U	<0.3	U
2,4-Dichlorophenol	*NA*	<0.3	U	<0.3	U
2,4-Dimethylphenol	*NA*	<0.3	U	<0.3	U
2,4-Dinitrophenol	*NA*	<0.5	U	<0.5	U
2-Chloronaphthalene	*NA*	<0.06	U	<0.06	U

Table 4-9 (continued)
Summary of Subsurface Soil Results

	Location ID:	EBGss-012		EBGss-013	
	Sample ID:	EBGss-012M-0001-SS		EBGss-013M-0001-SS	
	Sample Date:	5/9/2012		5/9/2012	
	Depth (feet bgs):	3.5–4.0		3–3.5	
Analyte	BSV[1] (mg/kg)	Result (mg/kg)	VQ	Result (mg/kg)	VQ
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*	<0.25	U	<0.25	U
3-Nitroaniline	*NA*	<0.06	U	<0.06	U
4,6-Dinitro-2-Methylphenol	*NA*	<0.5	U	<0.5	U
4-Bromophenyl Phenyl Ether	*NA*	<0.06	U	<0.06	U
4-Chloro-3-Methylphenol	*NA*	<1	U	<1	U
4-Chloroaniline	*NA*	<0.1	U	<0.1	U
4-Chlorophenyl Phenyl Ether	*NA*	<0.06	U	<0.06	U
4-Nitrobenzenamine	*NA*	<0.06	U	<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

Table 4-9 (continued)
Summary of Subsurface Soil Results

	Location ID:	**EBGss-012**		**EBGss-013**	
	Sample ID:	**EBGss-012M-0001-SS**		**EBGss-013M-0001-SS**	
	Sample Date:	**5/9/2012**		**5/9/2012**	
	Depth (feet bgs):	**3.5–4.0**		**3–3.5**	
Analyte	**BSV[1] (mg/kg)**	**Result (mg/kg)**	**VQ**	**Result (mg/kg)**	**VQ**
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	<1.5	U
Benzyl Alcohol	*NA*	<0.2	U	<0.2	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*	<0.2	U	<0.2	U
Butyl Benzyl Phthalate	*NA*	<0.2	U	<0.2	U
Carbazole	*NA*	<0.06	U	<0.06	U
Chrysene	*NA*	<0.06	U	<0.06	U

Table 4-9 (continued)
Summary of Subsurface Soil Results

Analyte	Location ID:	EBGss-012		EBGss-013	
	Sample ID:	EBGss-012M-0001-SS		EBGss-013M-0001-SS	
	Sample Date:	5/9/2012		5/9/2012	
	Depth (feet bgs):	3.5–4.0		3–3.5	
	BSV[1] (mg/kg)	Result (mg/kg)	VQ	Result (mg/kg)	VQ
Cresols (Total)	*NA*	<1.8	U	<1.8	U
Dibenzo(a,h)anthracene	*NA*	<0.06	U	<0.06	U
Dibenzofuran	*NA*	<0.06	U	<0.06	U
Diethyl Phthalate	*NA*	<0.2	U	<0.2	U
Dimethyl Phthalate	*NA*	<0.2	U	<0.2	U
Di-n-Butyl Phthalate	*NA*	<0.2	U	<0.2	U
Di-n-Octyl Phthalate	*NA*	<0.1	U	<0.1	U
Fluoranthene	*NA*	<0.06	U	<0.06	U
Fluorene	*NA*	<0.06	U	<0.06	U
Hexachlorobenzene	*NA*	<0.06	U	<0.06	U
Hexachlorobutadiene	*NA*	<0.2	U	<0.2	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

Table 4-9 (continued)
Summary of Subsurface Soil Results

Analyte	Location ID:	EBGss-012		EBGss-013	
	Sample ID:	EBGss-012M-0001-SS		EBGss-013M-0001-SS	
	Sample Date:	5/9/2012		5/9/2012	
	Depth (feet bgs):	3.5–4.0		3–3.5	
	BSV[1] (mg/kg)	Result (mg/kg)	VQ	Result (mg/kg)	VQ
Naphthalene	*NA*	<0.06	U	<0.06	U
N-Nitroso-di-n-Propylamine	*NA*	<0.2	U	<0.2	U
N-Nitrosodiphenylamine	*NA*	<0.12	U	<0.12	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 4-9 (continued)
Summary of Subsurface Soil Results

Analyte	Location ID:	EBGss-012		EBGss-013	
	Sample ID:	EBGss-012M-0001-SS		EBGss-013M-0001-SS	
	Sample Date:	5/9/2012		5/9/2012	
	Depth (feet bgs):	3.5–4.0		3–3.5	
	BSV[1] (mg/kg)	Result (mg/kg)	VQ	Result (mg/kg)	VQ
General Chemistry					
Hexavalent Chromium	*NA*	<5	U	<5	U
Nitrocellulose	*NA*	<100	U	<100	U
Total organic carbon	*NA*	3,900		3,400	
pH (SU)	*NA*	8.01		7.64	
Total Solids (%)	*NA*	99.2		99	

[1] Background values as presented in the Final Facility-Wide Human Health Cleanup Goals at the RVAAP, Ravenna, Ohio *(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 RVAAP 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.
HMX denotes octogen explosives.
ID denotes identification.
MC denotes munitions constituents.
mg/kg denotes milligrams per kilogram.
NA denotes not applicable/available.
PETN denotes pentaerythritol tetranitrate.
RDX denotes research department explosives.
RVAAP denotes Ravenna Army Ammunition Plant.
SU denotes standard unit.
VQ denotes validation qualifier.

Validation Qualifiers:
J denotes that the result is reported as an estimated value.
U denotes result is not detected or the concentration is below the detection limit.

Table 4-10
SRC Screening Summary for Soil

Analyte	CAS Number	Frequency of Detection	Maximum Detect		Minimum Detect		Mean Result (mg/kg)	BSV (mg/kg)	SRC?	SRC Justification
			Result (mg/kg)	VQ	Result (mg/kg)	VQ				
Aluminum	7429-90-5	2/2	5,110	J	6,830		5,970	19500	No	Below BSV
Antimony	7440-36-0	2/2	0.15	J	0.56		0.355	0.96	No	Below BSV
Barium	7440-39-3	2/2	35.5		49		42.25	124	No	Below BSV
Cadmium	7440-43-9	2/2	0.036	J	0.054		0.045	0	Yes	No BSV
Chromium (as Cr^{+3})	7440-47-3	2/2	6.6		8.6		7.6	27.2	No	Below BSV
Copper	7440-50-6	2/2	9.4		10.7	J	10.1	32.3	No	Below BSV
Iron	7439-89-6	2/2	8,030		11,000	J	9,515	35200	No	Below BSV
Lead	7439-92-1	2/2	9.6		14.1		11.85	19.1	No	Below BSV
Mercury	7439-97-6	2/2	0.014		0.027		0.021	0.044	No	Below BSV
Strontium	7440-24-6	2/2	3.6		5.0		4.3	0	Yes	No BSV
Zinc	7440-36-0	2/2	41.7		42		41.85	93.3	No	Below BSV

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.
SRC denotes site-related chemical.
VQ denotes validation qualifier.

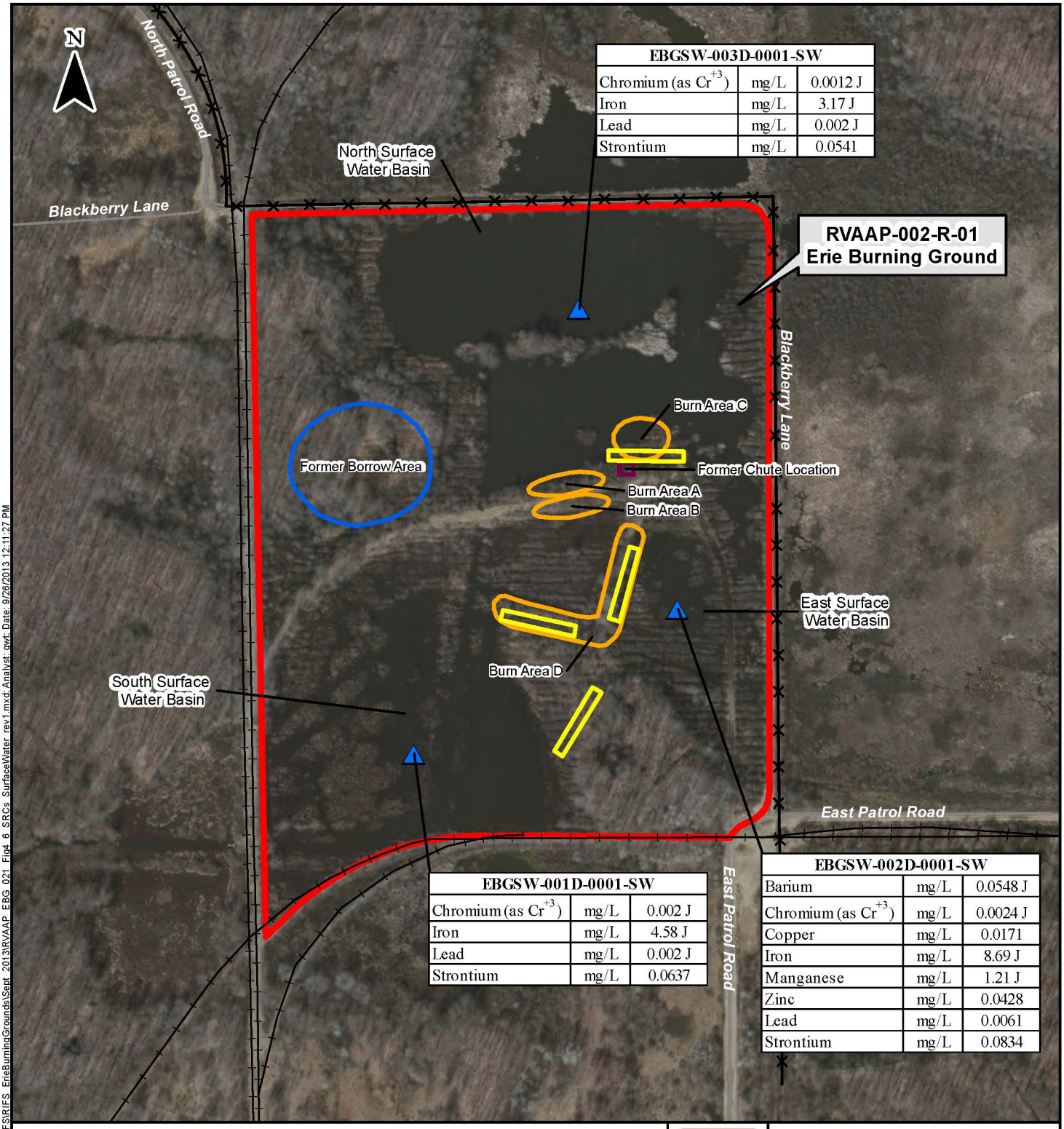
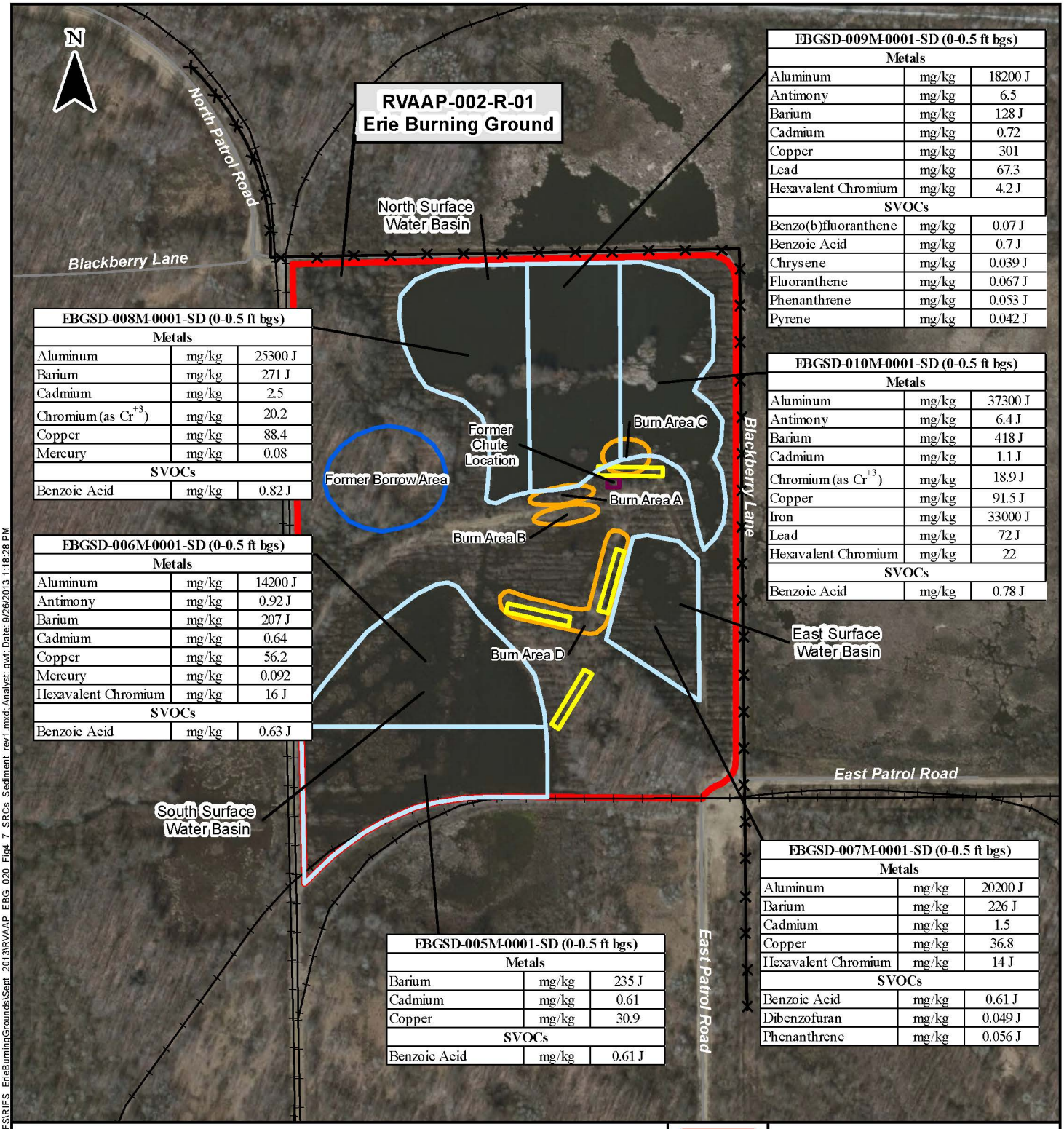


FIGURE 4-6 SRCS IN SURFACE WATER



EBGSD-009M-0001-SD (0-0.5 ft bgs)		
Metals		
Aluminum	mg/kg	18200 J
Antimony	mg/kg	6.5
Barium	mg/kg	128 J
Cadmium	mg/kg	0.72
Copper	mg/kg	301
Lead	mg/kg	67.3
Hexavalent Chromium	mg/kg	4.2 J
SVOCs		
Benzo(b)fluoranthene	mg/kg	0.07 J
Benzoic Acid	mg/kg	0.7 J
Chrysene	mg/kg	0.039 J
Fluoranthene	mg/kg	0.067 J
Phenanthrene	mg/kg	0.053 J
Pyrene	mg/kg	0.042 J

EBGSD-008M-0001-SD (0-0.5 ft bgs)		
Metals		
Aluminum	mg/kg	25300 J
Barium	mg/kg	271 J
Cadmium	mg/kg	2.5
Chromium (as Cr^{+3})	mg/kg	20.2
Copper	mg/kg	88.4
Mercury	mg/kg	0.08
SVOCs		
Benzoic Acid	mg/kg	0.82 J

EBGSD-010M-0001-SD (0-0.5 ft bgs)		
Metals		
Aluminum	mg/kg	37300 J
Antimony	mg/kg	6.4 J
Barium	mg/kg	418 J
Cadmium	mg/kg	1.1 J
Chromium (as Cr^{+3})	mg/kg	18.9 J
Copper	mg/kg	91.5 J
Iron	mg/kg	33000 J
Lead	mg/kg	72 J
Hexavalent Chromium	mg/kg	22
SVOCs		
Benzoic Acid	mg/kg	0.78 J

EBGSD-006M-0001-SD (0-0.5 ft bgs)		
Metals		
Aluminum	mg/kg	14200 J
Antimony	mg/kg	0.92 J
Barium	mg/kg	207 J
Cadmium	mg/kg	0.64
Copper	mg/kg	56.2
Mercury	mg/kg	0.092
Hexavalent Chromium	mg/kg	16 J
SVOCs		
Benzoic Acid	mg/kg	0.63 J

EBGSD-007M-0001-SD (0-0.5 ft bgs)		
Metals		
Aluminum	mg/kg	20200 J
Barium	mg/kg	226 J
Cadmium	mg/kg	1.5
Copper	mg/kg	36.8
Hexavalent Chromium	mg/kg	14 J
SVOCs		
Benzoic Acid	mg/kg	0.61 J
Dibenzofuran	mg/kg	0.049 J
Phenanthrene	mg/kg	0.056 J

EBGSD-005M-0001-SD (0-0.5 ft bgs)		
Metals		
Barium	mg/kg	235 J
Cadmium	mg/kg	0.61
Copper	mg/kg	30.9
SVOCs		
Benzoic Acid	mg/kg	0.61 J

U.S. ARMY CORPS OF ENGINEERS
BALTIMORE DISTRICT

MILITARY MUNITIONS RESPONSE PROGRAM

ERIE BURNING GROUNDS MRS
RAVENNA ARMY AMMUNITION PLANT
RAVENNA, 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 ErieBurningGrounds\Sept 2013\RVAAP EBG 020 Fig4 7 SRCs Sediment rev1.mxd Analyst: gwt Date: 9/26/2013 1:18:28 PM

FIGURE 4-7 SRCS IN SEDIMENT

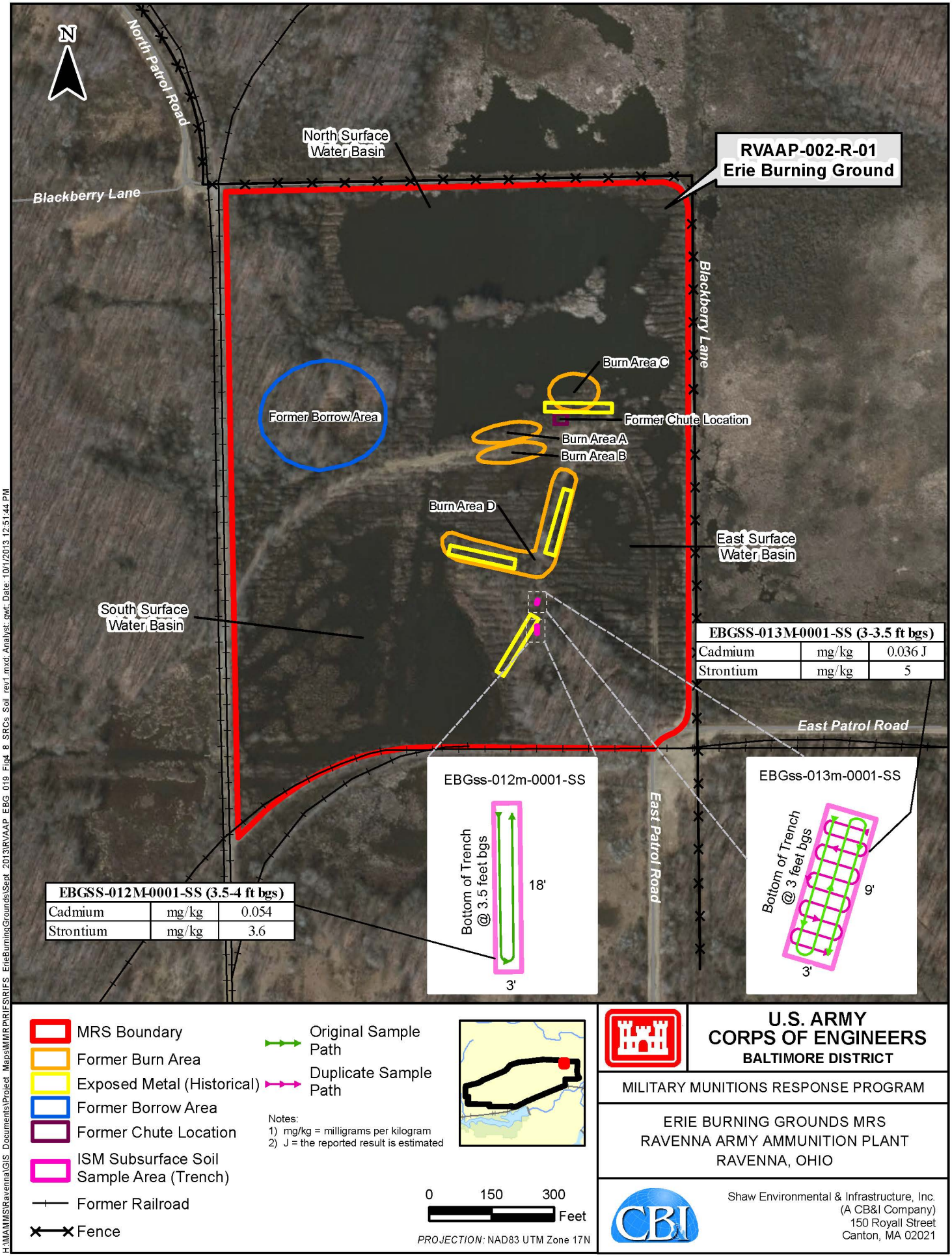


FIGURE 4-8 SRCS IN SUBSURFACE SOIL

4.3.1.5 Data Use Evaluation

During the RI field effort, surface water and ISM wet sediment samples were collected at predetermined locations based on historical information for the Erie Burning Grounds MRS. Additional ISM subsurface soil samples were collected from trenches where MD was 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 representativeness with respect to current MRS conditions.

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 Erie Burning Grounds MRS samples is presented in **Table 4-4**.

4.4 Nature and Extent of SRCs

This section presents the nature and extent of SRCs within the surface water, wet sediment and subsurface soil data aggregates evaluated for this RI Report.

4.4.1 Surface Water

Data from the RI surface water samples were screened to identify SRCs representing current conditions at the surface water basins at the Erie Burning Grounds MRS. The SRC screening data for surface water (not including field duplicate or QC samples) included samples EBGsw-001D-0001-SW, EBGsw-002D-0001-SW, and EBGsw-003D-0001-SW.

The surface water samples were collected from each of the three primary surface water basins at the MRS and were submitted for laboratory analysis for metals, explosives, nitrocellulose, and SVOCs. Metals analysis consists of inorganic MCs that are attributed to munitions historically used or disposed at the MRS. For the Erie Burning Grounds MRS, the inorganic MCs are considered to be aluminum, antimony, barium, cadmium, trivalent chromium (Cr^{+3}), Cr^{+6}, copper, iron, lead, mercury, and zinc. Analysis for SVOCs, including polycyclic aromatic hydrocarbons (PAHs), were recommended in the Work Plan Addendum (Shaw, 2011) for the Erie Burning Grounds MRS, since these chemicals are commonly associated with byproducts resulting from the open burn operations that historically occurred at the MRS.

The surface water 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 Erie Burning Grounds MRS, geochemical parameters are not evaluated further in this RI Report.

Table 4-5 presents the summary of results for the surface water samples. **Table 4-6** presents the results of the SRC screening. **Figure 4-6** presents the distribution of SRCs in the surface water samples for the Erie Burning Grounds MRS. A summary of the complete laboratory analytical results for the data collected during the RI field work is presented in **Appendix D**.

4.4.1.1 Metals

Eight of the 11 metals considered as MC associated with the historical open burn activities at the MRS were detected in all three of the surface water samples. Barium, copper, iron, and zinc were metals with detected concentrations that exceeded the BSVs and were retained as SRCs. No BSVs are available for chromium (as Cr^{+3}), lead, and strontium in surface water; therefore, these metals were automatically retained as SRCs for further evaluation. The detected aluminum concentrations were less than the BSV and this metal was not considered a SRC in surface water.

4.4.1.2 Explosives, Propellants and SVOCs

No concentrations of explosives, propellants, or SVOCs were detected in the surface water samples collected from the surface water basins at the Erie Burning Grounds MRS.

4.4.2 Wet Sediment

Data from the wet sediment samples collected during the RI field activities were screened to identify SRCs representing current conditions in the surface water basins at the Erie Burning Grounds MRS. The SRC screening data for sediment (not including field duplicate or QC samples) included samples EBGsd-005M-0001-SD, EBGsd-006M-0001-SD, EBGsd-007M-0001-SD, EBGsd-008M-0001-SD, EBGsd-009M-0001-SD, and EBGsd-010M-0001-SD. These samples were collected using the ISM and the sample depth for each increment was 0 to 0.5 feet beneath the sediment surface.

The wet sediment samples were collected from each of the three primary surface water basins at the MRS that the surface water samples were collected from and were submitted for laboratory analysis for metals, explosives, nitrocellulose, SVOCs and PCBs. Metals analysis consists of the inorganic MCs that are attributed to munitions historically used or disposed at the MRS. The inorganic MCs analyzed for the MRS include aluminum, antimony, barium, cadmium, chromium (as Cr^{+3}), Cr^{+6}, copper, iron, lead, mercury, and zinc. Analysis for PCBs and SVOCs, including PAHs, were recommended in the Work Plan Addendum (Shaw, 2011) for the Erie Burning Grounds MRS, since these chemicals are commonly associated with

waste oils that may have been used or byproducts resulting from the open burn operations that historically occurred at the MRS.

The wet sediment samples were also submitted for geochemical parameters that included calcium, magnesium, and manganese for the rationale discussed in Section 4.3.1.3. However, since a geochemical analysis was not performed for the data collected at the Erie Burning Grounds MRS, geochemical parameters are not evaluated further in this RI Report.

Table 4-7 presents the summary of results for the wet sediment samples. **Table 4-8** presents the results of the SRC screening. **Figure 4-7** presents the distribution of SRCs in the wet sediment samples for the Erie Burning Grounds MRS. A summary of the complete laboratory analytical results for the data collected during the RI field work is presented in **Appendix D**.

4.4.2.1 Metals

All 11 metals that are considered as MC associated with historical open burn activities at the MRS were detected in the ISM wet sediment samples. Aluminum, barium, chromium (as Cr^{+3}), copper, iron, lead, mercury, and strontium were detected at concentrations that exceeded the BSVs and were metals that were retained as SRCs for further evaluation. Antimony, cadmium, and strontium were detected and retained as SRCs in the wet sediment samples since no facility-wide BSV is available for these metals. Cr^{+6} that is analyzed as a general chemistry parameter is an inorganic that was detected in four out of the six wet sediment samples and is retained as an SRC since no BSV is available. Zinc was detected at concentrations below its BSV and; therefore, is not retained as an SRC in wet sediment.

4.4.2.2 Explosives and Propellants

Low concentrations of explosives were detected in wet sediment sample EBGsd-009M-0001-SD that was collected at the central portion of the North Surface Water Basin. The detected explosives consisted of TNT (0.63 milligrams per kilogram [mg/kg]) and 4-amino-2,6-dinitrotoluene (DNT) (0.13 J mg/kg) The "J"-flagged data are considered estimated and are retained as a detected value.

A low concentration of the propellant nitrocellulose was detected in wet sediment sample EBGsd-010M-0001-SD at an estimated ("J"-flagged) concentration of 100 mg/kg. This sample was collected at the eastern portion of the North Surface Water Basin, adjacent to the east of wet sediment sample EBGsd-009M-0001-SD. The facility does not have established BSVs for explosives or propellants; therefore, both analytes were retained as SRCs in wet sediment for the Erie Burning Grounds MRS. No additional concentrations of explosives or propellants were detected in the sediment samples collected at the Erie Burning Grounds MRS.

4.4.2.3 SVOCs

Seven SVOCs, five of which are PAHs, were identified as SRCs in the ISM wet sediment samples collected at the Erie Burning Grounds MRS. Wet sediment sample EBGsd-009M-0001-SD had the greatest number of detected SVOCs (6). This sample was collected at the central portion of the North Surface Water Basin. Three SVOCs were detected at wet sediment sample EBGsd-007M-0001-SD that was collected at the East Surface Water Basin. No more than one SVOC was detected in the remaining wet sediment samples. Benzoic acid was the most prevalent SVOC and was detected in all six wet sediment samples. The facility does not have established BSVs for SVOCs in any environmental medium; therefore, all of the detected SVOCs were retained as SRCs for further evaluation in wet sediment for the MRS.

4.4.2.4 PCBs

Aroclor-1254 was detected in sediment sample EBGsd-010M-0001-SD that was collected at the eastern portion of the North Surface Water Basin. No additional concentrations of PCBs were detected in the sediment samples collected from the Erie Burning Grounds MRS. PCBs are not naturally occurring; therefore, all of the detected SVOCs were retained as SRCs for further evaluation of wet sediment for the MRS.

4.4.3 Subsurface Soil

Data from the RI subsurface soil samples were screened to evaluate whether there are SRCs beneath the buried MD found at the Erie Burning Grounds MRS. The SRC screening data for subsurface soil (not including field duplicate or QC samples) included samples EBGss-012M-0001-SS and EBGss-013M-0001-SS. These samples were collected using the ISM and the sample depth for each increment was 0 to 0.5 feet at the bottom of the trench locations where buried MD was encountered during the RI field activities. The total range of depth that the subsurface samples were collected was 3 to 4 feet bgs.

The ISM subsurface samples were collected at grid locations that encompassed the entire bottom of each trench that was sampled to characterize the subsurface soils for residual MC from the buried MD. The ISM subsurface soil samples collected during the RI sampling event were submitted for laboratory analysis for metals, explosives, nitrocellulose, SVOCs and PCBs based on the same rationale as presented in Section 4.4.2 for the wet sediment samples.

The subsurface soil samples were also submitted for geochemical parameters that included calcium, magnesium, and manganese for the rationale discussed in Section 4.3.1.3. However, since a geochemical analysis was not performed for the data collected at the Erie Burning Grounds MRS, geochemical parameters are not evaluated further in this RI.

Table 4-9 presents the summary of results for the ISM subsurface soil samples. **Table 4-10** presents the results of the SRC screening. **Figure 4-8** presents the distribution of SRCs in subsurface soils at the trench locations. A summary of the complete laboratory analytical results for the data collected during the RI field work is presented in **Appendix D**.

4.4.3.1 Metals

All 11 metals that are considered as MC associated with historical open burn activities at the MRS were detected in both of the ISM subsurface soil samples. Aluminum, antimony, barium, chromium (as Cr^{+3}), copper, iron, lead, mercury, and zinc were all detected at concentrations that were below the BSVs and were not retained as SRCs. Cadmium and strontium were detected and retained as SRCs in both subsurface soil samples since no facility-wide BSV is available for either metal.

4.4.3.2 Explosives, Propellants, SVOCs, and PCBs

No concentrations of explosives, propellants, SVOCs, or PCBs were detected in the ISM subsurface soil samples collected at the Erie Burning Grounds MRS.

4.4.4 Summary of Nature and Extent of SRCs

This section presents a summary of the nature and extent of SRCs identified in surface water, wet sediment, and subsurface soils at the Erie Burning Grounds MRS following the facility data evaluation process.

4.4.4.1 Surface Water

Seven SRCs were identified among the surface water samples collected at the MRS and all of the SRCs were metals. There were no detected concentrations for explosives, propellants, or SVOCs that were also analyzed for each of the surface water samples.

The East Surface Water Basin, where surface water sample EBGsw-002D-0001-SW was collected, is the smallest of the surface water areas that were sampled for the RI (approximately 1.5 acres). This surface water basin is bounded by the former burn areas to the north and west, burial areas identified during the RI field work to the south, and the perimeter road (Blackberry Lane) to the east. The maximum detected concentration for each of the seven metal SRCs were identified in this basin area.

Chromium (as Cr^{+3}), iron, lead, and strontium were identified as SRCs in all three surface water samples. The surface water sample from the North Surface Water Basin (EBGsw-003D-0001-SW) exhibited the lowest detected concentrations for these four SRCs. The maximum detected concentrations for each of the SRCs in surface water were generally less than 3 times the minimum detected concentrations with the exception of copper and lead.

The maximum detected concentrations for copper and lead were nearly 5 (4.6) times and just over 3 (3.05) times the minimum detected concentrations, respectively.

4.4.4.2 Wet Sediment

A total of 22 SRCs were identified in the ISM wet sediment decision unit. The SRCs consisted of 10 metals, 2 explosives, 7 SVOCs, 1 PCB, and 2 general chemistry parameters (Cr^{+6} and nitrocellulose) that are considered as MC associated with the historical open burning activities that occurred at the MRS. For the purposes of this wet sediment discussion, Cr^{+6} is evaluated as inorganic along with the other metals.

The North Surface Water Basin is the largest of the three ponds at the MRS and was split into three sampling units for the purposes of the RI. The greatest numbers of metals (10) identified as SRCs were detected in wet sediment sample EBGsd-010M-0001-SD that was collected at the eastern portion of the North Surface Water Basin. Eight metal SRCs were detected in wet sediment sample EBGsd-009M-0001-SD that was collected at the central portion of the North Surface Water Basin. Seven metal SRCs were detected in wet sediment sample EBGsd-008M-0001-SD that was collected at the western portion of the North Surface Water Basin.

The highest concentrations of aluminum, barium, iron, lead, and Cr^{+6} in the North Surface Water Basin were detected in wet sediment sample EBGsd-010M-0001-SD. The highest concentrations of antimony and copper in this surface water area were detected in wet sediment sample EGBsd-009M-0001-SD. The highest concentrations of cadmium, chromium, strontium, and mercury in this surface water area were detected in wet sediment sample EBGsd-008M-0001-SD. Among the metal SRCs identified in the North Surface Water Basin, the maximum detected concentration for Cr^{+6} was 5.2 times the minimum detected concentration. The maximum detected concentrations for barium, cadmium, copper, iron, lead, mercury, and Cr^{+6} were generally between three to 4 times the minimum detected concentrations. The maximum concentrations for antimony, chromium, and strontium were less than 2 times the minimum detected concentrations.

The former burn areas are located adjacent to the southeast portion of the North Surface Water Basin and the number of metal SRCs decreased in the ISM wet sediment samples the further the samples were collected from this portion of the MRS. The greatest number of metal SRCs (10) and the number of these SRCs with the highest detected concentrations (5) are situated in wet sediment sample EBGsd-010M-0001-SD at the eastern portion of the North Surface Water Basin that is located adjacent to the former burn areas.

The South Surface Water Basin is the second largest of the three ponds at the MRS and was split into two sampling units for the purposes of the RI. The greatest numbers of metal SRCs

(8) in this surface water basin were detected in wet sediment sample EBGsd-006M-0001-SD that was taken from the northern half of the South Surface Water Basin. Four metal SRCs were detected in wet sediment sample EBGsd-005M-0001-SD that was collected from the southern portion of the South Surface Water Basin.

With the exception of barium, the maximum concentrations for the remaining metal SRCs (aluminum, antimony, barium, cadmium, copper, mercury, strontium, and Cr^{+6}) in the South Surface Water Basin were detected in wet sediment sample EBGsd-006M-0001-SD. Cr^{+6} was only detected in the South Surface Water Basin in wet sediment sample EBGsd-006M-0001-SD at an estimated concentration; however, the maximum detected concentrations for the remaining metal SRCs were less than 2 times the minimum detected concentrations. The Track 49 embankment and the Former Burn Area D abuts the north and northeast portions of the South Surface Water Basin, respectively, and may be the source for the increased number of SRCs in wet sediment sample EBGsd-006M-0001-SD.

The East Surface Water Basin is the smallest of the three ponds at the MRS and only one wet sediment sample, EBGsd-007M-0001-SD, was collected from the surface water area for the purposes of the RI. A total of 6 metal SRCs were detected in the sample. This surface water basin is bounded by the burn areas to the north and west, burial areas identified during the RI field work to the south, and the perimeter road (Blackberry Lane) to the east.

The maximum concentration for mercury among all of the wet sediment samples collected for the RI was detected in sample EBGsd-006M-0001-SD at the northern portion of the South Surface Water Basin. The maximum concentrations for the remaining metal SRCs were detected among the three wet sediment samples collected in the North Surface Water Basin, in particular sediment sample EBGsd-010M-0001-SD. The maximum concentrations for aluminum, barium, iron, lead, and Cr^{+6} among the sediment samples were detected in this sediment sample. Between the combined surface water basins, the maximum detected concentration for copper in wet sediment sample EBGsd-010M-0001-SD was nearly 10 (9.7) times the minimum detected concentration among the sediment samples. The maximum detected concentration for antimony in wet sediment sample EBGsd-009M-0001-SD was 7 times the minimum detected concentration among the sediment samples. The maximum detected concentrations for the rest of the inorganic SRCs among the sediment samples ranged between 1.6 (for strontium) to 5.2 (for Cr^{+6}) times the minimum detected concentrations.

The remaining SRCs in the wet sediment samples were primarily found at the two sediment samples where most of the elevated concentrations for the metals were detected; EBGsd-009M-0001-SD and EBGsd-010M-0001-SD. The two explosives that were detected (TNT and 2-amino-4,6-DNT) were found in wet sediment sample EBGsd-009M-0001-SD only.

Nitrocellulose is a propellant that was analyzed as general chemistry parameter and was detected in the wet sediment sample EBGsd-010M-0001-SD only. Additionally, wet sediment sample EBGsd-009M-0001-SD had the greatest number of detected SVOCs (6). The one detected PCB concentration of Aroclor-1254 was found in wet sediment sample EBGsd-010M-0001-SD.

Overall, the greatest concentrations and variations in the types of SRCs (i.e., combination of inorganics, explosives, propellants, SVOCs, PCBs, and nitrocellulose) were detected in wet sediment samples EBGsd-009M-0001-SD or EBGsd-010M-0001-SD that were both collected at the North Surface Water Basin. The burn areas along the Track 49 embankment, in particular Burn Area A and Burn Area C, abuts the southern portions of sampling units EBGsd-009M-0001-SD and EBGsd-010M-0001-SD and may contribute to the total number of SRCs detected in the underwater sediment at these locations.

4.4.4.3 Subsurface Soil

Cadmium and strontium were retained as SRCs in the subsurface soil decision unit due to a lack of a BSV for either metal. The concentrations for each of these SRCs were well within the same order of magnitude between each of the trenches that make up the subsurface soil decision unit. The cadmium concentration in sample EBGss-012M-0001-SS collected at Trench 6 was 0.054 mg/kg and was slightly higher than the cadmium concentration of 0.036 mg/kg in sample EBGss-013M-0001-SS collected at Trench 8 that was estimated (i.e., "J" flagged). Strontium concentrations between the two trenches were relatively close with results of 5 mg/kg in sample EBGss-013M-0001-SS and 3.6 mg/kg in sample EBGss-012M-0001-SS. There were no detected concentrations for explosives, propellants, SVOCs, or PCBs that were also analyzed for each of the subsurface soil samples.

5.0 FATE AND TRANSPORT OF MEC AND MC

This section describes the fate of contaminants 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. Contaminant transport refers to migration mechanisms away from the source area. Sections 5.1 and 5.2 discuss 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.

With regards to the soil types at the MRS, the erosion potential is slight. The types of plants and trees at the MRS include conifers and hardwoods that consist of both shallow and deep root systems that aid in preventing or limiting significant erosion (USDA et al., 1978). The soil types at the MRS have a high water capacity and poor permeability. As is noted in Section 1.3.3, January is the coldest month of the year with a normal minimal temperature of 17.4 degrees Fahrenheit (NOAA). The maximum frost depth in northern Ohio is approximately 36 inches bgs. Based on the soil types and climate conditions 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.

Any buried MEC or MEC items exposed to the atmosphere may corrode or degrade based on weather and climate conditions and thereby release MC into the environment. No MEC was found at the Erie Burning Grounds 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 4 feet bgs at 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. Photographs that show the conditions of the MD items found are presented in **Appendix F**.

The areas where any MEC is encountered become the points of potential direct contact exposure to the personnel engaged in the various activities. Future land use at the MRS may include intrusive activities associated with the periodic removal of beaver dams in the surface water areas and maintenance activities. As a result, there is a potential for human activities to expose land users to subsurface MEC that may remain at the MRS.

5.2 Fate and Transport of MC

This section describes the fate and transport of the MC identified as SRCs in the environment 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 contaminant (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 chemical sources in the environmental media at the Erie Burning Grounds MRS. A summary of the SRCs identified in the data aggregates at the Erie Burning Grounds MRS is as follows:

- **Surface Water (0 to 1.5 feet below water surface)**—Barium, chromium (as Cr^{+3}), copper, iron, lead, strontium, and zinc
- **Wet Sediment (0 to 0.5 feet below sediment surface)**—Nitrocellulose, aluminum, antimony, barium, cadmium, chromium (as Cr^{+3}), Cr^{+6}, copper, iron, lead, mercury, strontium, TNT, 4-amino-2,6-DNT, Aroclor-1254, benzo(b)fluoranthene, benzoic acid, chrysene, dibenzofuran, fluoranthene, phenanthrene, and pyrene
- **Subsurface Soil (3.0 to 4.0 feet bgs)**—Cadmium and strontium

The chemicals analyzed for the MRS were agreed upon in the Work Plan Addendum (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

An explosive compound degradation rate is a function of low-temperature kinetics as well as the influence of visible light, infrared, ultraviolet (UV) 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 the Erie Burning Grounds MRS are as follows.

- **TNT** is a munitions compound currently used for commercial and military purposes. TNT is characterized as being insoluble in water. The vapor pressure of

TNT is 1.28×10^{-6} mm of mercury, which indicates that it will not volatilize to the atmosphere. This is further supported by the Henry's Law Constant, which for TNT is equal to 1.10×10^{-8} atmospheric cubic meters per mole (atm-m^3/mole). The logarithm of the organic carbon/water partition coefficient (K_{oc}) is 0.43. This value indicates that TNT will not tend to sorb to the organic fraction of soil and will tend to leach into groundwater or surface water runoff. The logarithm of the octanol/water partition coefficient (K_{ow}) is 2.06, which indicates that TNT will partition to the polar water phase instead of sorbing to soil. TNT can be biotransformed, mineralized, or conjugated into higher molecular weight complex products. It has been shown that a reductive pathway exists for biotransformation of TNT (McCormick et al., 1976; Carpenter et al., 1978; Kaplan and Kaplan 1982a–e, Greene et al., 1985). This pathway has been observed in a number of systems including aqueous, sewage, soil, and compost (Walker and Kaplan., 1992). Under anoxic conditions, one or more of the nitro groups is reduced through nitroso and hydroylamino intermediates to form aminodinitrotoluenes (2-amino-4,6-DNT and 4-amino-2,6-DNT) and diaminonitrotoluenes (2,4-diamino-6-nitrotoluene and 2,6-diamino-4-nitrotoluene). Biodegradation is the most probable degradative process that may occur for TNT at the Erie Burning Grounds MRS. Research has shown that TNT can be completely biotransformed through a series of successive denitration steps. The presence of breakdown products (4-amino-2,6-DNT) in the MRS provide evidence that biodegradation is occurring. Complete degradation of these compounds is anticipated at rates that vary as a function of MRS-specific conditions (Walker and Kaplan, 1992).

- **Aminodinitrotoluenes** (i.e., 2-amino-4,6-DNT and 4-amino-2,6-DNT) are breakdown products of TNT under anoxic conditions. Under these conditions, one or more of the TNT nitro groups is reduced through nitroso and hydroylamino intermediates to form aminodinitrotoluenes (2-amino-4,6-DNT and 4-amino-2,6-DNT). Transformation rate coefficients generally follow first-order kinetics (Brannon and Myers, 1997). Both partition and transformation rate coefficients for the TNT-related compounds are higher in a high clay surface soil than in a low clay aquifer soil (Pennington et al., 2001). The amino transformation products of TNT can covalently bind to soil organic matter, thereby becoming immobilized (Thorn et al., 2002).

- **Nitrocellulose** is categorized as a low explosive. Low explosives undergo chemical reactions, such as decomposition or autocombustion, at rates of a few centimeters per minute to approximately 400 meters per second. Nitrocellulose also serves as a propellant. As a nitrated natural polymer, nitrocellulose has the required mechanical strength and resilience to maintain its integrity during

handling and firing. Nitrocellulose is partially soluble in some organic solvents, such as acetone, ethanol, ether/ethanol, and nitroglycerine. This compound is immiscible in water (EPA, 2005).

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 and sediment, metal contaminants are dissolved in the soil or sediment solution, adsorbed or ion-exchanged in inorganic constituents, complexed with soluble organic matter, and precipitated as pure or mixed solids. Metals in the soil or sediment 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 above background concentrations at the Erie Burning Grounds MRS are as follows:

- **Aluminum** is the most abundant metal in the earth's crust. It can also be released as a result to soil from mining wastes as well as solid wastes from coal combustion, aluminum reduction, and other metal processing operations (U.S. Department of the Interior [DOI], 1983 and 1984). The fate and transport of aluminum is largely affected by the following factors: pH, salinity, and the presence of various species with which it may form complexes. In general, the monomeric forms of aluminum tend to increase in mobility as pH decreases. In addition, aluminum tends to absorb onto clay surfaces. Aluminum does not bioaccumulate to a significant extent. Aluminum contained in wind-borne soil is generally found in larger particles. These particles settle to the ground or are washed out of the air by rain. Aluminum that is attached to very small particles may stay in the air for many days. Most aluminum will ultimately end up in the soil or sediment. Aluminum in soil is taken up into plants, which are eaten by animals. Aluminum is not known to bioconcentrate up the food chain and therefore, vegetables, fruits, fish, and meat will not generally contain high concentrations of aluminum. Because of the toxicity of dissolved aluminum to many aquatic organisms, including fish, these animals would die before the amount of aluminum in the animal became very high (Agency for Toxic Substances and Disease Registry, 2008).
- **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).

- **Barium** is a naturally occurring element that is found in small but widely distributed amounts in the earth's crust, especially in igneous rocks, sandstone, shale, and coal (Kunesh, 1978; Miner, 1969). It is an alkaline earth group element, with chemical behavior similar to calcium. Barium enters the environment naturally through the weathering of rocks and minerals. Anthropogenic releases are primarily associated with industrial processes. The element is soluble in low total dissolved solids water, but it will precipitate with sulfate or carbonate as the minerals barite ($BaSO_4$) or witherite ($BaCO_3$), respectively if those anions are present. These minerals have low solubilities and frequently control barium mobility, especially in groundwater with higher total dissolved solids. Barium also has a strong affinity to adsorb on manganese oxides as well as iron oxides and clays to a lesser extent. Barium is not very mobile in most soil systems due to its affinity to adsorb on minerals surfaces and its tendency to precipitate as low-solubility sulfate or carbonate minerals. The element does not form volatile compounds in the aquatic environment; therefore, partitioning from water into the atmosphere doesn't occur (EPA, 1979).

- **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 can be taken up by plants. However, cadmium may leach into water under acidic conditions (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 (DOI, 1985; EPA, 1979; Feijtel et al., 1988; Muntau and Baudo, 1992). In addition, cadmium does not tend to form volatile compounds in the aquatic environment; therefore, partitioning from water into the atmosphere doesn't occur (EPA, 1979).

- **Chromium** exists in two valence states in the environment: trivalent (Cr^{+3}) and 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** is strongly sorbed by soil particles (e.g., 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, lime, and hydrous iron oxides 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).

- **Iron** is an abundant element that contains very stable nuclei. Iron is the second most abundant metal in the earth's crust (second to aluminum) and is the fourth most abundant element, by weight, making up the crust of the earth. The redox state of the environment has the greatest influence on the fate and transport of iron. Iron naturally occurs in the environment in two oxidation states: ferrous iron (Fe^{+2}) and ferric iron (Fe^{+3}). Ferric iron is commonly present in oxic soils as iron oxides and hydroxides, which are present as discrete minerals or as coatings on the surfaces of other minerals (Kabata-Pendias, 2001). Iron oxides are relatively insoluble in oxic soils under circumneutral pH conditions and are soluble only under very low pH (below about 4) or high pH (above about 11) (Langmuir et al., 2004). The physical transport of ferric iron occurs mostly due to the erosion of soil material and sediments with the deposition of the minerals occurring at a downgradient point. Under reducing conditions (low redox conditions), ferric iron is reduced to ferrous iron. Free ferrous iron is very soluble and is easily transported under reducing conditions. Precipitation of ferrous iron is possible under strongly reducing conditions in the presence of sulfide (S^{-2}). The

precipitation of iron sulfide minerals limits the mobility of ferrous iron; however, if conditions become oxidizing, the precipitated ferrous iron is released to solution and may be subject to reprecipitation (as ferric iron oxides or hydroxides) if oxic conditions are encountered (Kabata-Pendias, 2001).

- **Lead** is a naturally occurring metal found in small amounts in the earth's crust. The most common form of lead (Pb) 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** is a naturally occurring metal in the environment. Mercury has a tendency to sorb to soils, which is influenced by the organic matter content of the soils or sediment. In addition, mercury is strongly sorbed to humic materials and 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. Volatile forms of mercury are anticipated to evaporate to the atmosphere, whereas 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 mercury from soils may be 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 to move from soil to water, especially in soils with high humic content (Meili, 1991).

- **Strontium** is a naturally occurring element in the environment with typical concentrations around 0.2 mg/kg. Elevated concentrations of strontium can be attributed to the disposal of coal ash, incinerator ash, and industrial wastes (ASTDR, 2004). In addition, strontium nitrate is a component of munitions used/produced at the former RVAAP. In soils and sediments, strontium has

moderate mobility and sorbs moderately to metal oxides and clays (Hayes and Traina, 1998). 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.

- **Zinc** occurs naturally in the earth's crust with an average concentration of about 70 mg/kg (Hazardous Substances Data Bank [HSDB], 2012a). The zinc content of noncontaminated soils ranges between 10 and 300 mg/kg (Efroymson et al., 1997a). Zinc is found virtually in all living organisms as an essential element for life; however, it is toxic particularly to aquatic organisms at elevated concentrations. Zinc is expected to adsorb to suspended particles and sediment in the water column and volatilization is not anticipated to be a primary transport pathway (HSDB, 2012a; Eisler, 1993). Zinc generally demonstrates low mobility in the subsurface environment because it is strongly adsorbed to soil at a pH of 5 or greater (Evans, 1989; Blume and Brummer, 1991). Mobility is also reduced as permeability decreases, and the amount of clay, lime, anhydrous iron oxides, and other ions such as phosphate increases. Volatilization of zinc from soil or water surfaces is not an important transport process because of the ionic nature of zinc salts (Efroymson et al., 1997a).

5.2.1.3 SVOCs

Seven SVOCs were identified as SRCs at the MRS, of which five analytes were PAHs. The fate and transport of the SVOCs identified as SRCs at the Erie Burning Grounds MRS is as follows:

- A combined group of five PAHs [benzo(b)fluoranthene, chrysene, fluoranthene, phenanthrene, and pyrene] were identified as SRCs in the wet sediment at the Erie Burning Grounds MRS. 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 volatiles 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 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 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 or sediment rather than partition into the polar water phase (Environment Canada, 1998).

- **Benzoic Acid**, $C_7H_6O_2$, (or C_6H_5COOH) is a colorless crystalline solid and the simplest aromatic carboxylic acid. It has a molecular weight of 122.12 grams per mole. Its structure is a benzene ring with a COOH group attached to one carbon atom. The compound occurs naturally as free benzoic acid and is bound as benzoic acid esters in many plant and animal species. Appreciable amounts have been found in most berries (around 0.05 percent). Cranberries contain as much as 300–1,300 mg of free benzoic acid per kg of fruit. Benzoic acid is a fungistatic compound that is widely used as a food preservative along with its salt sodium benzoate. It often is conjugated to glycine in the liver and excreted as hippuric acid. Benzoic acid is a byproduct of phenylalanine metabolism in bacteria. It is also produced when gut bacteria process polyphenols (from ingested fruits or beverages). Benzoic acid also forms as a major intermediate product in the anaerobic degradation of benzene (Chaudhuri and Wiesmann, 1995) and other aromatics (Muthukumar, et al., 2009). The compound has a high solubility in water in the range of 2,000 to 3,000 milligrams per liter (mg/L) but has a log K_{oc} of 2.26, indicating that it will adsorb on the organic fraction of soil, which will limit its mobility in the soil environment (Montgomery and Welcom, 1989). Its low vapor pressure suggests that releases to air will be minimal. Microbial degradation is an important process affecting the fate of this compound. Rapid degradation rates (complete in 30 hours) were measured by Muthukumar, et al. (2009) under aerobic groundwater conditions. An anaerobic reactor designed to simulate a constructed wetland environment observed a nearly 99-percent removal of benzoic acid at concentrations up to 40 mg/L (Zachritz, et al., 1996).
- **Dibenzofuran** is a heterocyclic aromatic compound that has two benzene rings fused to one furan ring in the middle (Montgomery and Welcom, 1989). The structure of dibenzofuran is similar to carbazole except it has oxygen instead of an N-H group on the center ring. Dibenzofuran's presence in coal-tar, as a component of heat-transfer oils, as a carrier for dyeing and printing textiles, as an intermediate for production of dyes, and as an antioxidant in plastics may result in its release to the environment through various waste streams. It also forms along with PAH compounds during combustion of organic materials such as wood, coal, and municipal waste. If released to air, a vapor pressure of 0.00248 mm of mercury at 25 degrees Celsius indicates dibenzofuran will exist solely as a vapor in the ambient atmosphere. Vapor-phase dibenzofuran will be degraded in the atmosphere by reaction with photochemically produced hydroxyl radicals; the half-life for this reaction in air is estimated to be 4 days. Dibenzofuran absorbs

little UV light above 300 nanometers, but UV absorption rises sharply below 300 nm, which indicates the potential for direct photolysis in the environment. If released to soil, dibenzofuran is expected to have limited mobility based upon an estimated K_{oc} of 4,200. Volatilization from moist soil surfaces is expected to be an important fate process based upon an estimated Henry's Law Constant of 2.1×10^{-4} atm-m^3/mole. However, adsorption to soil is expected to attenuate volatilization. Indigenous soil microorganisms at contaminated sites can degrade dibenzofuran if stimulated. If released into water, dibenzofuran is expected to adsorb to suspended solids and sediment based upon the estimated K_{oc}. Biodegradation screening tests indicate that dibenzofuran is not readily biodegradable. However in laboratory studies, dibenzofuran was degraded in a few days using subsurface materials which had been contaminated by creosote chemicals. Once microbial adaptation had occurred, dibenzofuran rapidly biotransformed under aerobic conditions. Volatilization from water surfaces is expected to be an important fate process based upon the estimated Henry's Law Constant. Estimated volatilization half-lives for a model river and model lake are 5 hours and 7 days, respectively. However, volatilization from water surfaces is expected to be attenuated by adsorption to suspended solids and sediment. Hydrolysis is not expected to be an important environmental fate process since this compound lacks functional groups that hydrolyze under environmental conditions. Occupational exposure to dibenzofuran may occur through inhalation and dermal, particularly at sites where coal tar, coal tar derivatives, and creosote is produced or used (i.e., the handling of creosote-treated wood). Monitoring data indicate that the general population may be exposed to dibenzofuran via inhalation of ambient air and dermal contact with wood products containing dibenzofuran (National Center for Biotechnology Information, 2012).

5.2.1.4 PCBs

PCBs, also known by the Monsanto trade name "Aroclor," were produced by the partial chlorination of biphenyl in the presence of a catalyst. PCBs are distinguished by a four-digit code in which the first two digits indicate the production process and the second two digits indicate the weight percent of chlorine. PCBs as a group are considered to be highly immobile, persistent in the environment, and resistance to oxidation and hydrolysis. In general, the persistence of PCBs increases with an increase in the degree of chlorination (HSDB, 2012b).

- **Aroclor-1254** is a PCB with an average chlorine content of 54 percent. The vapor pressure of Aroclor-1254 is 7.71×10^{-5} mm of mercury at 25 degrees Celsius and therefore volatilization is not anticipated from dry soils (EPA, 1981).

Volatilization from wet soils and sediment is possible based on the Henry's Law Constant of 2.83×10^{-4} atm-m^3/mole (Burkhard et al., 1985). However, the tendency for Aroclor-1254 to adsorb strongly to soils is expected to attenuate volatilization. The log K_{oc} for Aroclor-1254 ranges from 4.6 to 6.1, which indicates that the PCBs will tend to stay bound to the organic fraction of the soil instead of leaching into groundwater or surface water runoff, or volatilizing to the atmosphere (EPA, 1981). Based on the same principle, volatilization from surface water to the atmosphere is also not anticipated to occur as PCBs will adsorb to sediment and suspended particles in the water column.

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 Erie Burning Grounds MRS.

The SRCs consisting of metals have a tendency to adsorb to soil with a pH of 4 or greater depending on the specific analyte. Much of the inundated areas of the MRS were primarily dry until the 1990s when beaver dam activity flooded the MRS; therefore, the makeup of the current underwater sediment at much of the MRS consists of the previous terrestrial soil conditions. The soils at the MRS consist primarily of the Sebring variant and silty loams with high clay content that are for the most part very poorly drained soils with low permeabilities and are susceptible to flooding (USDA et al., 1978). The similarities between the soils and the underwater sediment are also supported by moderately analogous pHs of approximately 6.7 and 6.4 for the terrestrial soil and underwater sediment, respectively. The low permeable soil conditions and moderate pH results indicate that metal SRCs would be expected to be found in the top several inches where they were released, with only limited downward migration. Several of the detected metals in sediment have a tendency to mobilize or redissolve in aquatic environments (in particular antimony, barium, cadmium, and Cr^{+6}); however, of these metals only barium was identified as an SRC in surface water and was detected at low estimated concentrations. However, periodic and/or constant inundation, recurring anaerobic conditions, and accumulation and retention of organic matter may result in more limited downward migration of metals from wet sediment than soil. The surface water results provide supporting evidence that metal SRCs in sediment have not mobilized.

One of the principal migration pathways at the Erie Burning Grounds MRS is infiltration through the unsaturated soil, sediment, and surface water to groundwater. The water table at the Erie Burning Grounds MRS is shallow, typically 2 to 3 feet bgs, and groundwater flow is generally from north to south across the MRS consistent with surface drainage patterns. The inorganic SRCs in subsurface soil were cadmium and strontium in samples that were

collected at the approximate soil and groundwater interface (3 to 4 feet bgs). Strontium in soils is moderately mobile while the mobility of cadmium in soils and sediment is more strongly influence by pH, organic content, and clay minerals (EPA, 1979). Based upon the pH and heavy clay contents in the soils at the MRS, strontium and cadmium would be expected to bind to soils close to a source. Because of the extensive wetland areas within the MRS, a high degree of interaction exists between groundwater and surface water (SAIC, 2007). Antimony, barium, cadmium, and Cr^{+6} in sediments have a potential to migrate to groundwater due to their tendency to mobilize or redissolve in aquatic environments. Inorganic SRCs consisting of barium, chromium (as Cr^{+3}), copper, iron, lead, and strontium were identified in both the sediment and surface water samples collected at the MRS. The presence of metals in both the surface water and sediment, when combined with the high degree of interaction between surface water and groundwater, may potentially result in the migration of inorganic SRCs to groundwater. However, high dilution/attenuation factors would be presumed to result in few groundwater concentrations above background (SAIC, 2005).

Inorganic SRCs were detected in groundwater as part of the Phase II RI and included potential MC consisting of antimony, barium, copper, lead, nickel, and zinc. These inorganic SRCs were considered consistent with upgradient background concentrations in groundwater outside of the Erie Burning Grounds (SAIC, 2005). The antimony, barium, copper, and lead SRCs identified in groundwater are consistent with the SRCs identified between the wet sediment and surface water media that have interaction with groundwater. The concentrations of the inorganic SRCs in groundwater were relatively low and were detected at isolated well locations with the exception of barium that was detected at all eight monitoring wells installed under the IRP (SAIC, 2005). These results suggest that there is minimal leaching of the inorganic SRCs detected in sediment and surface water during the RI field activities, that the occurrence of the detected inorganics in groundwater may be naturally occurring, or that dilution factors are high.

Because of their low solubility and high affinity for organic carbon, the detected PCBs and SVOCs that include PAHs in aquatic systems, such as in the sediment at the MRS, are primarily found sorbed to particles that either have settled to the bottom or are suspended in the water column. When found in soil or sediment, these chemicals will tend to stay bound to the organic fraction of the soil/sediment instead of leaching into groundwater or surface water runoff, or volatilizing to the atmosphere (EPA, 1981). Based on the same principle volatilization from surface water to the atmosphere is also not anticipated to occur as PCBs will adsorb to sediment and suspended particles in the water column. Two low (estimated) concentrations of SVOCs consisting of bis(2-ethylhexyl)phthalate and di-n-butyl phthalate were detected in groundwater during the Phase II RI. These SVOCs were found between two

well locations that are located at the central portion of the MRS near the former burn areas (SAIC, 2005). Neither of these SVOCs were identified as SRCs in the soil, sediment or surface water samples collected for this RI and these results indicate that SVOCs and PCBs in sediments are relatively immobile.

The TNT concentration that was detected in wet sediment is not expected to sorb to the organic fraction of soil and will tend to leach into the groundwater. Biodegradation is the most probable degradative process that may occur for TNT in the sediment at the MRS. The presence of 4-amino-2,6-DNT in the sediment provides evidence that biodegradation is likely occurring. Unlike TNT, 4-amino-2,6-TNT can bind to the organic fractions of soil and sediment is thereby immobilized (Walker and Kaplan, 1992). No explosives were identified as SRCs in groundwater as part of the Phase II RI indicating that potential leaching to groundwater is minimal or that dilution factors are high (SAIC, 2005).

6.0 MEC HAZARD ASSESSMENT

In accordance with the Work Plan Addendum (Shaw, 2011), a MEC hazard assessment (HA) for the Erie Burning Grounds MRS was to be prepared in accordance with the *Interim Munitions and Explosives of Concern Hazard Assessment Methodology* (EPA, 2008a). The MEC HA allows a project team to evaluate the potential explosive hazard associated with an MRS given current conditions and under various cleanup, land-use activities, and land-use control alternatives. It was developed through a collaborative, consensus-based approach to promote consistent evaluation of potential explosive hazards at MRSs (EPA, 2008a). 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 on the ground surface and in subsurface burial trenches and point-source anomaly locations 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 Erie Burning Grounds MRS.

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7.0 HUMAN HEALTH RISK ASSESSMENT

The purpose of the HHRA is to document whether SRCs present at the Erie Burning Grounds 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 Addendum (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 final FWCUGs in the following steps:

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

The following sections discuss the HHRA approach, the data used in the HHRA, and the COPC and COC evaluation for the samples collected at the Erie Burning Grounds MRS during the RI field activities.

This HHRA was initiated before the finalization of the U.S. Army's technical memorandum (ARNG, 2014); therefore, evaluation for the Commercial Industrial Land Use using the EPA's Industrial Regional Screening Levels (RSLs) was not included. In addition, the National Guard Trainee was not assessed as the Representative Receptor. Instead, other likely receptors were assessed to evaluate the Military Training Land Use.

7.1 Data Used in the HHRA

The MC investigation at the Erie Burning Grounds MRS consisted of the collection of three surface water samples, six ISM wet sediment samples, and two ISM subsurface soil samples. The MRS is considered the EU based on the anticipated future land use. Although the MRS is being evaluated as a single EU, the soil data collected within the MRS were aggregated by depth intervals since different future use receptors with different depths of potential exposure

are required to be evaluated in accordance with the FWCUG guidance (SAIC, 2010 and USACE, 2012) for the facility. 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 Location ID	Sample Date	Sample Area	Depth	Sample Type	Analysis
Surface Water					
EBGsw-001D-0001-SW	5/7/2012	NA	1.5 ft bws	D	Metals[1] Explosives Nitrocellulose SVOCs TOC pH
EBGsw-002D-0001-SW					
EBGsw-003D-0001-SW					
Wet Sediment					
EBGsd-005M-0001-SD	5/8/2012	1.5 acres	0–0.5 ft bss	ISM	Metals[1] Explosives Nitrocellulose SVOCs PCBs TOC pH
EBGsd-006M-0001-SD		3.2 acres			
EBGsd-007M-0001-SD		3.2 acres			
EBGsd-008M-0001-SD		2.8 acres			
EBGsd-009M-0001-SD		2.8 acres			
EBGsd-010M-0001-SD		2.8 acres			
Subsurface Soil					
EBGss-012M-0001-SS	5/9/2012	54 sq ft	3.5–4 ft bgs	ISM	Metals[1] Explosives Nitrocellulose SVOCs PCBs TOC pH
EBGss-013M-0001-SS		27 sq ft	3–3.5 ft bgs		

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

bgs denotes below ground surface.
bss denotes below sediment surface.
bws denotes below water surface.
D denotes discrete (grab) sample.
ft denotes foot/feet.
ID denotes identification.
ISM denotes incremental sampling methodology.
NA denotes not applicable/available.
SVOC denotes semivolatile organic compound.
PCB denotes polychlorinated biphenyl.
sq ft denotes square feet.
TOC denotes total organic carbon.

7.2 Human Receptors

The Erie Burning Grounds MRS is currently managed as an "Authorized Access" area due to the high-quality wetlands that are present and the potential for MEC (SAIC, 2007). Due to the high quality wetland and inundation of the MRS from water, military training is unlikely to occur at the MRS. Since this investigation was initiated prior to the finalization of the U.S. Army's technical memorandum (ARNG, 2014), the National Guard Trainee was not evaluated as the Representative Receptor for the Military Training Land Use. The Security Guard/Maintenance Worker. Hunter/Trapper and Fire/Dust Suppression Worker were identified as potential receptors at the MRS. The evaluation of COCs for these receptors in conjunction with the evaluation of the Resident Receptor (Adult and Child) for the Unrestricted Land Use form the basis for identifying COCs in the RI (USACE, 2005a). The National Guard Trainee was included in the initial part of the HHRA evaluation for COPCs in accordance with the facility screening procedures presented in the Position Paper (USACE, 2012).

The exposure scenarios for receptors in the HHRAM (USACE, 2005a) are defined exposure depths; however, the exposure depths may not necessarily relate to the actual sample depths collected at the MRS during the RI field activities. 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 depth 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 likely 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 facility defined exposure depths for the human receptors is presented below.

7.2.1 Surface Water

The surface water samples were grab samples that were collected at the center of the water basin depths at approximately 1 to 2 feet below the water surface. It is expected that the extent of SRCs in the water basin areas are ubiquitous and the entire combined areas of the surface water basins are considered as the surface water EU. The sample data for the surface water EU is considered suitable for comparison against the established facility HHRA screening criteria for the Resident Receptor (Adult and Child), National Guard Trainee,

Hunter/Trapper, and Fire/Dust Suppression Worker. The FWCUG guidance states that there is no exposure to surface water for the Security Guard/Maintenance Worker.

7.2.2 Wet Sediment

The wet sediment samples were collected at the same water basin areas as the surface water samples. The sediment sample intervals were 0 to 0.5 feet below the sediment surface and are considered to be representative of the sediment conditions within the combined water basins at the MRS that is the EU for sediment. The facility defined wet sediment exposure depth for the human receptors are 0 to 0.5 feet (6 inches). The sample data for the sediment EU is considered suitable for comparison against the established facility HHRA screening criteria for the Resident Receptor (Adult and Child), National Guard Trainee, Hunter/Trapper, and Fire/Dust Suppression Worker. The FWCUG guidance (SAIC, 2010) states that there is no exposure to wet sediment for the Security Guard/Maintenance Worker.

7.2.3 Subsurface Soil

The ISM subsurface soil samples collected during the RI field activities were collected at 0-to-0.5–foot (6-inch) increments since this is the maximum depth that contamination that may have leached from the buried MD would be expected to vertically migrate in the soil column. This sampling methodology is consistent with the sample depth intervals recommended in the *Munitions Response Remedial Investigation/Feasibility Study Guidance* (U.S. Army, 2009).

For the RI field activities, the ISM subsurface soil samples were collected at two sampling units (Trenches 6 and 8) at the bottoms of the trenches. Sample EBGss-012M-0001-SS was collected at Trench 8 at a depth of 3 to 3.5 feet bgs. Sample EBGss-013M-0001-SS was collected at Trench 6 at a depth of 3.5 to 4 feet bgs. These sample depths cross over the facility surface and subsurface soil exposure scenarios for the Representative Receptors and the receptors for Unrestricted Land Use. Surface soil at the facility is defined as 0 to 1 foot bgs for the Resident Receptor (Adult and Child), Security Guard/Maintenance Worker, Hunter/Trapper, and Fire/Dust Suppression Worker. Surface soil is defined as 0 to 4 feet bgs for the National Guard Trainee that is being evaluated in accordance with the facility screening procedures (USACE, 2012). Based on these exposure scenarios, in comparison to the trench soil samples that were collected at depths greater than 1 foot bgs, an evaluation of the surface soil exposure scenario cannot be performed for the Resident Receptor (Adult and Child), Security Guard/Maintenance Worker, Hunter/Trapper, and Fire/Dust Suppression Worker. Surface soil can be evaluated for the National Guard Trainee using both samples since they were collected at depths less than 4 feet bgs. Subsurface soil at the facility is defined as 1 to 13 feet bgs for the Resident Receptor (Adult and Child) and 4 to 7 feet bgs for the National Guard Trainee (SAIC, 2010). Based on these exposure scenarios in comparison

to the depths of the samples collected at the MRS during the RI field activities, the subsurface soil exposure scenario for Unrestricted Land Use—the Resident Receptor (Adult and Child)—can be evaluated for both soil samples. Since no samples were collected greater than 4 feet bgs, the subsurface soil exposure scenario cannot be evaluated for the National Guard Trainee. The FWCUG guidance (SAIC, 2010) assumes no exposure to subsurface soil (i.e., greater than 1 foot bgs) for the Security Guard/Maintenance Worker, Hunter/Trapper, and Fire/Dust Suppression Worker. The soil exposure scenarios for the identified receptors based on the RI sample strategy at the Erie Burning Grounds MRS can be summarized as follows:

- **National Guard Trainee**—Surface soil at 3 to 4 feet bgs
- **Resident Receptor (Adult and Child)**—Subsurface soil at 3 to 4 feet bgs

The subsurface soil decision unit is the portion of the MRS in which a decision regarding MC in burial trenches at the terrestrial portions of the MRS will be made and is the EU for the evaluation of COPCs in surface soil (3 to 4 feet bgs) for the National Guard Trainee at the MRS as well. The sample data for the subsurface soil EU is considered suitable for comparison against the established facility HHRA screening criteria in the FWCUG guidance (SAIC, 2010).

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 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 same criteria described in Section 4.3.1.3 to eliminate chemicals that are not SRCs (i.e., infrequently detected chemicals, background comparisons, 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 SRCs identified for the environmental media sampled during the RI field activities included the following:

- **Surface Water**—Barium, chromium (as Cr^{+3}), copper, iron, lead, strontium, and zinc
- **Wet Sediment**—Nitrocellulose, aluminum, antimony, barium, cadmium, chromium (as Cr^{+3}), Cr^{+6}, copper, iron, lead, mercury, strontium, TNT, 4-amino-2,6-DNT, Aroclor-1254, benzo(b)fluoranthene, benzoic acid, chrysene, dibenzofuran, fluoranthene, phenanthrene, and pyrene

- **Subsurface Soil (3.0 to 4.0 feet bgs)**—Cadmium and strontium

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

- The final FWCUGs developed for the Resident Receptor (Adult and Child) and the National Guard Trainee for each chemical were used. If there were no final FWCUGs developed for a particular chemical, then the RSLs based on residential exposure were used (EPA, 2012). If neither a final 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. Final FWCUGs or RSLs were available for all chemicals not previously eliminated; therefore, development of a final FWCUG was not needed.
- The final FWCUGs at the 1×10^{-6} 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 final FWCUG to the exposure point concentration (EPC) was completed. The EPCs for the Erie Burning Grounds MRS are the maximum detected concentrations.
- The chemical was retained as a COPC if the EPC exceeded the most stringent final 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 final FWCUG was available.

The Work Plan Addendum (Shaw, 2011) specifies that in addition to screening the final FWCUGs for the Resident Receptor (Adult and Child) and the National Guard Trainee, evaluation will also be made against the remaining OHARNG receptors in order to ensure that the most stringent receptor is identified. For the chemicals detected at the Erie Burning Grounds MRS, the final FWCUGs for the Resident Receptor (Adult and Child) or National Guard Trainee FWCUGs 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 D**.

Tables 7-2 through **7-5** present the screening results for COPCs for the Resident Receptor (Adult and Child) and the National Guard Trainee in accordance with the FWCUG Report (SAIC, 2010). These tables include the final FWCUGs that are based on the lower of the 1 ×

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

Site-Related Chemical	Range of Values, µg/L						Location of MDC	R(A) FWCUG[1] (µg/L)	R(C) FWCUG[1] (µg/L)	NGT FWCUG[1] (µg/L)	RSL[2] (µg/L)	COPC?	COPC Justification
	Detected Concentrations				Reporting Limits								
	Minimum	VQ	Maximum	VQ	Minimum	Maximum							
Metals													
Barium	24.9	J	54.8	J	1.8	1.8	EBGsw-002D	12,131	2,901	10,640		No	Below risk screening criteria
Chromium (as Cr^{+3})	1.2	J	2.4	J	4	4	EBGsw-002D	28,442	11,173	6,165		No	Below risk screening criteria
Copper	3.7	J	17.1		7	7	EBGsw-002D	2,788	614	7,199		No	Below risk screening criteria
Iron	3,170	J	8,690	J	100	100	EBGsw-002D	20,000	4,527	31,296		Yes	Above risk screening criteria for R(C)
Lead	2	J	6.1		4	4	EBGsw-002D	NA	NA	NA	15	No	Below risk screening criteria
Strontium	54.1		83.4		2	2	EBGsw-002D	NA	NA	NA	9,300	No	Below risk screening criteria
Zinc	15.1		42.8		10	10	EBGsw-002D	21,002	4,617	58,216		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 tap water (Nov. 2012). Those based on noncancer risk are adjusted to a HQ of 0.1 (as opposed to published value based on HQ of 1) except for lead. The Maximum Contaminant Level is listed for lead.*

µg/L denotes micrograms per liter.

COPC denotes chemical of potential concern.

Cr^{+3} denotes trivalent chromium.

FWCUG denotes facility-wide cleanup goal per the Final Facility-Wide Human Health Cleanup Goals for the RVAAP *(SAIC, 2010).*

HQ denotes hazard quotient.

J denotes that the result is reported as an estimated value.

MDC denotes maximum detected concentration.

NA denotes not applicable/available.

NGT denotes National Guard Trainee.

R(A) denotes Resident Receptor (Adult).

R(C) denotes Resident Receptor (Child).

RVAAP denotes Ravenna Army Ammunition Plant.

VQ denotes validation qualifier.

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Table 7-3
Summary of Screening Results for COPCs in Wet Sediment for the Resident Receptor and the National Guard Trainee

Site-Related Chemical	Range of Values, mg/kg						Location of MDC	R(A) FWCUG[1] (mg/kg)	R(C) FWCUG[1] (mg/kg)	NGT FWCUG[1] (mg/kg)	RSL[2] (mg/kg)	COPC?	COPC Justification
	Detected Concentrations				Reporting Limits								
	Minimum	VQ	Maximum	VQ	Minimum	Maximum							
Metals													
Aluminum	13,900	J	37,300	J	1.7	4.8	EBGsd-010M	52,923	7,380	3,496		Yes	Above risk screening criteria for R(C) and NGT
Antimony	0.92	J	6.5		1.1	1.7	EBGsd-009M	13.6	2.82	175		Yes	Above risk screening criteria for R(C)
Barium	128	J	418	J	0.071	1	EBGsd-010M	8,966	1,413	351		Yes	Above risk screening criteria for NGT
Cadmium	0.61		2.5		0.057	0.086	EBGsd-008M	22.3	6.41	329		No	Below risk screening criteria
Chromium (as Cr^{+3})	11.9		20.2		0.2	0.3	EBGsd-008M	19,694	8,147	329,763		No	Below risk screening criteria
Copper	30.9		301		0.57	0.86	EBGsd-009M	2,714	311	25,368		No	Below risk screening criteria
Iron	8,740	J	33,000	J	2.6	36	EBGsd-010M	19,010	2,313	184,370		Yes	Above risk screening criteria for R(C)
Lead	14.7		72	J	0.36	0.54	EBGsd-010M	NA	NA	NA	400	No	Below risk screening criteria
Mercury	0.025		0.092		0.012	0.017	EBGsd-006M	16.5	2.27	172		No	Below risk screening criteria
Strontium	18.4		29.6		0.11	0.17	EBGsd-008M	NA	NA	NA	4,700	No	Below risk screening criteria
Explosives and Propellants													
2,4,6-Trinitrotoluene	0.63		0.63		0.5	0.5	EBGsd-009M	21.1	3.65	249		No	Below risk screening criteria
4-Amino-2,6-Dinitrotoluene	0.13	J	0.13	J	0.3	0.3	EBGsd-009M	12.8	1.54	124		No	Below risk screening criteria
Semivolatile Organic Compounds													
Benzo(b)fluoranthene	0.07	J	0.07	J	0.17	0.25	EBGsd-009M	0.221	0.65	4.77		No	Below risk screening criteria
Benzoic Acid	0.61	J	0.82	J	4.3	6.3	EBGsd-008M	NA	NA	NA	24,000	No	Below risk screening criteria
Chrysene	0.039	J	0.039	J	0.17	0.25	EBGsd-009M	22.1	65	477		No	Below risk screening criteria
Dibenzofuran	0.049	J	0.049	J	0.17	0.25	EBGsd-007M	119	15.3	1,192		No	Below risk screening criteria
Fluoranthene	0.067	J	0.067	J	0.17	0.25	EBGsd-009M	276	163	5,087		No	Below risk screening criteria
Phenanthrene	0.053	J	0.056	J	0.17	0.25	EBGsd-007M	207	122	3,815		No	Below risk screening criteria
Pyrene	0.042	J	0.042	J	0.17	0.25	EBGsd-009M	207	122	3,815		No	Below risk screening criteria
Polychlorinated Biphenyls													
Aroclor-1254	0.052	J	0.052	J	0.15	0.21	EBGsd-010M	0.203	0.12	3.46		No	Below risk screening criteria
General Chemistry													
Nitrocellulose	100	J	100	J	200	200	EBGsd-010M	NA	NA	NA	1.8E+07	No	Below risk screening criteria
Hexavalent Chromium	4.2	J	22		14	20	EBGsd-010M	90.4	19.9	1.64		Yes	Above risk screening criteria for R(C) and NGT

Table 7-3 (continued)
Summary of Screening Results for COPCs in Wet Sediment for the Resident Receptor and the National Guard Trainee

[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 (Nov. 2012). Those based on noncancer risk are adjusted to a HQ of 0.1 (as opposed to published value based on HQ of 1) except for lead.
COPC denotes chemical of potential concern.
Cr^{+3} denotes trivalent chromium.
FWCUG denotes facility-wide cleanup goal per the Final Facility-Wide Human Health Cleanup Goals for the RVAAP *(SAIC, 2010). FWCUG for pyrene used for phenanthrene.*
HQ denotes hazard quotient.
J denotes that the result is reported as an estimated value.
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 Ravenna Army Ammunition Plant.
VQ denotes validation qualifier.

Table 7-4
Summary of Screening Results for COPCs in Surface Soil (3 to 4 feet bgs) for the National Guard Trainee

Site-Related Chemical	Range of Values, mg/kg						Location of MDC	NGT FWCUG[1] (mg/kg)	RSL[2] (mg/kg)	COPC?	COPC Justification
	Detected Concentrations				Reporting Limits						
	Minimum	VQ	Maximum	VQ	Minimum	Maximum					
Metals											
Cadmium	0.036	J	0.054		0.039	0.04	EBGss-012M	10.9		No	Below risk screening criteria
Strontium	3.6		5		0.077	0.08	EBGss-013M	NA	4,700	No	Below risk screening criteria

[1] *FWCUG is lower noncarcinogenic FWCUG at a hazard index of 0.1 and excess carcinogenic FWCUG risk of 10^{-6}.*

[2] *RSL denotes Regional Screening Level for residential soil (Nov. 2012). Those based on noncancer risk are adjusted to a HQ of 0.1 (as opposed to published value based on HQ of 1) except for lead.*

COPC denotes chemical of potential concern.

FWCUG denotes facility-wide cleanup goal per the Final Facility-Wide Human Health Cleanup Goals for the RVAAP *(SAIC, 2010).*

HQ denotes hazard quotient.

J denotes that the result is reported as an estimated value.

MDC denotes maximum detected concentration.

mg/kg denotes milligrams per kilogram.

NA denotes not applicable/available.

NGT denotes National Guard Trainee.

RVAAP denotes Ravenna Army Ammunition Plant.

VQ denotes validation qualifier.

Table 7-5
Summary of Screening Results for COPCs in Subsurface Soil (3 to 4 feet bgs) for the Resident Receptor

Site-Related Chemical	Range of Values, mg/kg						Location of MDC	R(A) FWCUG[1] (mg/kg)	R(C) FWCUG[1] (mg/kg)	RSL[2] (mg/kg)	COPC?	COPC Justification
	Detected Concentrations				Reporting Limits							
	Minimum	VQ	Maximum	VQ	Minimum	Maximum						
Metals												
Cadmium	0.036	J	0.054		0.039	0.04	EBGss-012M	22.3	6.41		No	Below risk screening criteria
Strontium	3.6		5		0.077	0.08	EBGss-013M	NA	NA	4,700	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 (Nov. 2012). Those based on noncancer risk are adjusted to a HQ of 0.1 (as opposed to published value based on HQ of 1) except for lead.*

COPC denotes chemical of potential concern.

FWCUG denotes facility-wide cleanup goal per the Final Facility-Wide Human Health Cleanup Goals for the RVAAP *(SAIC, 2010).*

HQ denotes hazard quotient.

J denotes that the result is reported as an estimated value.

MDC denotes maximum detected concentration.

mg/kg denotes milligrams per kilogram.

NA denotes not applicable/available.

R(A) denotes Resident Receptor (Adult).

R(C) denotes Resident Receptor (Child).

RVAAP denotes Ravenna Army Ammunition Plant.

VQ denotes validation qualifier.

10^{-6} excess cancer risk level and an HQ of 0.1 for noncancer effect values. As previously mentioned, if a chemical was detected for which there was no final FWCUG, the RSLs (EPA, 2012) were used. There are no sediment-specific RSLs; therefore, the residential soil RSLs were also used for wet sediment. The RSLs were based on the lower of values derived considering an excess cancer risk of 10^{-6} and noncancer hazard considering a hazard index (HI) of 1. However, the RSLs included in these tables were derived based on noncancer risk that were adjusted to a HI of 0.1 in order to be consistent with the noncancer final FWCUGs.

The RSL for lead was not adjusted in this manner since it was not derived using the HI approach. The RSL for lead in soil is used for soil and sediment in the HHRA based on the soil value recommended by the EPA as generally safe for residential settings (EPA, 2012). In some cases, FWCUGs or RSLs were not available for the detected chemical, and values for a closely related compound are 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 final FWCUG, or the RSL if no final FWCUGs are available, are considered COPCs. The COPCs identified for the identified for Resident Receptor (Unrestricted Land Use) and the National Guard Trainee (Military Training Land Use) are summarized in **Table 7-6**.

Table 7-6
Summary of COPCs for the Resident Receptor and the National Guard Trainee

Receptor	COPCs Identified[1]
Surface Water	
Resident Receptor (Adult and Child)	Iron
National Guard Trainee	None
Wet Sediment	
Resident Receptor (Adult and Child)	Aluminum
	Antimony
	Hexavalent Chromium
	Iron
National Guard Trainee	Aluminum
	Barium
	Hexavalent Chromium

Table 7-6 (continued)
Summary of COPCs for the Resident Receptor and the National Guard Trainee

Receptor	COPCs Identified[1]
Surface Soil (3 to 4 feet bgs)	
National Guard Trainee	None
Subsurface Soil (3 to 4 feet bgs)	
Resident Receptor (Adult and Child)	None

*[1] COPCs for surface water, wet sediment, and subsurface soil as identified in **Tables 7-2** through **7-5**.*
bgs denotes below ground surface.
COPC denotes chemical of potential concern.

7.3.1 COPCs in Surface Water

Iron was the only COPC identified in the surface water samples for the Resident Receptor (Adult and Child). No COPCs were identified in surface water for the National Guard Trainee. The results for the screening process used to evaluate for COPCs in surface water for Unrestricted Land Use and the Military Training Land Use is presented in **Table 7-2**. **Table 7-6** summarizes the results of the evaluation process for COPCs in surface water for Unrestricted Land Use using the Resident Receptor (Adult and Child) and the Military Training Land Use using the National Guard Trainee.

7.3.2 COPCs in Wet Sediment

The COPCs were identified for Unrestricted Land Use in wet sediment and included aluminum, antimony, Cr^{+6}, and iron. Aluminum, barium, and Cr^{+6} were identified as COPCs for the National Guard Trainee. The evaluation process for COPCs in wet sediment for Unrestricted Land Use and the Military Training Land Use is provided in **Table 7-3**. **Table 7-6** summarizes the results of the evaluation process for COPCs in wet sediment for Unrestricted Land Use using the Resident Receptor (Adult and Child) and the Military Training Land Use using the National Guard Trainee.

7.3.3 COPCs in Soil

No COPCs were identified in the soil medium that was evaluated for surface soil for the National Guard Trainee or subsurface soil for the Resident Receptor (Adult and Child). The evaluation process for COPCs in surface soil for the National Guard Trainee is provided in **Table 7-4**. The evaluation process for COPCs in subsurface soil for the Resident Receptor (Adult and Child) is provided in **Table 7-5**. **Table 7-6** summarizes the results of the evaluation process for COPCs in the trench soil samples for Unrestricted Land Use using the Resident Receptor (Adult and Child) and the Military Training Land Use using the National Guard Trainee.

7.4 COC Evaluation

This section presents the COC evaluation process for the human health risk receptors. The COCs are identified through additional screening of the COPCs identified in Section 7.3. The determination of COCs for the Erie Burning Grounds MRS was conducted in accordance with the Position Paper (USACE, 2012) as follows:

- The final FWCUG values for the Resident Receptor (Adult and Child) and the receptors evaluated in the HHRA were selected using the 1×10^{-5} carcinogenic value and the noncancer value at an HQ of 1.
- All carcinogenic and noncarcinogenic risk values for all receptors and all critical effects and target organs are reported.
- A comparison of the final FWCUG to the EPC was conducted. The EPC was the maximum detected concentration due to the small number of samples.
- For carcinogens and noncarcinogens, the EPCs were compared to the target risk final FWCUG using the Sum of Ratios approach presented in the Position Paper (USACE, 2012).
- The chemical was retained as a COC if: (1) the EPC exceeded the most stringent risk value for either the Adult Resident Receptor or the Child Resident Receptor that are evaluated for Unrestricted Land Use, or the receptors evaluated for the Military Training Land Use, considering the 1×10^{-5} carcinogenic value and the noncancer value for an HQ of 1.0; or (2) the sum of ratios for all carcinogens or all noncarcinogens that may affect the same organ was greater than 1 and the chemical contributed at least 5 percent to the sum.

The use of the Sum of Ratios approach is intended to account for additive effects from exposure to multiple chemicals that can cause the same effect (i.e., cancer) or affect the same target organ. Each of these steps is discussed in more detail below.

7.4.1 Final FWCUG Identification

Final FWCUGs are needed that reflect the planned future use of Erie Burning Grounds MRS. The Erie Burning Grounds MRS is currently managed as an "Authorized Access" area due to the high-quality wetlands that are present and the potential for MEC (SAIC, 2007). Current activities at the Erie Burning Grounds MRS include maintenance and natural resource management activities. The MRS may also be used for hunting/trapping and fire suppression activities. Therefore, the Security Guard/Maintenance Worker, Hunter/Trapper, and Fire/Dust Suppression Worker were identified as potential receptors at the MRS.

The FWCUG Report (SAIC, 2010) assumes no exposure to surface water or sediment for the Security Guard/Maintenance Worker, and the final FWCUGs for Fire/Dust Suppression Worker were used for these media, as these were the same as or lower than those for the Hunter/Trapper. The final FWCUGs used also include those for the Resident Receptor (Adult and Child) to evaluate COCs for Unrestricted Land Use. The final FWCUGs selected are those based on a 10^{-5} excess cancer risk for carcinogenic effects, and an HQ equal to 1 for noncancer effects. The final FWCUGs for the identified COPCs are provided in **Tables 7-7** through **7-14**.

7.4.2 EPC Development

The maximum detected concentration for each COPC was used as the EPC. For the sediment samples, the maximum detected concentration is used as the EPC because these ISM samples represent an average concentration over the area sampled. For the discrete surface water samples, there were too few samples to derive a 95-percent upper confidence limit (UCL) based on the mean result. The EPCs used are provided in **Tables 7-7** through **7-14**.

7.4.3 Comparison of EPCs to Final FWCUGs

The EPCs are compared to the final FWCUGs for cancer and noncancerous effects through the development of a ratio (USACE, 2012). These ratios are summed to account for potential cumulative effects. For noncancerous effects, the ratios are summed for target organs, which are shown for each COPC as reported in the FWCUG guidance (SAIC, 2010). COCs are identified if one of the following occurs:

- The cancer or noncancer ratio for a given COPC is greater than 1.
- The sum of the ratios for cancer or noncancer effects for any target organ is greater than 1, and the COPC contributes more than 5 percent to the sum.

Tables 7-7 through **7-14** identify which COPCs have been identified as COCs, and the justification for COPCs that are not considered COCs. The COCs identified for all receptors are summarized in **Table 7-15**.

7.4.4 COCs in Surface Water

No COCs were identified in surface water at the Erie Burning Grounds MRS for the Resident Receptor (Adult and Child), the Fire/Dust Suppression Worker, or the Hunter/Trapper. The evaluation process for COCs in surface water for Unrestricted Land Use using the Resident Receptor (Adult and Child) and the Military Training Land Use using the other facility receptors evaluated is provided in **Tables 7-7** through **7-10**. **Table 7-15** summarizes the COCs identified in the environmental media sampled at the MRS for Unrestricted Land Use and the other receptors following the COC evaluation process.

Table 7-7
Summary of COC Evaluation for Noncancer Risk Effects in Surface Water for the Resident Receptor

Parameter	EPC (µg/L)	R(C) FWCUG[1] (µg/L)	Target Organ	Ratio of EPC to FWCUG	% Contribution to the Total Sum	COC?	COC Justification
Gastrointestinal Effects							
Iron	8,690	45,269	Gastrointestinal effects	0.19	100%	No	Sum of ratios by target organ < 1
		Sum of Ratios—Gastrointestinal Effects:		**0.19**			

[1] *FWCUG is noncarcinogenic FWCUG at HQ of 1. Only child FWCUG is shown, as this is lower than adult for noncancer effects.*

µg/L denotes micrograms per liter.

COC denotes chemical of concern.

EPC denotes exposure point concentration. EPC is maximum detected concentration.

FWCUG denotes facility-wide cleanup goal per the Final Facility-Wide Human Health Cleanup Goals for the RVAAP *(SAIC, 2010).*

HQ denotes hazard quotient.

R(C) denotes Resident Receptor (Child).

RVAAP denotes Ravenna Army Ammunition Plant.

Table 7-8
Summary of COC Evaluation for Cancer Risk in Surface Water for the Resident Receptor

Parameter	EPC (µg/L)	BSV (µg/L)	R(A) FWCUG[1] (µg/L)	Ratio of EPC to FWCUG	% Contribution to the Total Sum	COC?	COC Justification
Iron	8,690	2,560	NA	NA	NA	No	Not carcinogenic
			Sum of Ratios:	**0.34**			

[1] *FWCUG is cancer risk FWCUG at risk of 10^{-5} for adult; values for child are higher.*

µg/L denotes micrograms per liter.

BSV denotes background screening value.

COC denotes chemical of concern.

EPC denotes exposure point concentration. EPC is maximum detected concentration.

FWCUG denotes facility-wide cleanup goal per the Final Facility-Wide Human Health Cleanup Goals for the RVAAP *(SAIC, 2010).*

NA denotes not applicable/available.

R(A) denotes Resident Receptor (Adult).

RVAAP denotes Ravenna Army Ammunition Plant.

Table 7-9
Summary of COC Evaluation for Noncancer Risk Effects in Surface Water for RVAAP-Specific Receptors

Parameter	EPC (µg/L)	Fire/Dust Suppression Worker FWCUG[1] (µg/L)	Target Organ	Ratio of EPC to FWCUG	% Contribution to the Total Sum	COC?	COC Justification
Gastrointestinal Effects							
Iron	8,690	2.7E+06	Gastrointestinal effects	0.0032	100%	No	Sum of ratios by target organ < 1
			Sum of Ratios—Gastrointestinal Effects:	**0.0032**			

[1] *FWCUG is noncarcinogenic FWCUG at HQ of 1 for the National Guard Fire/Dust Suppression Worker, since it is lower than the Hunter/Trapper.*

µg/L denotes micrograms per liter.

COC denotes chemical of concern.

EPC denotes exposure point concentration. EPC is maximum detected concentration.

FWCUG denotes facility-wide cleanup goal per the Final Facility-Wide Human Health Cleanup Goals for the RVAAP *(SAIC, 2010).*

HQ denotes hazard quotient.

RVAAP denotes Ravenna Army Ammunition Plant.

Table 7-10
Summary of COC Evaluation for Cancer Risk in Surface Water for RVAAP-Specific Receptors

Parameter	EPC (µg/L)	BSV (µg/L)	Fire/Dust Suppression Worker FWCUG[1] (µg/L)	Ratio of EPC to FWCUG	% Contribution to the Total Sum	COC?	COC Justification
Iron	8,690	2,560	NA	NA	NA	No	Not carcinogenic
			Sum of Ratios:	**0.34**			

[1] *FWCUG is cancer risk FWCUG at risk of 10^{-5} for the National Guard Fire/Dust Suppression Worker, since it is lower than the Hunter/Trapper.*

µg/L denotes micrograms per liter.

BSV denotes background screening value.

COC denotes chemical of concern.

EPC denotes exposure point concentration. EPC is maximum detected concentration.

FWCUG denotes facility-wide cleanup goal per the Final Facility-Wide Human Health Cleanup Goals for the RVAAP *(SAIC, 2010).*

NA denotes not applicable/available.

RVAAP denotes Ravenna Army Ammunition Plant.

Table 7-11
Summary of COC Evaluation for Noncancer Risk Effects in Wet Sediment for the Resident Receptor

Parameter	EPC (mg/kg)	R(C) FWCUG[1] (mg/kg)	Target Organ	Ratio of EPC to FWCUG	% Contribution to the Total Sum	COC?	COC Justification
Neurotoxicity Effects							
Aluminum	37,300	73,798	Neurotoxicity in offspring	0.51	100%	No	Sum of ratios by target organ <1
			Sum of Ratios—Neurotoxicity Effects:	**0.51**			
Gastrointestinal Effects							
Iron	33,000	23,125	Gastrointestinal effects	1.43	93%	Yes	Sum of ratios by target organ >1, contributes more than 5% to the sum
Hexavalent Chromium	22	199	Gastrointestinal, hepatic, and renal effects	0.11	7%	No	Sum of ratios by target organ > 1, contributes more than 5% to the sum; not considered COC since iron is primary contributor to sum, and is largely attributable to background
			Sum of Ratios—Gastrointestinal Effects:	**1.54**			
Vascular Effects							
Antimony	6.5	28.2	Longevity, blood glucose, and cholesterol	0.23	100%	No	Sum of ratios by target organ < 1
			Sum of Ratios—Vascular Effects:	**0.23**			
Renal Effects							
Hexavalent Chromium	22	199	Gastrointestinal, hepatic, and renal effects	0.11	100%	No	Sum of ratios by target organ < 1
			Sum of Ratios—Renal Effects:	**0.11**			

Table 7-11 (continued)
Summary of COC Evaluation for Noncancer Risk Effects in Wet Sediment for the Resident Receptor

Parameter	EPC (mg/kg)	R(C) FWCUG[1] (mg/kg)	Target Organ	Ratio of EPC to FWCUG	% Contribution to the Total Sum	COC?	COC Justification
Liver Effects							
Hexavalent Chromium	22	199	Gastrointestinal, hepatic, and renal effects	0.11	100%	No	Sum of ratios by target organ < 1
			Sum of Ratios—Liver Effects:	**0.11**			

[1] *FWCUG is noncarcinogenic FWCUG at HQ of 1. Only child FWCUG is shown, as this is lower than adult for noncancer effects.*

> denotes greater than.

COC denotes chemical of concern.

EPC denotes exposure point concentration. EPC is maximum detected concentration.

FWCUG denotes facility-wide cleanup goal per the Final Facility-Wide Human Health Cleanup Goals for the RVAAP *(SAIC, 2010).*

HQ denotes hazard quotient.

mg/kg denotes milligrams per kilogram.

R(C) denotes Resident Receptor (Child).

RVAAP denotes Ravenna Army Ammunition Plant.

Table 7-12
Summary of COC Evaluation for Cancer Risk in Wet Sediment for the Resident Receptor

Parameter	EPC (mg/kg)	BSV (mg/kg)	R(A) FWCUG[1] (mg/kg)	Ratio of EPC to FWCUG	% Contribution to the Total Sum	COC?	COC Justification
Aluminum	37,300	13,900	NA	NA	NA	No	Not carcinogenic
Antimony	6.5	ND	NA	NA	NA	No	Not carcinogenic
Hexavalent Chromium	22	NA	1,874	0.012	100%	No	Sum of ratios < 1
Iron	33,000	28,200	NA	NA	NA	No	Not carcinogenic
			Sum of Ratios:	**0.012**			

[1] FWCUG is cancer risk FWCUG at risk of 10^{-5} for adult; values for child are higher.

BSV denotes background screening value.

COC denotes chemical of concern.

EPC denotes exposure point concentration. EPC is maximum detected concentration.

FWCUG denotes facility-wide cleanup goal per the Final Facility-Wide Human Health Cleanup Goals for the RVAAP *(SAIC, 2010).*

mg/kg denotes milligrams per kilogram.

NA denotes not applicable/available.

ND denotes not detected.

R(A) denotes Resident Receptor (Adult).

RVAAP denotes Ravenna Army Ammunition Plant.

Table 7-13
Summary of COC Evaluation for Noncancer Risk Effects in Wet Sediment for the RVAAP-Specific Receptors

Parameter	EPC (mg/kg)	Fire/Dust Suppression Worker FWCUG[1] (mg/kg)	Target Organ	Ratio of EPC to FWCUG	% Contribution to the Total Sum	COC?	COC Justification
Neurotoxicity Effects							
Aluminum	37,300	1E+06	Neurotoxicity in offspring	0.037	100%	No	Sum of ratios by target organ < 1
			Sum of Ratios—Neurotoxicity Effects:	**0.037**			
Gastrointestinal Effects							
Iron	33,000	1E+06	Gastrointestinal effects	0.033	99%	No	Sum of ratios by target organ < 1
Hexavalent Chromium	22	66,659	Gastrointestinal, hepatic, and renal effects	0.00033	1%	No	Sum of ratios by target organ < 1
			Sum of Ratios—Gastrointestinal Effects:	**0.033**			
Vascular Effects							
Antimony	6.5	10,297	Longevity, blood glucose, and cholesterol	0.00063	100%	No	Sum of ratios by target organ < 1
			Sum of Ratios—Vascular Effects:	**0.00063**			
Renal Effects							
Barium	418	1E+06	Nephropathy	0.00042	56%	No	Sum of ratios by target organ < 1
Hexavalent Chromium	22	66,659	Gastrointestinal, hepatic, and renal effects	0.00033	44%	No	Sum of ratios by target organ < 1
			Sum of Ratios—Renal Effects:	**0.00075**			

Table 7-13 (continued)
Summary of COC Evaluation for Noncancer Risk Effects in Wet Sediment for the RVAAP-Specific Receptors

Parameter	EPC (mg/kg)	Fire/Dust Suppression Worker FWCUG[1] (mg/kg)	Target Organ	Ratio of EPC to FWCUG	% Contribution to the Total Sum	COC?	COC Justification
Liver Effects							
Hexavalent Chromium	22	66,659	Gastrointestinal, hepatic, and renal effects	0.11	100%	No	Sum of ratios by target organ < 1
			Sum of Ratios—Liver Effects:	**0.11**			

[1] *FWCUG is noncarcinogenic FWCUG at HQ of 1 for the National Guard Fire/Dust Suppression Worker, since it is lower than the Hunter/Trapper.*

> denotes greater than.

COC denotes chemical of concern.

EPC denotes exposure point concentration. EPC is maximum detected concentration.

FWCUG denotes facility-wide cleanup goal per the Final Facility-Wide Human Health Cleanup Goals for the RVAAP *(SAIC, 2010).*

HQ denotes hazard quotient.

mg/kg denotes milligrams per kilogram.

RVAAP denotes Ravenna Army Ammunition Plant.

Table 7-14
Summary of COC Evaluation for Cancer Risk in Wet Sediment for the RVAAP-Specific Receptors

Parameter	EPC (mg/kg)	BSV (mg/kg)	Fire/Dust Suppression Worker FWCUG[1] (mg/kg)	Ratio of EPC to FWCUG	% Contribution to the Total Sum	COC?	COC Justification
Aluminum	37,300	13,900	NA	NA	NA	No	Not carcinogenic
Antimony	6.5	ND	NA	NA	NA	No	Not carcinogenic
Barium	418	123	NA	NA	NA	No	Not carcinogenic
Hexavalent Chromium	22	NA	141,791	0.00016	100%	No	Sum of ratios < 1
Iron	33,000	28,200	NA	NA	NA	No	Not carcinogenic
			Sum of Ratios:	**0.0016**			

[1] *FWCUG is cancer risk FWCUG at risk of 10^{-5} for the National Guard Fire/Dust Suppression Worker, since it lower than for the Hunter/Trapper.*

BSV denotes background screening value.

COC denotes chemical of concern.

EPC denotes exposure point concentration. EPC is maximum detected concentration.

FWCUG denotes facility-wide cleanup goal per the Final Facility-Wide Human Health Cleanup Goals for the RVAAP *(SAIC, 2010).*

mg/kg denotes milligrams per kilogram.

NA denotes not applicable/available.

ND denotes not detected.

RVAAP denotes Ravenna Army Ammunition Plant.

Table 7-15
Summary of COCs

Receptor	COCs Identified[1]
Surface Water[2]	
Unrestricted Land Use—Resident Receptor (Adult and Child)	None
Military Training Land Use—Fire/Dust Suppression Worker and Hunter Trapper	None
Wet Sediment[2]	
Unrestricted Land Use—Resident Receptor (Adult and Child)	Iron
Military Training Land Use—Fire/Dust Suppression Worker and Hunter Trapper	None

*[1] COCs are identified by evaluating noncancerous hazard and cancer risk, see **Tables 7-7** through **7-14**.*

[2] The Security Guard/Maintenance Worker is identified as a future land use receptor at the Erie Burning Grounds MRS; however, the Facility-Wide Human Health Cleanup Goals for the RVAAP (SAIC, 2010) guidance assumes no exposure to surface water or sediment for this receptor.

COC denotes chemical of concern.

7.4.5 COCs in Wet Sediment

Iron is identified as a COC for the Resident Receptor (Adult and Child) based on the consideration of one ISM wet sediment sample result that exceeds the facility screening criteria (**Table 7-11**); however, the consideration of this substance as a COC for the FS is not recommended. The final FWCUG for iron in sediment is 23,125 mg/kg, which is below the BSV of 28,200 mg/kg.

Additionally, the results for the five other wet sediment samples were all well below both the BSV and the final FWCUG. The detected iron result that exceeded the BSV was at a concentration of 33,000 mg/kg, which is relatively close to the BSV; therefore, the elevated iron concentrated is most likely attributable to the background.

As part of the COC evaluation for Unrestricted Land Use in wet sediment, Cr^{+6} was identified as contributing 7 percent to the sum of ratios for gastrointestinal effects where the sum of ratios that may affect the same organ was greater than 1 (**Table 7-11**). In general, the Position Paper (USACE, 2012) dictates that chemicals contributing greater than 5 percent to the sum of ratios for a given effect be identified as COCs. However, if the contribution is less than 10 percent, then the chemical can be excluded with justification. In the case of the Erie Burning Grounds MRS, the detected concentration of Cr^{+6} in the wet sediment (22 mg/kg) was much less than the more stringent of the final FWCUGs for the Resident Receptor (Adult and Child) at an HQ of 1 (199 mg/kg). Since the contribution of Cr^{+6} to the sum of ratios is less than 10 percent, it was excluded as a COC.

Based upon the aforementioned rationale, no COCs were recommended for further evaluation in wet sediment for the Resident Receptor (Adult and Child), the Fire/Dust Suppression Worker, or the Hunter/Trapper. The evaluation process for COCs in wet sediment for the Unrestricted Land Use using the Resident Receptor (Adult and Child) and the Military Training Land Use using the other facility receptors is provided in **Tables 7-11** through **7-14**. **Table 7-15** summarizes the COCs identified in the environmental media sampled at the MRS for Unrestricted Land Use and the other facility receptors following the COC evaluation process.

7.5 HHRA Summary

The only COC identified for any of the receptors evaluated in the HHRA was iron in wet sediment for the Resident Receptor (Adult and Child) only. However, as discussed in Section 7.4.5, weight of evidence suggests that the detected iron concentration is unlikely to pose a hazard for this receptor; therefore, the Unrestricted Land Use is achieved. No other MC related SRCs were determined to pose a hazard to likely human receptors in the evaluated potential exposure pathways of surface water, wet sediment, and subsurface soil.

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 final 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. In this assessment soil and sediment 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. Surface sampling was conducted using the grab technique. Since surface water concentrations are unlikely to be as heterogeneous as soil or sediment, the concentrations obtained are considered representative of potential exposure.

The identification of COPCs and COCs is based on the identification of SRCs. The identification of SRCs is largely based on MRS-specific background concentrations. Several inorganics were identified as COPCs in surface water and wet sediment and iron was

identified as a COC in wet sediment for evaluation of Unrestricted Land Use. 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 background data sets.

The evaluation of total chromium in this assessment is based on the final FWCUGs for Cr^{+3} for each media sample for the RI. Samples were also analyzed for Cr^{+6}, which was not detected in soil or surface water. Cr^{+6} was detected in wet sediment, and those results were compared to the final FWCUG for this species. Therefore, the EPC for total chromium in sediment is considered an over-estimation of the trivalent concentration. Since total chromium was not identified as a COC, this assumption represents a minor uncertainty to the risk assessment.

A number of substances detected at the MRS have no final FWCUGs. In these cases, the RSLs for soil were used as the screening values for all receptors. This provides a conservative evaluation, since RSLs used are based on residential exposure. In addition, there were no final FWCUGs for sediment for a number of chemicals, so those for surface soil were used. In some cases, if no final FWCUGs or RSLs were available, screening values for closely related chemicals were used. These assumptions represent an uncertainty to the risk assessment, although the frequency of detection and concentrations of most substances without final FWCUGs or RSLs were quite low. In addition, the chemicals for which there was a final FWCUG available were the ones that had been detected in previously completed investigations on the facility. This means that if a chemical lacks a final 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 Erie Burning Grounds 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 is required in accordance with CERCLA and represents a conservative evaluation of possible future exposures. A likely receptor for the MRS is considered to be the Security Guard/Maintenance Worker; however, there are no exposure scenarios for this receptor in surface water or sediment at the facility. Therefore, the National Guard Fire/Dust Suppression Worker and the Hunter Trapper, which have less exposure potential at the MRS, were also evaluated. Of these two receptors, the final FWCUGs for the National Guard Fire/Dust Suppression Worker were used in the HHRA, as the final FWCUGs are lower for this receptor than for the Hunter/Trapper. Therefore, risks are not expected to be underestimated for the Security Guard/Maintenance Worker or other facility receptors.

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8.0 ECOLOGICAL RISK ASSESSMENT

The ERA evaluates the potential for adverse effects posed to ecological receptors from potential releases at the Erie Burning Grounds MRS and was prepared in accordance with the Unified Approach to ERAs that was established at sites under environmental investigation at the former RVAAP. This ERA is 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, 2010b). Other supporting documents used in the preparation of the ERA include the EPA *Ecological Risk Assessment Guidance for Superfund* (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 facility Unified Approach for performing ERAs, a screening-level ERA (SLERA) was performed on the Erie Burning Grounds MRS. The SLERA is an initial screening step in the ERA eight-step approach as described in EPA (1997) guidance. 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 chemicals of potential ecological concern (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 ERA (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 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 (2003b and 2010). 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 is to evaluate the potential for adverse ecological effects to ecological receptors from MC at the Erie Burning Grounds MRS. This objective is 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 addresses 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 is to provide an estimate of the potential for adverse ecological effects associated with contamination resulting from former activities at the Erie Burning Grounds MRS. The results of the ERA will contribute to the overall characterization of the MRS and may be used to determine the need for additional investigations or to develop, evaluate, and select appropriate remedial alternatives.

The ERA uses MRS-specific analyte concentration data for surface water and sediment from the Erie Burning Grounds MRS. 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. The COPECs are analytes whose concentrations are great enough to pose potential adverse effects to ecological receptors. Following the determination of COPECs, an ecological CSM is developed that describes 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 includes descriptions of habitats, biota, and threatened and endangered and other rare species, selection of an EU, and identification of COPECs at the MRS. If a potential threat to ecological receptors is suspected then the ERA proceeds to the Level II Screening step.

8.2.1 Site Description and Land Use

The MRS has been largely inundated since the early 1990s as a result of the subdued topography and beaver activity that blocked the former surface water drainage channel just downstream of the large culvert under Track 10 where the water exits the MRS. Natural drainage at the terrestrial portions of the MRS drain toward the water basins and wetland

areas that now make up most of the MRS. The surface water basins themselves are shallow and subject to seasonal fluctuations in water level. The water level reaches a maximum depth of 5 feet within the former drainage channel portion of the surface water basins, but is generally less than 3 feet in most areas. Wetlands extend to the north and east beyond the Erie Burning Grounds.

Current activities at the Erie Burning Grounds MRS include maintenance and natural resource management activities. The MRS may also be used for hunting/trapping and fire suppression activities. The MRS is located within a larger area designated for Military Training Land Use; and since the MRS is a high-quality wetland, training activities are unlikely to occur there (OHARNG, 2008).

8.2.2 Ecological Significance

The ecological features 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 management goals (Section 8.2.3).

The topography at the Erie Burning Grounds MRS is relatively flat and elevation ranging from 938.1 to 942.4 feet amsl (SAIC, 2005). Approximately 80 percent of the MRS is inundated and includes high-quality wetlands (SAIC, 2007). The vegetation community at the Erie Burning Grounds MRS is categorized as a mixture of mixed cold-deciduous successional forest, and semipermanently and permanently flooded herbaceous alliances. White ash, wild black cherry, red maple, cattails, spatterdock, and white water lily are dominant species in these associations (AMEC, 2008). Additional details pertaining to the ecological setting are provided in the following sections.

8.2.3 Management Goals for the Facility

The INRMP (AMEC, 2008) has been 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 Erie Burning Grounds 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).

8.2.4 Terrestrial and Aquatic Resources

This section summarizes the terrestrial resources identified for the Erie Burning Grounds MRS that are evaluated in the ERA. Although portions of the MRS are forested, nearly 80 percent of the MRS is covered with water. Furthermore, NFA was recommended for soil and dry sediment at the MRS under the IRP in accordance with the *Final Record of Decision Soil and Dry Sediment at the Erie Burning Grounds* (SAIC, 2007). Therefore, the focus of this ERA is on aquatic and semi-aquatic resources, rather than terrestrial resources.

A majority of the MRS is comprised of wetlands, open water, and bottomland woods. There are three primary water basins at the MRS: (1) the North Surface Water Basin, (2) the South Surface Water Basin, and (3) the East Surface Water Basin. The North Surface Water Basin is connected to another water basin outside the MRS boundary to the north of Blackberry Lane via a culvert that flows from north to south. The South Surface Water Basin is connected to a wetland to the west via a culvert under former Track 10 that flows from east to west. The East Surface Water Basin is surrounded by the remaining terrestrial portions of the MRS that include the former Track 49 embankment and the perimeter road (Blackberry Lane).

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 Erie Burning Grounds MRS from the natural heritage data searches.

8.2.4.2 Wetlands

Numerous wetland surveys, including planning-level surveys and jurisdictional delineations have been conducted at the facility. Based on the planning-level survey data for wetlands provided in the INRMP, nearly the entire MRS area is a wetland (AMEC, 2008). No jurisdictional delineation for wetlands has been completed at the MRS.

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 a total of 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 Erie Burning Grounds MRS consists of a mixture of bottomland woods and wetlands. Common bird species that could be expected to use the wooded areas adjacent to the wetland include the common yellowthroat (*Geothlypis trichas*), chestnut-sided warbler (*Dendroica pennsylvanica*), and red-eyed vireo (*Vireo olivaceus*). The wetlands may support dabbling and wading waterfowl such as mallard ducks (*Anas platyrhynchos*) and green heron (*Butorides virescens*). 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 Erie Burning Grounds 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, 77 state-listed species are confirmed to be on the former RVAAP property and are listed in **Table 1-3**.

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 species of state special interest, the green-winged teal (*Anas crecca*), and two state species of concern, the Virginia rail (*Rallus limicola*) and the sora (*Porzana carolina*), have been identified at locations immediately adjacent to 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 is recommended for this ERA. The Level II Screening is presented in Section 8.3.

8.3 Level II Screening

A Level II Screening was performed at the MRS 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 MRS media. Specific assessment and measurement endpoints are identified based on the CSM to describe ecological features targeted for protection. Then, a COPEC identification step is performed to determine what SRCs, if any, potentially represent a threat to the ecological receptors present at the MRS.

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 the Erie Burning Grounds MRS were developed using the available MRS-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.

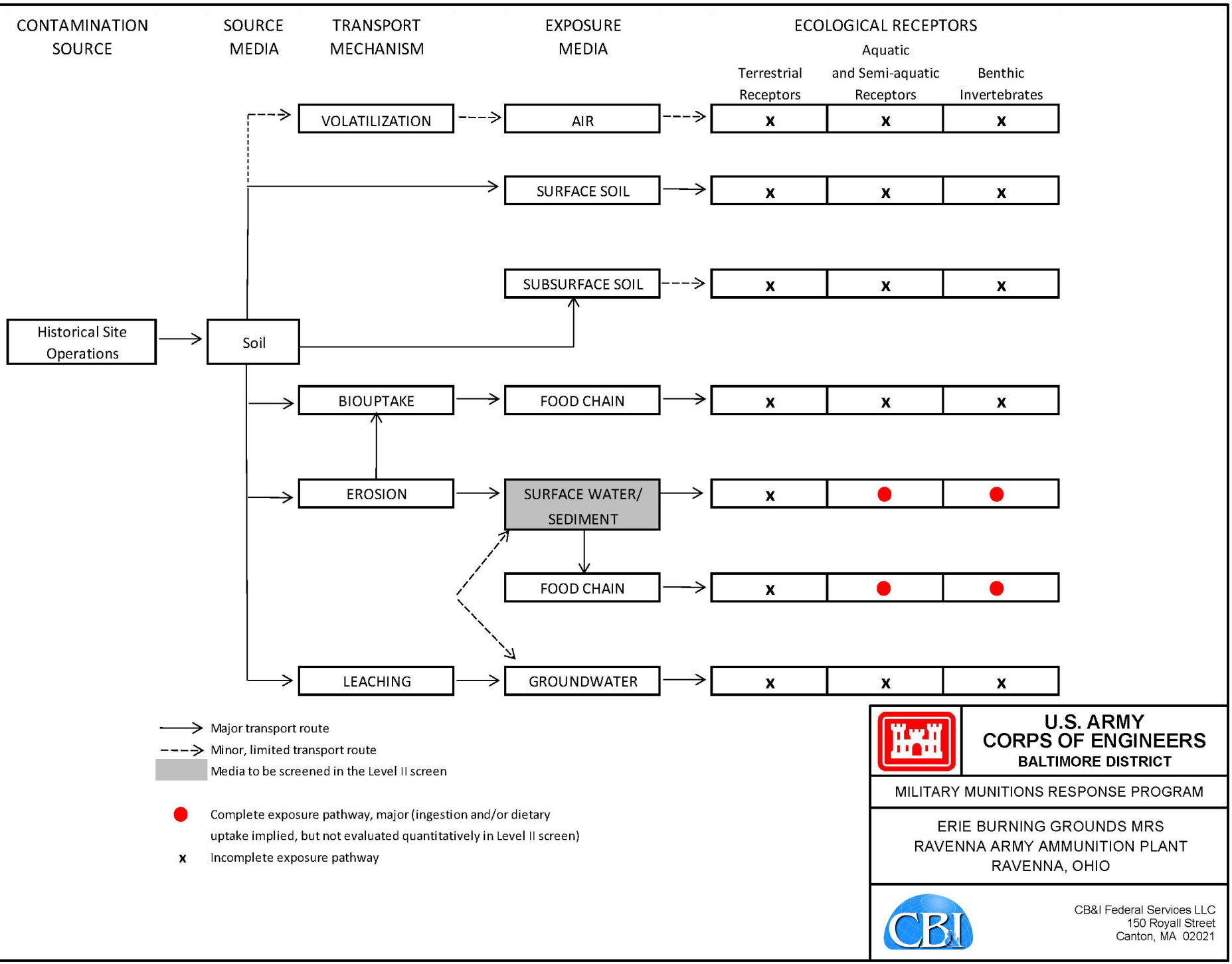


FIGURE 8-1 LEVEL II CONCEPTUAL SITE MODEL

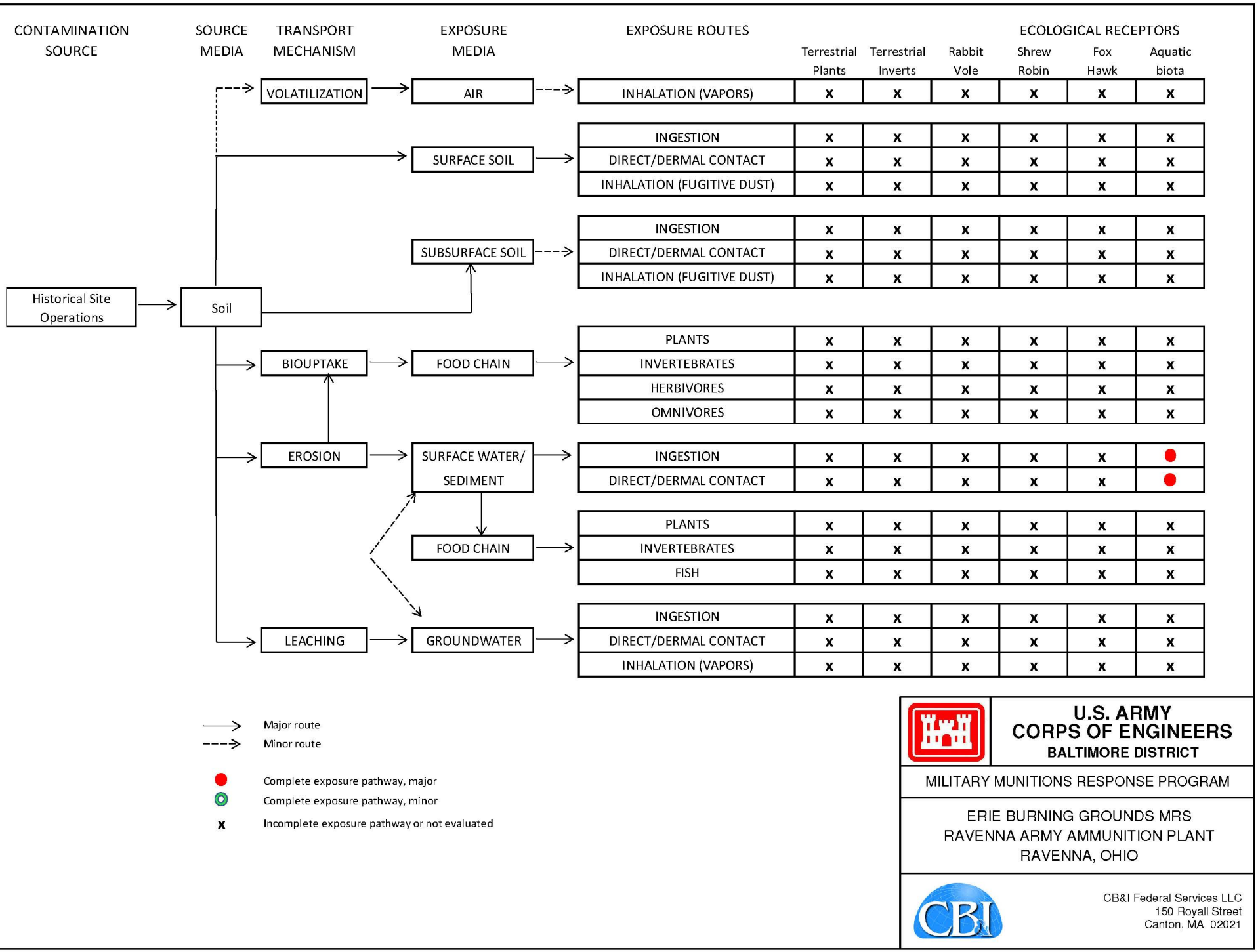


FIGURE 8-2 PRELIMINARY LEVEL III CONCEPTUAL SITE MODEL

8.3.1.1 Contamination Source

The source of chemical contamination at the MRS includes releases from open burn activities that historically occurred at Erie Burning Grounds. The open burn activities included thermal treatment of bulk, obsolete, off-specification propellants, conventional explosives, rags, and large explosive contaminated items (e.g., railcars) by open burning on the ground surface. Ash residue from open burn activities was left on the MRS after the burn. In addition to open burn activities, bomb bodies were transported to Erie Burning Grounds for flashing after they were cleaned out.

8.3.1.2 Source Media

The original source media at Erie Burning Grounds was surface soil where MC was likely released as a result of historical open burn activities that occurred at the MRS. Additionally, MC associated with MD found on the ground surface and buried at various depths may have released to the surrounding soils. Current conditions at the Erie Burning Grounds MRS differ greatly from when the MRS was active. The majority of the MRS became inundated in the early 1990s as a consequence of sedimentation and vegetation growth and beaver damming of the small stream that drains the former burning ground. Surface water basins now occupy the lowlands at the MRS and MC in surface soil may have released to surface water and underwater sediment. Therefore, the source media evaluated in this RI includes potential MC in the surface water and sediment that cover the MRS where the historical open burn activities occurred.

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. Soil has been evaluated previously under the IRP, and no post-IRP surface soil data from ecologically relevant depths (i.e., 0 to 1 foot bgs) were incorporated into this ERA. Therefore, surface water and underwater sediment at the Erie Burning Grounds MRS represent the aquatic EUs evaluated in the ERA. No other EUs are identified for ecological assessment for the MRS.

8.3.1.4 Transport Mechanisms

Transport mechanisms at the MRS include biota uptake, direct transfer to surface water, and sediment, and leaching to groundwater. Biota uptake is a transport mechanism because some of the SRCs are known to accumulate in biota, which may act as a vehicle to spatially disperse contaminants, as well as represent a secondary exposure medium for upper trophic

level receptors that prey on the biota. The former open burn areas at the MRS are now inundated and the deposition of soils containing MC into surface water and sediment is also a valid transport mechanism for both ecological CSMs.

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 surface soil, surface water, sediment, and the food chain. Surface soil has been previously investigated under the IRP with a recommendation of NFA (SAIC, 2007). Subsurface soil collected from the bottoms of the investigation trenches during the RI field activities includes soil at depths greater than 1 foot bgs that ecological receptors typically do not come into contact with and is not evaluated in this ERA. Groundwater is not considered an exposure medium because ecological receptors are unlikely to contact groundwater. Therefore, surface water, wet sediment, and biota comprising prey items for higher trophic level receptors are the principle exposure media for the Erie Burning Grounds MRS.

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 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 surface water and sediment 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 and were derived from the *RVAAP Facility-Wide Ecological Risk Assessment Work Plan* (USACE, 2003c). The major exposure routes for chemical toxicity from surface

water and sediment include ingestion (for aquatic biota, muskrat, duck, mink, and heron) and direct contact (for aquatic biota and benthic invertebrates). The ingestion exposure routes for muskrat, duck, mink, and heron include surface water and sediment, as well as ingestion of plant and/or animal food or prey items that were exposed to these media.

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, aquatic and semi-aquatic biota is considered as a whole. However, for the Level III Baseline evaluation, specific aquatic and semi-aquatic ecological receptors are identified as part of the ecological CSM (**Figure 8-2**). The aquatic receptors include aquatic biota, muskrat, duck, mink, heron, and benthic invertebrates (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 aquatic habitats at the MRS. The following three criteria were used to identify the MRS-specific receptors:

1. **Ecological Relevance**—The receptor has or represents a role in an important function such as energy fixation (e.g., plants), nutrient cycling (e.g., benthic invertebrates), and population regulation (e.g., herons). Receptor species were chosen to include representatives of all applicable trophic levels identified by the ecological CSM for the MRS. 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 the MRS, 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 the MRS'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 former RVAAP (AMEC, 2008).

At the Erie Burning Grounds MRS, the following types of ecological receptors are likely to be present: aquatic plants, aquatic and benthic invertebrates, mammalian and avian herbivores such as muskrat (*Ondatra zibenthicus*) and mallard ducks (*Anas platyrhynchos*) and mammalian and avian carnivores such as mink (*Mustela vison*), and great blue heron (*Ardea herodias*) The aquatic exposures for each of these receptors is described in the following sections and are discussed in greater detail in the *RVAAP Facility-Wide Ecological Risk Assessment Work Plan* (USACE, 2003c) and in the Ohio guidance (2008).

Exposure of Aquatic Biota to Water

Exposure of aquatic biota to water is applicable to the Erie Burning Grounds MRS. Aquatic biota (e.g., aquatic invertebrates and fish) represent the ecological receptors for the aquatic biota exposure class, and aquatic habitat is available at this MRS. Aquatic biota have ecological relevance because they represent the range of living organisms in the aquatic ecosystem and they provide food for various predators.

Aquatic biota are susceptible to exposure to, and toxicity from, COPECs in surface water. The exposure concentration for aquatic biota is assumed to be equal to the measured environmental concentration because the biota have constant contact with water and the aquatic toxicity benchmarks that are used are expected to protect aquatic life from all exposure pathways, including ingestion of surface water as well as contaminated plants and animals. Toxicity benchmarks are available for aquatic biota, but the Ohio Administrative Code Chapter 3745-1, *Water Quality Standards*, for surface water must also be met.

As referenced in Section 8.2.3, management goals as set forth by the INRMP (AMEC, 2008) help protect these species (e.g., Goal 1, manage natural resources in a manner that is compatible with and supports the military mission while complying with applicable federal and state laws and U.S. Army regulations and policies; and Goal 6, manage wildlife resources in a manner compatible with the military mission and within the limits of the natural habitat). In addition, aquatic biota is susceptible to contamination by virtue of continual exposure in water, and they have ecological relevance within the aquatic ecosystems. Thus, there is sufficient justification to warrant aquatic biota as a candidate receptor for the Erie Burning Grounds MRS.

Exposure of Sediment-Dwelling Biota to Sediment

Sediment-dwelling biota exposure to sediment is applicable to the MRS-specific analysis. Benthic invertebrates such as aquatic insect larvae like caddisflies (*Trichoptera*), mayflies (*Ephemeroptera*), and midges (*Chironomidae*), as well as noninsects such as crayfish (*Decapoda*), snails (*Gastropoda*), and clams and bivalves (*Pelycypoda*), represent the

receptors for the sediment-dwelling biota aquatic exposure class. These biota have ecological relevance because they provide food for many aquatic species and also for some aquatic and semi-aquatic mammals and birds such as raccoons, mallards, and herons.

Benthic invertebrates are susceptible to exposure to and toxicity from COPECs in sediment. These biota have direct contact with sediment and sediment pore water. Toxicity benchmarks are available for benthic invertebrates.

As referenced in Section 8.2.3, management goals as set forth by the INRMP (AMEC, 2008) help protect these species (e.g., Goal 1, manage natural resources in a manner that is compatible with and supports the military mission while complying with applicable federal and state laws and U.S. Army regulations and policies; and Goal 6, manage wildlife resources in a manner compatible with the military mission and within the limits of the natural habitat). These biota are susceptible to contamination by virtue of continual exposure in sediment, and they have ecological relevance as a major food source for aquatic biota. Thus, there is sufficient justification to warrant sediment-dwelling biota as a candidate receptor for the MRS.

Herbivore Exposure to Water, Sediment, and the Aquatic Food Web

Aquatic herbivores like muskrats and mallard ducks are exposed to water and sediment. Therefore, these exposures are applicable to the Erie Burning Grounds MRS. There is also suitable habitat for them at the MRS. Muskrats ingest aquatic vegetation. Mallard ducks are surface-feeding ducks that obtain much of their food by dabbling in shallow water and filtering through soft mud with their bills. Their food consists mostly of seeds of aquatic plants, as well as aquatic invertebrates (EPA, 1993). Animal matter accounts for the majority of the diet for breeding female ducks during the spring and summer, but decreases to less than 10 percent of the diet during the winter. Mallards have ecological relevance as important components of the aquatic food web. As aquatic herbivores, muskrats and mallards help maintain the size and composition of the aquatic vegetation community.

Muskrats and mallards are susceptible to exposure to and toxicity from COPECs in surface water and aquatic vegetation. The potential for exposure to contaminants is high because they consume aquatic and sediment-dwelling plants that can accumulate high concentrations of some chemicals from water. In addition, these species can have further exposure via ingestion of contaminants in surface water that they use for a drinking water source. Since there is a potential difference in the toxicological sensitivity of mammals and birds exposed to the same COPECs, one mammal and one bird were examined for exposure to water, sediment, and the aquatic food chain. Dietary toxicity benchmarks for many inorganic and some organic substances are available for mammals and birds.

As referenced in Section 8.2.3, management goals as set forth by the INRMP (AMEC, 2008) help protect these species (e.g., Goal 1, manage natural resources in a manner that is compatible with and supports the military mission while complying with applicable federal and state laws and U.S. Army regulations and policies; and Goal 6, manage wildlife resources in a manner compatible with the military mission and within the limits of the natural habitat). Both species are susceptible to COPECs, especially via ingestion exposure, and they have ecological relevance. Thus, there is sufficient justification to warrant the muskrat and mallard as candidate receptors for the Erie Burning Grounds MRS.

Semi-Aquatic Carnivores

Exposure of predators to aquatic biota is applicable to the Erie Burning Grounds MRS because persistent, bioaccumulative, and toxic (PBT) chemicals are present at the MRS. There is also suitable habitat for these receptors at the MRS. Exposure evaluation for piscivores (fish-eating predators) is required by Ohio EPA (2008) when a PBT compound or a COPEC with no screening benchmark is found in surface water or sediment. Mink and great blue herons are semi-aquatic carnivores selected to represent mammalian and bird receptors for the fish-eating predator exposure class. These semi-aquatic carnivores feed predominantly in and along the riparian zone along the banks of streams. Both species have ecological relevance because they are important components of the aquatic food web representing the top predators. As top predators, they help limit the population size for some aquatic and some sediment-dwelling biota communities.

Both species are susceptible to exposure to, and toxicity from, COPECs in surface water, aquatic biota, and sediment-dwelling biota. The potential for exposure to COPECs is high for these two species because they consume fish, which can accumulate high concentrations of some chemicals from water. In addition, both species can have further exposure via ingestion of COPECs in surface water that is used for a drinking water source. Dietary toxicity benchmarks are available for mammals and birds. There can be differences in toxicological sensitivity between mammals and birds exposed to the same COPEC, so both species are appropriate for consideration.

As referenced in Section 8.2.3, management goals as set forth by the INRMP (AMEC, 2008) help protect these species (e.g., Goal 1, manage natural resources in a manner that is compatible with and supports the military mission while complying with applicable federal and state laws and U.S. Army regulations and policies; and Goal 6, manage wildlife resources in a manner compatible with the military mission and within the limits of the natural habitat). Both the mink and heron species are susceptible to contamination, especially via ingestion exposure routes, and they have ecological relevance as predators. Thus, there is sufficient justification to warrant evaluating these two receptors as candidate receptors for the Erie Burning Grounds MRS.

8.3.1.9 Relevant and Complete Exposure Pathways

Relevant and complete exposure pathways for the ecological receptors at the Erie Burning Grounds MRS were described in the previous sections. There are relevant and complete exposure pathways for various ecological receptors including aquatic biota (aquatic and sediment-dwelling organisms), aquatic herbivores, and semi-aquatic carnivores. Thus, these categories of receptors could be exposed to COPECs in surface water and wet sediment at the Erie Burning Grounds 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-RVAAP–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 (e.g., the 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 aquatic habitat is being evaluated, there is only one general management goal for this MRS. However, the assessment endpoints differ between the general screen and the MRS-specific analysis screen. The general management goal for the ERA is to protect aquatic 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 (e.g., 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 threatened, endangered, and rare species are not a concern at the Erie Burning Grounds MRS, potential impacts to populations is the appropriate criterion for consideration at the MRS.

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 the 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 aquatic 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 aquatic 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 aquatic 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., NFA, 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 aquatic receptors such as benthic invertebrates and aquatic 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 aquatic populations, communities, and ecosystems.

The assessment endpoints are evaluated through the use of measurement endpoints. 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

Table 8-1
General Management Goals, Ecological Assessment Endpoints, Measures of Effect, and Decision Rules Identified for a Level II Screening

General Management Goals	Assessment Endpoint	Measures of Effect	Decision Rule
General Management Goal 1: The protection of aquatic populations, communities, and ecosystems	Assessment Endpoint 1: Survival, reproduction, and diversity of benthic invertebrate communities, as well as low enough concentrations of contaminants in their tissues so that higher trophic level animals that consume them are not at risk Receptor: benthic invertebrates	Measures of Effect 1: Measured concentration of contaminants in sediment and sediment toxicity thresholds, e.g., consensus-based TECs, EPA Region 5 ESLs, and Ohio EPA sediment reference values	Decision Rule for Assessment Endpoint 1: If HQs based on ratios of COPEC RME concentrations in sediment-to-sediment toxicity benchmarks are less than or equal to 1, then Assessment Endpoint 1 is met and sediment-dwelling organisms 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 MRS-usage-related COPECs in applicable media, or further investigation such as a Level III and Level IV Field Baseline.
	Assessment Endpoint 2: Growth, survival, and reproduction of aquatic biota (including fish and invertebrates) Receptor: aquatic biota	Measures of Effect 2: Measured concentrations of contaminants in surface water and Ohio EPA Chemical-Specific Water Quality Criteria	Decision Rule for Assessment Endpoint 2: If HQs based on ratios of COPEC RME concentrations in surface water to aquatic biota toxicity benchmarks are less than or equal to 1, then 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 MRS-usage-related COPECs in applicable media, or further investigation such as a Level III Baseline and Level IV Field Baseline.

Table 8-1 (continued)
General Management Goals, Ecological Assessment Endpoints, Measures of Effect, and Decision Rules Identified for a Level II Screening

General Management Goals	Assessment Endpoint	Measures of Effect	Decision Rule
General Management Goal 1: The protection of aquatic populations, communities, and ecosystems	Assessment Endpoint 3: Growth, survival, and reproduction of aquatic herbivores that ingest aquatic plants, surface water, and sediment Receptors: muskrats and mallards	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 COPEC RME concentrations in surface water and sediment to dietary limits corresponding to NOAEL TRV benchmarks for adverse effects on aquatic herbivorous mammals and birds are less than or equal to 1, then Assessment Endpoint 3 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 receptors, monitoring of the environment, remediation of any MRS-usage-related COPECs in applicable media, or further investigation such as a Level III and Level IV Field Baseline.
	Assessment Endpoint 4: Growth, survival, and reproduction of riparian carnivorous mammal and bird communities that feed on aquatic organisms Receptors: mink and herons	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 water to dietary limits corresponding to NOAEL TRV benchmarks for adverse effects on riparian carnivores is less than or equal to 1, then Assessment Endpoint 4 has been met and these receptor populations 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 receptors, monitoring of the environment, remediation of any MRS usage related COPECs in applicable media, or further investigation such as a Level III and Level IV Field Baseline.

Table 8-1 (continued)
General Management Goals, Ecological Assessment Endpoints, Measures of Effect, and Decision Rules Identified for a Level II Screening

> denotes greater than.
COPEC denotes chemical of potential ecological concern.
ESL denotes ecological screening level.
HQ denotes hazard quotient.
NOAEL denotes no observed adverse effect level.
RME denotes reasonable maximum exposure.
SMDP denotes scientific management decision point.
TEC denotes threshold effect concentration.
TRV denotes toxicity reference value.

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 concentrations of each chemical in surface water and sediment to ESV benchmarks. Measurement endpoints for the Level III Baseline include the comparison of estimated doses of chemicals in various receptor animals such as muskrats, mallard ducks, mink, and heron to toxicity reference values (TRVs).

In the Level II Screening, maximum detected concentrations in surface water and wet sediment 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 Unified Approach, 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 (RME) 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 are evaluated at this step.

For the Level III Baseline, decision rules for COPECs were obtained from Ohio EPA's 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 (e.g., a muskrat, representing aquatic 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" and the HI 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 samples collected from the Erie Burning Grounds MRS in surface water and sediment. 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 Field Baseline.

8.3.3.1 Data Used in the ERA

The available data set used in the ERA data set includes three surface water samples and six wet sediment samples that were collected during the RI field effort to characterize the nature and extent of SRCs associated with previous activities at the MRS. Soil samples for the RI field effort were collected at depths greater than 1 foot bgs and are not evaluated in the ERA, since most ecological exposure occurs within the top 1 foot of soil.

Data from the surface water and sediment samples were collected from representative locations as discussed in Section 3.2, "MC Characterization." The wet sediment samples were collected from the primary surface water areas at the MRS that include the North Surface Water Basin, the South Surface Water Basin, and the East Surface Water Basin. The wet sediment samples were collected from nonoverlapping ISM spatial areas that covered the three primary surface water areas at the MRS where the surface water samples were collected. The wet sediment samples were collected from the top 0.5 feet (6 inches) of sediment, which represents the sediment depth where most biological activity and exposure occur. Samples included in the ERA data set are identified in **Table 8-2**.

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

Sample Location ID	Sample Date	Sample Area	Depth	Sample Type	Analysis
Surface Water					
EBGsw-001D-0001-SW	5/7/2012	NA	1.5 ft bws	D	Metals[1] Explosives Nitrocellulose SVOCs TOC pH
EBGsw-002D-0001-SW					
EBGsw-003D-0001-SW					
Wet Sediment					
EBGsd-005M-0001-SD	5/8/2012	1.5 acres	0–0.5 ft bss	ISM	Metals[1] Explosives Nitrocellulose SVOCs PCBs TOC pH
EBGsd-006M-0001-SD		3.2 acres			
EBGsd-007M-0001-SD		3.2 acres			
EBGsd-008M-0001-SD		2.8 acres			
EBGsd-009M-0001-SD		2.8 acres			
EBGsd-010M-0001-SD		2.8 acres			

Table 8-2 (continued)
Ecological Risk Assessment Data Use Summary

[1] Metals analysis for surface soil and sediment includes aluminum, antimony, barium, cadmium, chromium (total and hexavalent),copper, iron, lead, mercury, strontium, and zinc.
bss denotes below sediment surface.
bws denotes below water surface.
D denotes discrete (grab) sample.
ft denotes foot/feet.
ID denotes identification.
ISM denotes incremental sampling methodology.
NA denotes not applicable/available.
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. The screen incorporates the same criteria described in Section 4.3.1.3 to eliminate chemicals that are not SRCs (i.e., infrequently detected chemicals, background comparisons, and essential nutrients). Some chemicals were analyzed for a specific purpose other than for identifying MC (i.e., the collection of magnesium concentrations for the purposes of performing a geochemical analysis on chemical concentration ratio data), and are not known or suspected MC-related contaminants at the MRS. With the exceptions of these chemicals, all detected chemicals considered as SRCs associated with the historical activities at the MRS are included in the COPEC screening step. The SRCs identified for the environmental media sampled during the RI field activities included the following:

- **Surface Water**—Barium, chromium (as Cr^{+3}), copper, iron, lead, strontium, and zinc
- **Wet Sediment**—Nitrocellulose, aluminum, antimony, barium, cadmium, chromium (as Cr^{+3}) , Cr^{+6}, copper, iron, lead, mercury, strontium, TNT, 4-amino-2,6-DNT, Aroclor-1254, benzo(b)fluoranthene, benzoic acid, chrysene, dibenzofuran, fluoranthene, phenanthrene, and pyrene

Comparison to Ecological Screening Values

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 water and wet sediment samples were compared with 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. The SRCs that exceed the ESVs, or for which no ESVs are available, were retained as COPECs. The hierarchy for surface water ESVs, in order of preference, was as follows:

1. *Water Quality Standards*, Ohio Administrative Code 3745-1 (Ohio EPA, 2011). (Based on total recoverable metals and assuming a hardness value of 100 mg/L for hardness dependent criteria, iron and nitrate/nitrite criteria are based on protection of agricultural use.)
2. *Region 5 Resource Conservation and Recovery Act Ecological Screening Levels* (EPA, 2003).
3. *Preliminary Remediation Goals for Ecological Endpoints* (Efroymson, et al., 1997a).
4. *ECORISK Database* (Release 2.5) (Los Alamos National Laboratory [LANL], 2010).
5. *Nitroaromatic Munitions Compounds: Environmental Effects and Screening Values* (Talmage et al., 1999).

The hierarchy for the sediment ESVs, in order of preference, was as follows:

1. *Development and Evaluation of Consensus-Based Sediment Quality Guidelines for Freshwater Ecosystems* (MacDonald et al., 2000).
2. *Region 5 Resource Conservation and Recovery Act Ecological Screening Levels* (EPA, 2003).
3. *Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects on Terrestrial Plants* (Efroymson et al., 1997b).
4. *ECORISK Database* (Release 2.5) (LANL, 2010).
5. *Nitroaromatic Munitions Compounds: Environmental Effects and Screening Values* (Talmage et al., 1999).

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

8.3.4 Summary of COPEC Selection

The results of the COPEC screening for the surface water and wet sediment samples evaluated in the ERA are presented in **Tables 8-3** and **8-4**, respectively. The tables present the following information for each medium:

- 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 chemical is a PBT compound
- Determination as to whether the chemical 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. A description and summary of the COPECs identified in the media at the Erie Burning Grounds MRS is presented in the following sections.

8.3.4.1 Surface Water COPEC Selection

Evaluation of the surface water SRCs in **Table 8-3** identified two COPECs: copper and iron. The concentrations for both of these metals exceeded the applicable ESVs and have HQs greater than 1 and are therefore automatically retained as COPECs for further evaluation in surface water.

8.3.4.2 Sediment COPEC Selection

Evaluation of the wet sediment SRCs in **Table 8-4** identified 10 COPECs that consist of 7 metals (antimony, barium, cadmium, copper, iron, lead, and mercury), 1 SVOC (dibenzofuran), 1 explosive compound (nitrocellulose), and 1 PCB compound (Aroclor-1254). Antimony, barium, cadmium, copper, iron, and lead were retained as COPECs since the detected concentrations exceeded the BSVs. Nitrocellulose was retained as a COPEC because it lacked an ESV. Mercury, Aroclor-1254, and dibenzofuran had HQs less than 1, but were retained as COPECs because they are considered PBT compounds with ESVs that may not be protective of food chain effects.

Table 8-3
Statistical Summary and Ecological Screening of Surface Water

Site-Related Chemical	Range of Values, µg/L						Location of MDC	BSV[1] (mg/kg)	ESV[1] (mg/kg)	Below ESV?	HQ	COPEC?[3]
	Detected Concentrations				Reporting Limits							
	Minimum	VQ	Maximum	VQ	Minimum	Maximum						
Barium	24.9	J	54.8	J	1.8	1.8	EBGsw-002D	47.5	220	Yes	0.2	No
Chromium (as Cr^{+3})	1.2	J	2.4	J	4	4	EBGsw-002D	0	86	Yes	0.03	No
Copper	3.7	J	17.1		7	7	EBGsw-002D	7.9	9.3	No	1.8	Yes
Iron	3170	J	8690	J	100	100	EBGsw-002D	2560	1000	No	8.7	Yes
Lead	2	J	6.1		4	4	EBGsw-002D	0	6.4	Yes	0.95	No
Strontium	54.1		83.4		2	2	EBGsw-002D	0	21000	Yes	0.004	No
Zinc	15.1		42.8		10	10	EBGsw-002D	42	120	Yes	0.4	No

[1] *See screening values in **Appendix I**.*

[2] *Chemicals with MDCs lower than the BSV are not considered as SRCs.*

[3] *Selection of COPECs:*

Yes = COPEC exceeds the ESV and BSV.

No = COPEC is not a PBT or site-related and the MDC is less than the ESV (the HQ did not exceed 1, when rounded).

µg/L denotes micrograms per liter.

BSV denotes background 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 result is reported as an estimated value.

MDC denotes maximum detected concentration.

NA denotes not applicable/available.

PBT denotes persistent, bioaccumulative, and toxic.

SRC denotes site-related chemical.

VQ denotes validation qualifier.

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Table 8-4
Statistical Summary and Ecological Screening of Wet Sediment

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?[3]
	Detected Concentrations				Reporting Limits								
	Minimum	VQ	Maximum	VQ	Minimum	Maximum							
Metals													
Aluminum	13,900	J	37,300	J	1.7	4.8	EBGsd-010M	13,900	25,000	No	1.49	No	No(a)
Antimony	0.92	J	6.5		1.1	1.7	EBGsd-009M	0	0.36	No	18	No	Yes
Barium	128	J	418	J	0.071	1	EBGsd-010M	123	150	No	2.8	No	Yes
Cadmium	0.61		2.5		0.057	0.086	EBGsd-008M	0	0.99	No	2.5	No	Yes
Chromium (as Cr^{+3})	11.9		20.2		0.2	0.3	EBGsd-008M	18.1	43.4	Yes	0.5	No	No(a)
Copper	30.9		301		0.57	0.86	EBGsd-009M	27.6	31.6	No	9.5	No	Yes
Iron	8740	J	33,000	J	2.6	36	EBGsd-010M	28,200	20,000	No	1.65	No	Yes
Lead	14.7		72	J	0.36	0.54	EBGsd-010M	27.4	35.8	No	2.0	No	Yes
Mercury	0.025		0.092		0.012	0.017	EBGsd-006M	0.059	0.18	Yes	0.5	Yes	Yes
Strontium	18.4		29.6		0.11	0.17	EBGsd-008M	0	1,700	Yes	0.02	No	No(a)
Explosives and Propellants													
2,4,6-Trinitrotoluene	0.63		0.63		0.5	0.5	EBGsd-009M	NA	420	Yes	0.002	No	No(a)
4-Amino-2,6-Dinitrotoluene	0.13	J	0.13	J	0.3	0.3	EBGsd-009M	NA	9.5	Yes	0.01	No	No(a)
Semivolatile Organic Compounds													
Benzo(b)fluoranthene	0.07	J	0.07	J	0.17	0.25	EBGsd-009M	NA	10.4	Yes	0.01	No	No(a)
Benzoic Acid	0.61	J	0.82	J	4.3	6.3	EBGsd-008M	NA	1.3	Yes	0.6	No	No(a)
Chrysene	0.039	J	0.039	J	0.17	0.25	EBGsd-009M	NA	0.166	Yes	0.2	No	No(a)
Dibenzofuran	0.049	J	0.049	J	0.17	0.25	EBGsd-007M	NA	0.449	Yes	0.1	Yes	Yes
Fluoranthene	0.067	J	0.067	J	0.17	0.25	EBGsd-009M	NA	0.423	Yes	0.2	No	No(a)
Phenanthrene	0.053	J	0.056	J	0.17	0.25	EBGsd-007M	NA	0.204	Yes	0.3	No	No(a)
Pyrene	0.042	J	0.042	J	0.17	0.25	EBGsd-009M	NA	0.195	Yes	0.2	No	No(a)
Polychlorinated Biphenyls													
Aroclor-1254	0.052	J	0.052	J	0.15	0.21	EBGsd-010M	NA	0.0598	Yes	0.9	Yes	Yes
General Chemistry													
Hexavalent Chromium	4.2	J	22		14	20	EBGsd-010M	NA	680	Yes	0.03	Yes	No(b)
Nitrocellulose	100	J	100	J	200	200	EBGsd-010M	NA	NA	NA	NA	No	Yes

Table 8-4 (continued)
Statistical Summary and Ecological Screening of Wet Sediment

[1] *See screening values in* ***Appendix I****.*

[2] *Chemicals with MDCs lower than the BSV are not considered as SRCs.*

[3] *Selection of COPECs:*

Yes = COPEC exceeds the ESV and BSV, or is a PBT pollutant whose ESV is not protective of food chain effects.

No(a) = COPEC is not a PBT or site-related and the MDC is less than the ESV (the HQ did not exceed 1, when rounded).

No(b) = COPEC is a PBT but the MDC is below the ESV that is protective of the food chain effects.

BSV denotes background 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 result is reported as 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.

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, 2010b). 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 the MRS. 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 and 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 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 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 this MRS. 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 (e.g., in solution) and that uses 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 aquatic systems often sorb to sediment, 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, the presence of manganese oxides cause

the rapid oxidation of Cr^{+3} to Cr^{+6} (HSDB, 2013), which, in sediment, is the less toxic form for ecological receptors. This assertion is reflected by an ESV approximately an order of magnitude higher for Cr^{+6} compared with Cr^{+3}. However, if partitioning to the water column occurs, dissolved Cr^{+6} is more toxic to aquatic species than Cr^{+3}, as reflected by a reverse order of magnitude of the ESVs in surface water. The ESVs for surface water and wet sediment are presented in **Appendix I**.

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.

8.3.5.1 Weight of Evidence Discussion for Surface Water Samples

Two metals (copper and iron) were identified as COPECs in surface water samples (**Table 8-3**). **Table 8-5** presents the concentrations of all COPECs by surface water sample. **Table 8-6** presents the HQs associated with each COPEC in each of the samples.

The HQs for neither copper nor iron exceeded the value of 10, with a maximum HQ of 1.8 for copper and 8.7 for iron (**Table 8-6**). Copper is a naturally occurring element, and concentrations of copper in surface water exceeded its BSV and ESV in only one out of three samples. Iron is a commonly occurring metallic element, comprising nearly 5 percent of igneous and sedimentary rocks. It is also essential for plant growth, and is generally considered to be a micronutrient. Although iron exceeded its screening values in all three samples, the detected concentrations were not particularly elevated; the maximum detected concentration exceeded the BSV by a factor of slightly more than 3 (**Table 8-5**). Although it is unlikely that either metal poses a significant threat to ecological receptors, they are retained for additional evaluation under the Level III Baseline.

8.3.5.2 Weight of Evidence Discussion for Wet Sediment Samples

Ten COPECs were identified in the wet sediment samples, including seven metals (antimony, barium, cadmium, copper, iron, lead, and mercury), one explosive compound (nitrocellulose), one PCB (Aroclor-1254), and one SVOC (dibenzofuran), as presented in **Table 8-4**. **Table 8-7** presents the concentrations of all COPECs by sediment sample, and **Table 8-8** presents the HQs associated with each COPEC in the individual samples.

Detected concentrations of chemicals in sediment were relatively low compared to available ESV and BSV values. The HQ values for all COPECs in wet sediment were below 10, except for antimony, which exceeded an HQ of 10 in two samples (**Table 8-8**). Antimony is a naturally occurring element, but no BSV was available for this metal. Of the metals identified as sediment COPECs, only mercury is identified as a PBT compound. Therefore, with the possible exception of mercury, the slightly elevated HQs for most of the metals suggests that local toxic effects to aquatic organisms cannot be discounted, but broader impacts to aquatic and semi-aquatic receptors via food chain effects is unlikely.

Nitrocellulose was identified as a COPEC in sediment because it lacked an ESV. It was detected in one out of six samples at an estimated ("J-qualified") concentration of 100 mg/kg, which was below its reporting limit of 200 mg/kg (**Table 8-4**). Because toxicity benchmark values for this chemical are lacking, its potential to result in adverse ecological effects following exposure is unknown. However, its low detection frequency suggests that it is not a widespread or prevalent contaminant in the MRS, and it is not a PBT chemical. Aroclor-1254 and dibenzofuran were also both detected at estimated ("J-qualified") concentrations in one out of six samples. Both organics were detected at concentrations below their ESV; however, these chemicals are considered to be bioaccumulative, and their ESVs are based on endpoints that may not be protective of food chain effects. Therefore, their potential to bioaccumulate in the food web and result in adverse effects following ingestion of prey items by higher trophic level organisms may not be accounted for in the COPEC screen.

8.3.5.3 Comparison of Results to the Facility-Wide Water Quality Study

The results of the FWBWQS investigation performed at the facility in 2003 by the USACE (2005b), with cooperation from the Ohio EPA, provide an additional source of information on the biological and chemical condition of aquatic streams and ponds in the vicinity of the Erie Burning Grounds MRS. For the "Streams" portion of the study, the FWBWQS evaluated a total of 26 stream sites along major stream and tributaries, ponds, and wetlands throughout the facility at locations that could have been impacted by former facility activities. At each site, biological monitoring based on fish and macroinvertebrate

Table 8-5
Summary of COPECs in Surface Water

				Sample Location:		EBGsw-002D		EBGsw-003D	
				Sample Number:		EBGsw-002D-0001-SW		EBGsw-003D-0001-SW	
				Sample Date:		5/7/2012		5/7/2012	
COPEC	**BSV**	**ESV**	**Units**	**Result**	**VQ**	**Result**	**VQ**	**Result**	**VQ**
Metals									
Copper	7.9	9.3	µg/L	4.7	J	***17.1***		3.7	J
Iron	2,560	1,000	µg/L	***4,580***	***J***	***8,690***	***J***	***3,170***	***J***

Detects in bold exceed the ESV; detects in italics exceed the BSV.
µg/L denotes micrograms per liter.
BSV denotes background screening value.
COPEC denotes chemical of potential ecological concern.
ESV denotes ecological screening value.
J denotes that the result is reported as an estimated value.
VQ denotes validation qualifier.

Table 8-6
Summary of HQs for COPECs in Surface Water

Sample Location:	EBGsw-001D	EBGsw-002D	EBGsw-003D
Sample Number:	EBGsw-001D-0001-SW	EBGsw-002D-0001-SW	EBGsw-003D-0001-SW
Sample Date:	5/7/2012	5/7/2012	5/7/2012
COPEC	HQ	HQ	HQ
Metals			
Copper		1.8	
Iron	4.6	8.7	3.2

Only HQs greater than 1 are shown.

*Only results that exceed the background and ecological screening values in **Table 8-5** are present.*

COPEC denotes chemical of potential ecological concern.

HQ denotes hazard quotient.

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Table 8-7
Summary of COPECs in Wet Sediment

			Sample Location:	**EBGsd-005M**		**EBGsd-006M**		**EBGsd-007M**		**EBGsd-008M**		**EBGsd-009M**		**EBGsd-010M**	
			Sample Number:	**EBGsd-005M-0001-SD**		**EBGsd-006M-0001-SD**		**EBGsd-007M-0001-SD**		**EBGsd-008M-0001-SD**		**EBGsd-009M-0001-SD**		**EBGsd-010M-0001-SD**	
			Sample Date:	**5/8/2012**		**5/8/2012**		**5/8/2012**		**5/8/2012**		**5/8/2012**		**5/8/2012**	
			Sample Depth (feet bss):	**0–0.5**		**0–0.5**		**0–0.5**		**0–0.5**		**0–0.5**		**0–0.5**	
COPEC	**BSV**	**ESV**	**Units**	**Result**	**VQ**	**Result**	**VQ**	**Result**	**VQ**	**Result**	**VQ**				
Metals															
Antimony	0	0.36	mg/kg	ND		**0.92**	**J**	ND		ND		**6.5**		**6.4**	**J**
Barium	123	150	mg/kg	**235**	**J**	**207**	**J**	**226**	**J**	**271**	**J**	**128**	**J**	**418**	**J**
Cadmium	0	0.99	mg/kg	0.61		0.64		**1.5**		**2.5**		0.72		**1.1**	**J**
Copper	27.6	31.6	mg/kg	30.9		**56.2**		**36.8**		**88.4**		**301**		**91.5**	**J**
Iron	28,200	20,000	mg/kg	**8,740**	**J**	**14,900**	**J**	**12,000**	**J**	**12,400**	**J**	**10,600**	**J**	**33,000**	**J**
Lead	27.4	35.8	mg/kg	14.7		27		17.5		22.9		**67.3**		**72**	**J**
Mercury[1]	0.059	0.18	mg/kg	0.04		0.092		0.048		0.08		0.025		0.055	J
Semivolatile Organic Compounds															
Dibenzofuran	NA	0.449	mg/kg	ND		ND		0.049	J	ND		ND		ND	
Polychlorinated Biphenyls															
Aroclor-1254	NA	0.0598	mg/kg	ND		ND		ND		ND		ND		0.052	J
General Chemistry															
Nitrocellulose	NA	NA	mg/kg	ND		ND		ND		ND		ND		**100**	**J**

[1] *All detected concentrations are below the ESVs; COPEC was retained only due to bioaccumulation concerns only.*

Detects in bold exceed the ESV; detects in italics exceed the BSV or indicate that a BSV is not available (metals only).

bss denotes below sediment surface.

BSV denotes background screening value.

COPEC denotes chemical of potential ecological concern.

ESV denotes ecological screening value.

J denotes that the result is reported as an estimated value.

mg/kg denotes milligrams per kilogram.

NA denotes not applicable/available. A screening value was not available for this chemical.

ND denotes not detected.

VQ denotes validation qualifier.

Table 8-8
Summary of HQs for COPECs in Wet Sediment

Sample Location:	EBGsd-005M	EBGsd-006M	EBGsd-007M	EBGsd-008M	EBGsd-009M	EBGsd-010M
Sample Number:	**EBGsd-005M-0001-SD**	**EBGsd-006M-0001-SD**	**EBGsd-007M-0001-SD**	**EBGsd-008M-0001-SD**	**EBGsd-009M-0001-SD**	**EBGsd-010M-0001-SD**
Sample Date:	**5/8/2012**	**5/8/2012**	**5/8/2012**	**5/8/2012**	**5/8/2012**	**5/8/2012**
Sample Depth (feet bss):	**0–0.5**	**0–0.5**	**0–0.5**	**0–0.5**	**0–0.5**	**0–0.5**
COPEC	**HQ**	**HQ**	**HQ**	**HQ**	**HQ**	**HQ**
Metals						
Antimony		2.6			**18**	**18**
Barium	1.6	1.4	1.5	1.8		2.8
Cadmium			1.5	2.5		1.1
Copper		1.8	1.2	2.8	9.5	2.9
Iron						1.7
Lead					1.9	2.0
Mercury[1]						
Semivolatile Organic Compounds						
Dibenzofuran						
Polychlorinated Biphenyls						
Aroclor-1254						
General Chemistry						
Nitrocellulose						

[1] *All detected concentrations are below the ESVs; COPEC was retained only due to bioaccumulation concerns only.*

Only HQs greater than 1.0 are shown. Cells in bold exceed an HQ of 10.

*Only results that exceed the background and ecological screening values in **Table 8-7** are present.*

bss denotes below sediment surface.

COPEC denotes chemical of potential ecological concern.

HQ denotes hazard quotient.

community assessments were completed. Surface water and sediment samples were also collected and analyzed for chemical contaminants. The FWBWQS investigation included four sampling locations on the tributary to the West Branch of the Mahoning River that were downstream of the Erie Burning Grounds MRS. The main impacts on this stream were identified during the 2003 FWBWQS to have originated from the Erie Burning Grounds and Load Line #1. No other areas from the main production at the facility were identified to have affected this stream.

Chemical data from surface water and sediment samples collected from the tributary to the West Branch of the Mahoning River during the FWBWQS indicated that water quality was considered good, with some minor enrichment noted. In surface water, with the exception of two chemicals detected at low concentrations, all organic parameters tested were reported as not detected. Metals and nutrients were reported at concentrations below water quality criteria. With the exception of arsenic, all organic and inorganic compounds in sediment were detected at concentrations protective of limited resource water use; arsenic was detected at two sample locations along the tributary at concentrations exceeding its threshold effect concentration. Impairment of the biological community was noted at the sampling location closest to the Erie Burning Grounds MRS (approximately 2,000 feet downstream at the intersection of Smalley Road), but based on sampling results, this impairment was attributed to reduced habitat quality and not sediment or surface water chemical contamination. Thus, the results of the investigation indicated that surface water quality at the Erie Burning Grounds water basins did not appear to impact the biological community (USACE, 2005b).

For the “Ponds” portion of the study, ponds from 11 various sites within the facility were sampled, including four reference ponds that were not suspected of being impacted by previous munitions activities. One of the sites in the “Ponds” study included the surface water basins at the Erie Burning Grounds. One surface water sample and six ISM sediment samples were collected at the Erie Burning Grounds and were analyzed for TAL metals, SVOCs, PCBs, pesticides, explosive compounds, percent solids, cyanide, ammonia, nitrate, and phosphorus. One surface water sample was collected from the North Surface Water Basin only. Three ISM sediment samples were collected at the North Surface Water Basin. Three ISM sediment samples were collected at the South Surface Water Basin. Biological studies performed for the FWBWQS included macroinvertebrate community assessments at all 11 ponds, and fish community assessments at 8 of the ponds. Physical habitat was also evaluated at the eight ponds that were sampled for fish.

Surface water quality in the Erie Burning Grounds MRS water basins slightly exceeded several chronic water quality standards, but did not appear to impact the biological community. Water quality conditions were comparable to reference ponds. Sediment sampling identified moderate levels of contamination, including various metals (antimony,

chromium, copper, lead, mercury, nickel, silver, and zinc) and four PAH compounds that were present at levels above ecological screening and reference values. Also, the Erie Burning Grounds MRS surface water basins were the only ponds evaluated that had detectable levels of explosive compounds (TNT, 2-amino-4,6-DNT, and 4-amino-2,6-DNT) in sediment. No sediment screening values were available for these compounds at the time of the FWBWQS; however, comparison to the ESVs used in this RI indicates that the maximum detected concentration for TNT (21 mg/kg) is below the ESV of 400 mg/kg. There are still no ESVs available for either 2-amino-4,6-DNT and 4-amino-2,6-DNT.

Fish communities were not studied at the Erie Burning Grounds MRS surface water basins due to shallow water conditions. The macroinvertebrate community at the Erie Burning Grounds MRS surface water basin was substantially different from reference sites, which may be the result of differing habitat and vegetation parameters, but sediment contamination could not be eliminated as a potential contributor to these differences. It should be noted that the difference in macroinvertebrate community between the Erie Burning Grounds MRS surface water basins and reference wetlands was within the range of differences observed between the reference sites themselves, suggesting that other factors besides the presence or absence of contamination (such as the different plant communities and the soft anoxic sediments at the Erie Burning Grounds MRS) may have resulted in relatively large observed differences in macroinvertebrate communities between ponds.

The findings of the FWBWQS indicate that is unlikely that aquatic receptors in water bodies in the vicinity of the Erie Burning Grounds MRS are affected by contaminants that may have been released from this MRS. Although some potential deviations from expected biological community parameters were identified in the Erie Burning Grounds MRS surface water basins and downgradient streams, these impacts were likely caused by factors other than the presence of chemical contamination, particularly for the downgradient streams. Although other factors may play a role, and the magnitude of differences between the Erie Burning Grounds MRS surface water basins and reference pond communities overlapped with intra-reference pond differences, contamination could not be eliminated as a possible explanation for the differences in biological communities from reference communities in the Erie Burning Grounds MRS surface water basins.

The findings from the FWBWQS add additional support to the weight of evidence discussions for surface water (Section 8.3.5.1) and wet sediment (Section 8.3.5.2) regarding the low potential for adverse impacts to aquatic populations as a result of exposure to chemical contamination in on-site water bodies. It should be noted that the FWBWQS did not evaluate potential bioaccumulation effects in upper trophic level receptors.

8.3.6 Level II Screening Conclusion and Recommendations

Several SRCs detected in the surface water and wet sediment samples collected at the Erie Burning Grounds MRS were detected at concentrations that exceed ESVs (as well as BSVs in metals) in multiple samples. The two surface water COPECs (copper and iron) and most of the inorganic wet sediment COPECs (antimony, barium, cadmium, copper, iron, and lead) are not PBT compounds and, with the exception of antimony in sediment, had HQs below 10 in all samples. Antimony was detected in two wet sediment samples at concentrations that resulted in HQs of 18. However, a BSV is not available for antimony, and it is possible the detected concentrations are naturally occurring. Although it is unlikely that these inorganics are present at concentrations that would significantly affect ecological receptor populations and communities, localized impacts to aquatic life in wet sediment and surface water associated with these detected inorganics cannot be entirely discounted. Therefore, it is recommended that the copper and iron in surface water and antimony, barium, cadmium, copper, iron, and lead concentrations in wet sediment be retained in the Level III Baseline for evaluation of potential hazard to ecological receptors resulting from direct contact pathways only (i.e., ingestion of sediment and/or surface water).

Three chemicals in wet sediment, including one inorganic (mercury) and two organic (Aroclor-1254 and dibenzofuran) chemicals were detected at concentrations below their ESVs; however, their potential to bioaccumulate in the food chain could result in biomagnification in lower trophic level organisms, resulting in concentrations in prey items consumed by higher trophic level organisms that are much greater than the concentrations observed in the source medium (sediment). Therefore, to evaluate the potential hazard associated with food chain effects, mercury, Aroclor-1254, and dibenzofuran are proposed for evaluation under a Level III Baseline.

Nitrocellulose was detected in a single wet sediment sample at an estimated concentration. Although the lack of an ESV for this chemical results in some uncertainty regarding its potential toxicity, its limited distribution and relatively low detected concentration reduces concern regarding its potential to affect ecological receptors. Also, propellant compounds such as nitrocellulose are unlikely to bioaccumulate in the food chain; therefore, this chemical is not recommended for further evaluation in the ERA.

Based on the results of the FWBWQS (USACE, 2005b) it was determined that it was unlikely that chemical contamination associated with the Erie Burning Grounds MRS has impacted biological and water quality in downgradient surface water bodies. Also, although differences in macroinvertebrate communities between the Erie Burning Grounds MRS water basins and reference pond communities were noted, the study concluded that factors other than chemical contamination could have resulted in the observed differences between the

Erie Burning Grounds MRS water basins and associated wetlands and the reference ponds (although chemical contamination could not be ruled out as a possible contributor to the observed differences). Impacts to upper trophic level receptors from bioaccumulative chemicals magnifying in the food chain was not assessed in the FWBWQS. A Level III Baseline may provide additional assurance that impacts to local populations of predatory receptors, in addition to organisms dwelling in the water bodies themselves, are also unexpected.

Based on the COPEC evaluation process presented in the ERA and the subsequent weight of evidence discussion, the COPEC and potential exposure pathways recommended for evaluation in a Level III Baseline are presented in **Table 8-9**.

Table 8-9
Summary of COPECs Recommended for Level III Baseline Evaluation

COPEC	Potential Exposure Pathways	
	Direct Contact?[1]	Food Chain Effects?
Surface Water		
Copper	Yes	No
Iron	Yes	No
Sediment		
Antimony	Yes	No
Barium	Yes	No
Cadmium	Yes	No
Copper	Yes	No
Iron	Yes	No
Lead	Yes	No
Mercury	Yes	Yes
Aroclor-1254	Yes	Yes
Dibenzofuran	Yes	Yes

[1] *Direct contact refers to direct ingestion of surface water or sediment.*

8.4 Level III Baseline Evaluation

The objective of a Level III Baseline evaluation is to estimate hazards to representative endpoint species using a deterministic risk assessment approach (Ohio EPA, 2008). This evaluation is performed in accordance with the ecological CSM presented during the Level II Screening process (Section 8.3), modified based on recommendations from the Level II Screening. According to the recommendations from the Level II Screening, the scope of the Level III Baseline is limited to direct ingestion exposure for all COPECs in surface water and

wet sediment from the Level II Screening, and indirect food chain exposure for the COPECs identified in wet sediment whose potential for significant food chain effects could not be adequately assessed during Level II Screening (i.e., mercury, Aroclor-1254, and dibenzofuran). A refined Level III CSM reflecting this scope is presented in **Figure 8-3**.

8.4.1 Exposure Assessment

An estimate of the nature, extent, and magnitude of potential exposure of assessment receptors to COPECs that are present at or migrating from the MRS is presented in this section, considering both current and reasonably plausible future use of the MRS. Exposure characterization is critical in further evaluating the risk of chemicals identified as COPECs during the screening process. The exposure assessment has been conducted by linking the magnitude (concentration) and distribution (locations) of the chemicals detected in the media sampled during the investigation, evaluating pathways by which chemicals may be transported through the environment, and determining the points at which organisms found in the study area may contact chemicals.

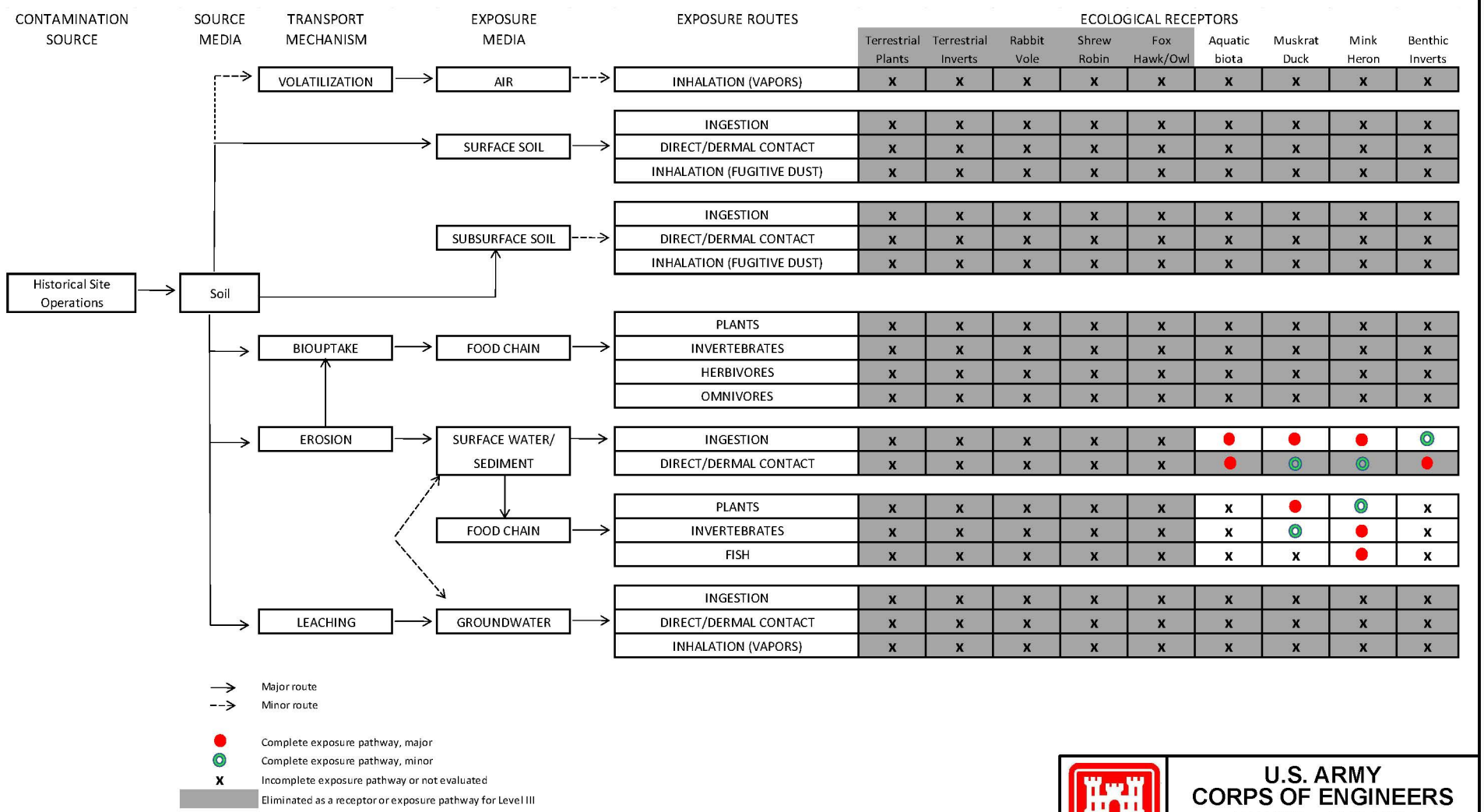
8.4.1.1 Exposure Analysis

An exposure analysis was performed that combines the spatial and temporal distribution of the ecological receptors with those of the COPECs to evaluate exposure. The exposure analysis focuses on the bioavailable chemicals and the means by which the ecological receptors are exposed (e.g., exposure pathways). The focus of the analysis is dependent on the assessment receptors being evaluated as well as the assessment and measurement endpoints.

Exposure pathways consist of four primary components: (1) source and mechanism of chemical release, (2) transport medium, (3) potential receptors, and (4) exposure route. A chemical may also be transferred between several intermediate media before reaching the potential receptor. All of these components are described in the ecological CSM (Section 8.3.1). If any of these components is not complete, then chemicals in the affected media do not constitute an environmental risk at the MRS. The major fate and transport properties associated with typical MRS chemicals are described in subsequent sections. These properties directly affect a chemical's behavior in each of the exposure pathway components.

Ecological routes of exposure for biota may be direct (bioconcentration) or through the food web via the consumption of contaminated organisms (biomagnification). Direct exposure routes include dermal contact, absorption, inhalation, and ingestion. Examples of direct exposure include animals incidentally ingesting contaminated sediment (e.g., during foraging activities), animals ingesting surface water, plants absorbing chemicals by uptake from contaminated sediment or soil, and the dermal contact of aquatic organisms with

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FIGURE 8-3 REFINED LEVEL III CONCEPTUAL SITE MODEL

contaminated surface water or sediment. Given the scarcity of available data for wildlife dermal and inhalation exposure pathways, potential risk from these pathways is not estimated in the ERA. For aquatic species that spend a majority of their life cycles immersed in sediment and/or surface water, direct contact can be a significant exposure route. However, this exposure route was previously evaluated during the Level II Screening, which compared concentrations in surface water and sediment to ESVs that are protective of direct contact pathways for aquatic and benthic communities. Therefore, this exposure route is not evaluated again in the Level III Baseline.

Food web exposure can occur when aquatic fauna consume contaminated biota. Examples of food web exposure include animals at higher trophic levels consuming plants or animals lower trophic level animals that bioaccumulate chemicals. This indirect exposure route is the primary focus of the Level III Baseline.

Bioavailability is an important chemical characteristic that influences the degree of chemical-receptor interaction. The bioavailability of a chemical refers to the degree to which a receptor is able to absorb a chemical from the environmental medium. A chemical's bioavailability is a function of several physical and chemical factors such as grain size, organic carbon content, water hardness, and pH. Unless MRS-specific data are available, bioavailability is conservatively assumed to be 100 percent.

Daily doses of COPECs for vertebrate receptors were calculated using standard exposure algorithms. These algorithms incorporate species-specific natural history parameters (i.e., feeding rates, water ingestion rates, dietary composition, etc.) and also use MRS-specific area use factors, as follows:

$$Total\ Daily\ Dose = \left(\frac{\left(\left[Sed_j * IR_{sed} \right] + \left[Water_j * IR_{water} \right] + \left[\sum_{i=1}^{N} B_{ji} * P_i * IR_{food} \right] \right)}{Body\ Weight} \right) * AUF \quad \text{Eq. 8.1}$$

Where:

Sed_j = Concentration of COPEC "j" in sediment
$Water_j$ = Concentration of COPEC "j" in surface water
B_{ji} = Concentration of COPEC "j" in food type "i"
IR_{soil} = Sediment ingestion rate
IR_{water} = Surface water ingestion rate
IR_{food} = Food ingestion rate
P_i = Proportion of food type in receptor diet
AUF = Area use factor (equal to area of EU/home range of receptor)
Body Weight = Body weight of receptor.

Feeding and drinking rates for the identified MRS receptors have been established and are described in the *RVAAP Facility-Wide Ecological Risk Assessment Work Plan* (USACE, 2003c). Species-specific parameters not included in this work plan were obtained from Ohio EPA (2008) guidance. To estimate dose associated with ingested food items, concentrations of COPECs in the vegetation or prey in the species' diet is estimated using bioaccumulation factors (BAFs) (sometimes referred to as bioconcentration factors). BAFs are based on regression models or scalar variables that reflect the potential for the COPECs to be present in food items at concentrations different from (usually greater than) the ambient environment. Differences in concentration are due to chemical-specific properties of the COPEC that affect its tendency to bioaccumulate in tissue, balanced by the innate ability of the species to regulate body burden levels of the chemical via metabolic and excretory processes.

Selection of appropriate BAFs is a critical component to food chain modeling. General approaches for BAF selection have been discussed in Sample and Suter (1994), EPA (1999), U.S. Army Environmental Center (2005), and EPA (2008b). An approach that is consistent with these sources was followed in the selection of BAFs for the facility. The general hierarchy for selection of BAFs based on types of sources is as follows:

1. Use of regression equations derived from paired field- or laboratory-based measurements
2. Ratio-derived BAFs developed based on paired data of tissue concentrations compared to media concentrations where the BAF is equal to the tissue concentration divided by the concentration in the abiotic medium
3. Modeled equilibrium partitioning-derived BAFs based on physical or chemical characteristics
4. Assumptions based on values common to chemical class

Both the U.S. Army Environmental Center (2005) and EPA (1999) support the use of ratio BAFs in preference to equilibrium partitioning-based BAFs, which are typically calculated based on factors such as log K_{ow} values, fraction of organic carbon in soil or sediment, or percent of lipids in invertebrates. Other general recommendations provided in EPA, 2008b were also followed, including the following:

- For selection of ratio-based BAFs, median values are selected over maximum or other high-end BAFs.
- BAFs for PAH accumulation into mammalian prey are assumed to equal zero due to the high metabolic breakdown of PAHs in mammals. Because PAHs were not

of concern in the ERA, this recommendation was moot for the Erie Burning Grounds MRS.

Regression equations used to calculate prey tissue concentrations of a specific chemical typically take the following general equation form:

$$\ln (C_{food}) = \text{slope value} \times \ln (C_{abiotic_media}) + \text{intercept value} \quad \text{Eq. 8.2}$$

Where:

C_{food} = Concentration of chemical in food type
$C_{abiotic_media}$ = Concentration of chemical in abiotic media.

Ratio BAFs can be generally presented as follows:

$$C_{food} = BAF \times (C_{abiotic_media}) \quad \text{Eq. 8.3}$$

Where:

C_{food} = Concentration of chemical in food type
$C_{abiotic_media}$ = Concentration of chemical in abiotic media
BAF = Bioaccumulation factor

BAFs calculated based on equilibrium partitioning typically use a physical constant of a chemical to generate a BAF. A generalized form for this calculation would be as follows:

$$\text{Log (BAF)} = \text{slope value} \times \text{Log } (K_{ow}) + \text{intercept value} \quad \text{Eq. 8.4}$$

Where:

Log (BAF) = Log of the BAF for chemical in food type
K_{ow} = Octanol-water partition coefficient.

BAFs calculated based on equilibrium partitioning are applied in the same fashion as ratio-based BAFs to generate a tissue concentration value. K_{ow} values needed for BAFs based on equilibrium partitioning are obtained using the K_{ow} WIN application in EPA's EPI Suite software (http://www.epa.gov/oppt/exposure/pubs/episuite.htm).

Finally, where ratio-based BAFs are missing and where no equilibrium partitioning method has been developed for calculating BAFs, other methods, such as using BAFs for chemicals in the same class as surrogates, may be presented for establishing ratio-based BAFs.

Because few studies are available that assess uptake of chemicals from sediment to aquatic plants, uptake was assumed to be similar to terrestrial systems, and soil-to-plant BAFs were used for sediment-to-aquatic plant BAFs. The BAFs used for the sediment COPECs that are evaluated for food chain effects are presented in **Table 8-10**.

Table 8-10
Bioaccumulation Factors or Regression Equations Used to Model Uptake

COPEC	Sediment-to-Plant BAF	Source	Sediment to Benthic Invertebrates BAF	Source
Metals				
Mercury	ln (AGP)=0.54(ln[sed])-1.00	Efroymson et al., 1997c	1.136	See Footnote a
Semivolatile Organic Compounds				
Dibenzofuran	0.084	Travis and Arms K_{ow} Regression Equation	78.8	See Footnote c
Polychlorinated Biphenyls				
Aroclor-1254	0.0036	Travis and Arms K_{ow} Regression Equation	3.2	See Footnote b

[a] *Median uptake factor for methyl mercury from Bechtel (1998), based on empirical data.*

[b] *From EPA (1999), BAF based on empirical data.*

[c] *From EPA (1999), BAF based on the following regression equation for organics: log BAF = 0.819 × log K_{ow} - 1.146.*

K_{ow} values obtained from EPA Estimation Programs Interface Suite Version 4.0, http://www.epa.gov/oppt/exposure/pubs/episuitedl.htm.

AGP denotes aboveground plant tissue concentration.

BAF denotes bioaccumulation factor.

COPEC denotes chemical of potential ecological concern.

EPA denotes United States Environmental Protection Agency.

K_{ow} denotes octanol/water partition coefficient.

8.4.1.2 Exposure Point Concentration

Ideally, the mean concentration that a receptor is exposed to on a daily basis would be used to calculate the intake dose that a receptor is exposed to for a given chemical. Because of the uncertainty associated with characterizing contamination in environmental media, a RME concentration is appropriately used as the EPC. The 95-percent UCL of the mean usually serves as an appropriate RME EPC in the Level III Baseline.

The EPA ProUCL software (EPA, 2011) was used to calculate UCLs for the data sets of all chemicals represented by at least five samples. The MDL data were available for all samples. The MDL is the minimum concentration of a substance that can be measured and reported with 99-percent confidence that the analyte concentration is detected. Thus, because it represents the lowest detectable concentration of a specific chemical by the analytical method employed, the MDL provides a more accurate maximum potential concentration for nondetected chemicals than other values (e.g., the reporting limit or half the reporting limit). Therefore, the MDL was used as the ProUCL input concentration for nondetects.

ProUCL generates a variety of UCL estimates for each data set. Generally, the results of one or two (sometimes more) of the UCL estimates are recommended. This recommendation is based on a variety of factors, including the statistical distribution (i.e., normal, lognormal, gamma, or nonparametric), number of nondetects, size of the data set, and skewness. Occasionally, ProUCL will recommend the 97.5- or 99-percent UCL on the arithmetic mean estimated by the Chebyshev method. In these cases, the 95-percent UCL estimated by the Chebyshev method was selected as the EPC because this is more consistent with the intent of the RME paradigm as defined by EPA (1989 and 2002). In situations where two 95-percent UCLs using different methods (e.g., Student's-t and Modified-t) are recommended by ProUCL, the higher (i.e., more conservative) of the two values was selected as the EPC.

The UCL generated by ProUCL or the maximum detected concentration, whichever is smaller, was selected as the EPC, and this value is understood to represent a conservative estimate of average for use in the ERA. Unusually high detected values were retained in the calculation of the UCL concentration. Inclusion of these high values increases the statistical variability and the overall conservativeness of the risk estimate. Because fewer than five samples were collected in the surface water data set, the calculation of a UCL is not recommended, and the maximum detected concentration is used as the EPC for surface water COPECs instead.

8.4.1.3 Aquatic Ecological Receptor Species

The exposed ecological receptors for the Level III Baseline were identified in the *RVAAP Facility-Wide Ecological Risk Assessment Work Plan* (USACE, 2003c) based on three criteria, including their ecological relevance; susceptibility to the chemicals likely to be

found at the MRS; and consistency with management goals. Based on these criteria, the following aquatic and semi-aquatic receptors were selected for evaluation, representing specific taxonomic and foraging guilds likely to be found at the MRS:

- **Aquatic Life**—Fish, amphibians, and invertebrates that spend a majority of their life cycles in the water column
- **Benthic Invertebrates**
- **Mammalian Herbivores**—Muskrat
- **Avian Herbivores**—Mallard
- **Mammalian Carnivores**—Mink
- **Avian Carnivores**—Great Blue Heron

These receptors are likely to be present at the facility and the MRS and were selected consistent with Ohio EPA guidance (2008). Evaluation of these receptors addresses the assessment endpoints presented in Level II Screening evaluation (Section 8.3.2). Additional descriptions of these receptors and justification for their selection are presented in the *RVAAP Facility-Wide Ecological Risk Assessment Work Plan* (USACE, 2003c).

For the Level III Baseline, hazards for aquatic plants and invertebrates are not quantitatively assessed, as the protection of plants and invertebrates, as well as other biota that is included as "aquatic life," was previously addressed by the comparisons to ESVs in the Level II Screening evaluation. Therefore, additional quantification of hazard for aquatic life and benthic invertebrate receptors is not performed in the Level III Baseline. Exposure parameters used for the mink and great blue heron are presented in the *RVAAP Facility-Wide Ecological Risk Assessment Work Plan* (USACE, 2003c). Exposure parameters used for the muskrat and mallard are presented in the Ohio EPA guidance (2008). Receptor parameters and exposure values for these four food chain receptors are summarized in **Table 8-11**.

It is noted that the mink and great blue heron may be assumed to have a diet that consists 100 percent of fish (Ohio EPA, 2008 and USACE, 2003c). However, sediment-dwelling invertebrates also comprise a significant portion of their diet (EPA, 1993), and no other receptor was selected for evaluating the sediment-to-benthic invertebrate pathway in the food chain modeling. Therefore, to ensure that this pathway is represented in the Level III Baseline, the benthic invertebrates are assumed to comprise 25 percent of the diet for both the mink and great blue heron.

Table 8-11
Exposure Parameters for Target Ecological Species

Ecological Receptor Species	Class/Order	Average Body Weight[1] (kg)	Average Home Range[1] (hectares)	Dietary Intake[1] (kg[dw]/day)	Soil/Sed. Intake (kg[dw]/day)	Water Intake[1] (L/day)	Temporal Use Factor	Trophic Level	Dietary Composition[1] (percent)
Muskrat (*Ondatra zibethicus*)	Mammalia/Rodentia	1.174	0.13	0.3522	0	1.15	1	Herbivore	Aquatic Plants: 100%
Mallard (*Anas platyrhyncos*)	Aves/Anseriformes	1.162	435	0.073	0	0.066	1	Herbivore	Aquatic Plants: 100%
Mink (*Mustela vison*)	Mammalia/Carnivora	1.02	2.24	0.163	0	0.08	1	Carnivore	Fish: 75% Benthic Invertebrates: 25%
Great Blue Heron (*Ardea herodias*)	Aves/Ciconiiformes	2.336	0.6	0.42	0	0.105	1	Carnivore	Fish: 75% Benthic Invertebrates: 25%

[1] *Obtained from USACE, 2003c,* RVAAP Facility Wide Ecological Risk Work Plan, *April.*

dw denotes dry weight.

kg denotes kilogram(s).

L denotes liter.

RVAAP denotes Ravenna Army Ammunition Plant.

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8.4.1.4 Exposure Characterization Summary

The estimated chemical intakes for each exposed receptor group under each exposure pathway and scenario are presented in the risk characterization spreadsheets in **Appendix J**. These intake estimates are combined with the COPEC toxicity values, discussed in the following section, to derive estimates and characterize potential ecological risk.

8.4.2 Toxicity Assessment

The toxicity assessment primarily describes the development of TRVs. The TRVs provide a reference point for the comparison of toxicological effects upon exposure to a chemical and are compared against calculated receptor doses. The TRVs are not used for evaluating plants or invertebrates, which are evaluated in terms of potential hazards at a community scale rather than a species scale. The TRVs focusing on the growth, survival, and reproduction of species and/or populations have been developed for the ERA. Empirical data are available for the specific receptor-endpoint combinations in some instances. The no observed adverse effect level (NOAEL) is a dose of each COPEC that produced no known adverse effects in the test species. The NOAEL was judged to be an appropriate toxicological endpoint since it would provide the greatest degree of protection to the receptor species. In addition, the lowest observed adverse effect level (LOAEL) was used as a point of comparison for risk management decisions.

The LOAEL is the lowest concentration in a laboratory test setting that is associated with an effect, and is considered to be a more realistic (although still conservative) endpoint (SAIC, 2008). In instances where data are unavailable for a MRS-associated COPEC, toxicological information for surrogate chemicals or groups of chemical were used. Safety factors were used to adjust for these differences and extrapolate risks to the MRS's receptors at the NOAEL and/or LOAEL endpoint. This process is described in the following paragraphs.

Because the measurement endpoint ranges from the NOAEL to the LOAEL, preference is given to chronic studies noting concentrations at which no adverse effects were observed and those for which the lowest concentrations associated with adverse effects were observed. Where data are unavailable for the exposure of a receptor to a COPEC, data for a surrogate chemical or group of chemicals may be considered.

TRVs are developed separately for birds and mammals, as it is inappropriate to apply TRVs across classes (e.g., a TRV for a bird species may not be used to estimate hazard for a mammal species) (EPA, 1997). In instances where TRVs for multiple avian or mammalian species are supported for a given chemical, the TRV for the most similar species to the measurement receptor based on feeding strategy and physiological attributes were used. For example, a mammalian TRV for mercury based on both a mink and mouse test species is available. The mink TRV was used in the food chain model to evaluate the mink receptor,

while the mouse TRV was used for the muskrat due to the closer taxonomic similarity and foraging patterns between these two species. Two avian TRVs were available for lead. The TRV based on the quail test species was used for the mallard, while the TRV based on a kestrel was used to evaluate the great blue heron.

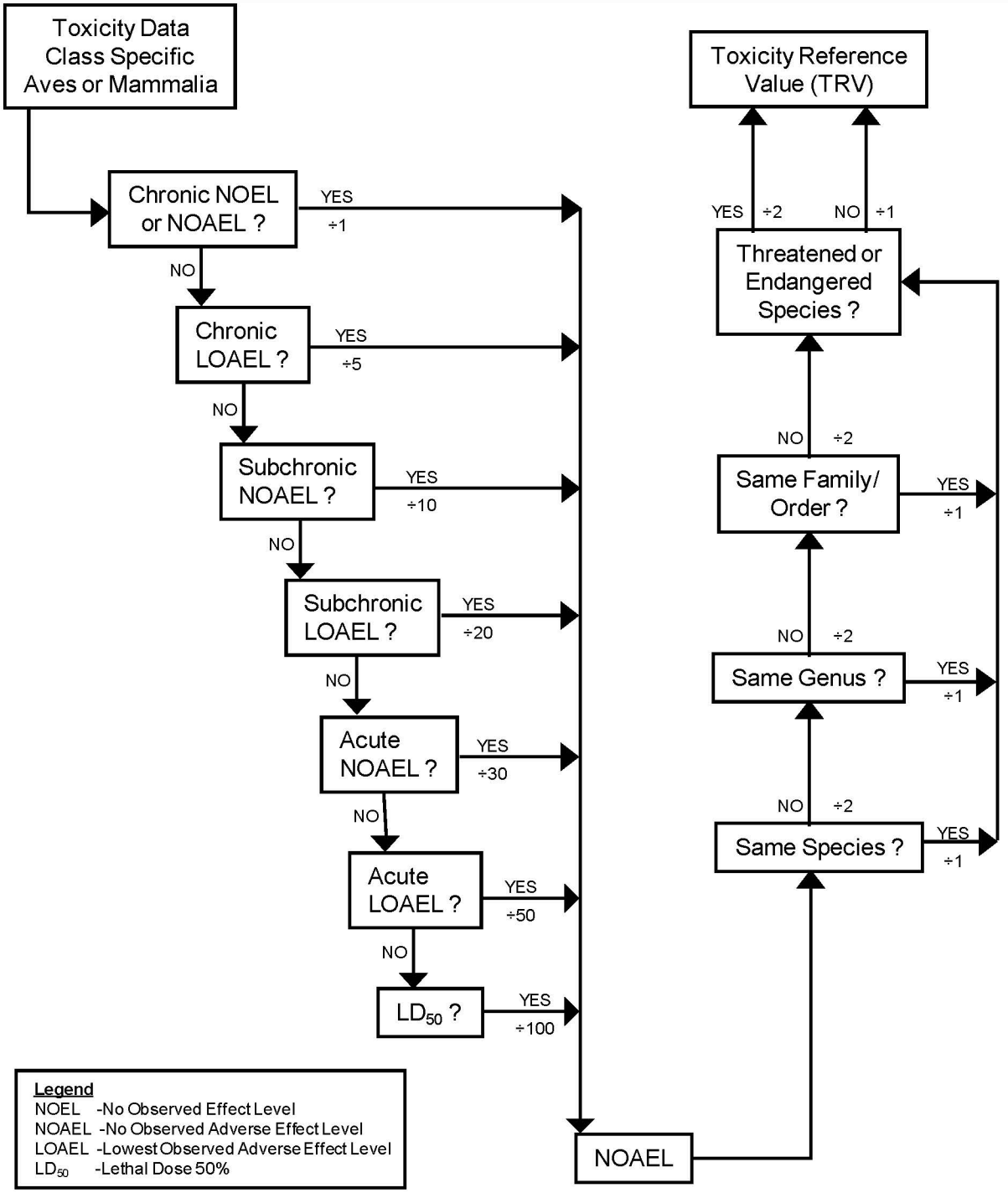
TRVs represent NOAELs and LOAELs with the safety factors presented in Wentsel, et al. (1996), applied to toxicity information that was derived from studies other than no-effects or lowest-effects studies (**Figure 8-4**). Because NOAELs and LOAELs for the selected wildlife receptor species are based on data from test species that are usually different from the species of concern, previous ERA guidance documents often applied a mathematical adjustment to the TRVs using a power function of the ratio of species body weights (e.g., Sample, et al., 1996). This practice is often referred to as allometric scaling. Alternately, uncertainty factors have also been used to adjust the TRVs when the toxicity values were based on a different species from the evaluated receptor to account for the potential differences in species' chemical sensitivities. However, in recent years, these practices have been discouraged by most scientific and regulatory groups. Recent reviews of these practices (EPA, 2008b and Allard, et al., 2009) have concluded that the use of allometric scaling of TRVs does not reflect a sound application of toxicological or ecological risk practices because supporting data for this practice are limited, and the ratio relationships used for the mathematical conversions were developed based on acute (rather than chronic) toxicity data. Allard, et al. (2009), also concluded that uncertainty factors based on an arbitrary multiplier should not be used without a scientific basis for their application. Therefore, the use of toxicity data without adjustments as reported in the literature is regarded as the most technically sound approach, and is the adopted approach for the ERA.

The TRVs used for the Level III Baseline are summarized in **Tables 8-12** and **8-13** for mammals and birds, respectively.

8.4.3 Risk Characterization

The risk characterization phase integrates information on exposure, exposure-effects relationships, and defined or presumed target populations. The result is a determination of the likelihood, severity, and characteristics of adverse effects to environmental stressors present at a site. Because potential adverse effects to aquatic plants and invertebrates have been qualitatively assessed during the Level II Screening (Section 8.3), the Level III Baseline risk characterization focuses on potential impacts to higher trophic-level receptors.

For the quantitative predictive assessment, TRVs and average daily doses were calculated and used to generate food chain HQs (Wentsel, et al., 1996). HQs are calculated by summing intake doses across all exposure pathways for each chemical for a given receptor to generate



Credit: Adapted from Ford et al. (1992) in *Tri-Service Procedural Guidelines for Ecological Risk Assessments*, 1996

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FIGURE 8-4 PROCEDURAL FLOW CHART FOR DERIVING TOXICITY REFERENCE VALUES FROM CLASS-SPECIFIC TOXICITY DATA

Table 8-12
Toxicity Reference Values for Mammals

COPEC	Toxicity Value	NOAEL (mg/kg/d)	Test Species	References	Toxicity Value	LOAEL (mg/kg/d)	Test Species	References
Metals								
Antimony	--	0.125	mouse	Sample, et al. (1996)	--	1.25	mouse	Sample, et al. (1996)
Barium	--	5.1	rat	Sample, et al. (1996)	--	19.8	rat	Sample, et al. (1996)
Cadmium	--	1	rat	Sample, et al. (1996)	--	10	rat	Sample, et al. (1996)
Copper	--	11.7	mink	Sample, et al. (1996)	--	15.14	mink	Sample, et al. (1996)
Iron	NA							
Lead	--	8	rat	Sample, et al. (1996)	--	80	rat	Sample, et al. (1996)
Mercury (mink)	--	1	mink	Sample, et al. (1996)	1.0 (NOAEL)	5	mink	Sample, et al. (1996)
Mercury (mouse)	--	13.2	mouse	Sample, et al. (1996)	--	132	mouse	Sample, et al. (1996)
Semivolatile Organic Compounds								
Dibenzofuran	NA							
Polychlorinated Biphenyls								
Aroclor-1254 (mink)	--	0.14	mink	Sample, et al. (1996)	--	0.69	mink	Sample, et al. (1996)
Aroclor-1254 (mouse)	--	0.068	mouse	Sample, et al. (1996)	--	0.68	mouse	Sample, et al. (1996)

COPEC denotes chemical of potential ecological concern.
LOAEL denotes lowest observed adverse effect level.
mg/kg/d denotes milligrams per kilogram per day.
NA denotes not applicable/available.
NOAEL denotes no observed adverse effect level.

Table 8-13
Toxicity Reference Values for Birds

COPEC	Toxicity Value	NOAEL (mg/kg/d)	Test Species	References	Toxicity Value	LOAEL (mg/kg/d)	Test Species	References
Metals								
Antimony	NA							
Barium	--	20.80	chicks	Sample, et al. (1996)	--	42	chicks	Sample, et al. (1996)
Cadmium	--	1.45	mallard duck	Sample, et al. (1996)	--	20	mallard duck	Sample, et al. (1996)
Copper	--	47	chicks	Sample, et al. (1996)	--	61.7	chicks	Sample, et al. (1996)
Iron	NA							
Lead (quail)	--	1.13	Japanese quail	Sample, et al. (1996)	--	11.3	Japanese quail	Sample, et al. (1996)
Lead (kestrel)	--	3.85	Am. Kestrel	Sample, et al. (1996)	--	38.5	Am. Kestrel	Sample, et al. (1996)
Mercury	--	0.45	Japanese quail	Sample, et al. (1996)	--	0.9	Japanese quail	Sample, et al. (1996)
Semivolatile Organic Compounds								
Dibenzofuran	NA							
Polychlorinated Biphenyls								
Aroclor-1254	--	0.18	ring neck pheasant	Sample, et al. (1996)	--	1.8	ring neck pheasant	Sample, et al. (1996)

COPEC denotes chemical of potential ecological concern.
LOAEL denotes lowest observed adverse effect level.
mg/kg/d denotes milligrams per kilogram per day.
NA denotes not applicable/available.
NOAEL denotes no observed adverse effect level.

an average daily dose and dividing by the TRV. The HQs for those chemicals that have a similar mode of toxicological action are typically summed to account for cumulative effects. None of the COPECs identified for the ERA were considered toxicologically similar enough to warrant summing their HQs.

8.4.3.1 Hazard Estimation for Aquatic Wildlife

The hazard estimation was performed through a series of quantitative HQ calculations that compare receptor-specific exposure doses with TRVs. The same HQ guidelines for assessing the risk posed from chemicals as described in the Level II Screening (Section 8.3) apply to the Level III Baseline as well.

The HQs for the identified COPECs based on both NOAEL and LOAEL values were calculated for all four representative receptor species, i.e., the muskrat, mallard, mink, and great blue heron. The 95-percent UCLs calculated with the ProUCL (EPA, 2011) software were used for sediment EPCs, and the maximum detected concentrations were used as the EPCs for the surface water COPECs. The ProUCL input and output are presented in **Appendix J**. The entire Erie Burning Grounds MRS area comprising 33.9 acres was used for the purposes of calculating area use factors for the various receptors.

No NOAEL- or LOAEL-based HQ exceeded 1 for any receptor (**Table 8-14**). Because the NOAEL is based on a no-effect dose, and given other conservative assumptions inherent in the food chain model (e.g., 100-percent bioavailability), these chemicals are unlikely to be present at concentrations harmful to environmental receptors. The HQs could not be calculated for antimony for the mallard or great blue heron because an avian TRV for this metal could not be identified. Also, neither mammalian nor avian TRVs could be identified for iron or dibenzofuran.

Iron is a commonly occurring metallic element, comprising nearly 5 percent of igneous and sedimentary rocks. It is also essential for plant growth, and is generally considered to be a micronutrient. Iron exceeded its ESV in all three surface water samples, and only one out of six wet sediment samples; however, the HQs for iron for each of the surface water and wet sediment sample locations was below 10. No BSV was available for iron, and its presence could be background related.

Antimony was detected in three of six wet sediment samples, and was the only chemical with an HQ greater than 10 (HQ equal to 18). However, there is no facility-specific BSV available for this chemical and its presence may be due to naturally occurring concentrations. Although its potential toxicity to avians cannot be assessed, it is not considered a PBT chemical, and its distribution and magnitude of detection were relatively low; therefore, it is unlikely to pose a significant hazard to ecological receptors.

Table 8-14
Wildlife Hazard Quotients for all Assessment Receptors

COPEC	Muskrat		Mallard		Mink		Great Blue Heron	
	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL
Metals								
Antimony	0	0	NA	NA	0	0	NA	NA
Barium	0	0	0	0	0	0	0	0
Cadmium	0	0	0	0	0	0	0	0
Copper	1.43E-03	1.11E-03	6.52E-07	4.96E-07	1.15E-04	8.86E-05	1.64E-05	1.25E-05
Iron	NA	NA	NA	NA	NA	NA	NA	NA
Lead	0	0	0	0	0	0	0	0
Mercury[1]	2.10E-03	2.10E-04	4.06E-04	2.03E-04	3.51E-03	7.02E-04	8.77E-03	4.39E-03
Semivolatile Organic Compounds								
Dibenzofuran	NA	NA	NA	NA	NA	NA	NA	NA
Polychlorinated Biphenyls								
Aroclor-1254	7.46E-04	7.46E-05	1.86E-06	1.86E-07	4.29E-02	8.71E-03	3.76E-02	3.76E-03

[1] Chemical evaluated for food chain effects. All other chemicals evaluated for direct contact (ingestion) only.

COPEC denotes chemical of potential ecological concern.

LOAEL denotes lowest observed adverse effect level.

NA denotes not applicable/available. No toxicity data is available; therefore, the hazard quotients are not calculated.

NOAEL denotes no observed adverse effect level.

Dibenzofuran was only detected in one out of six wet sediment samples at an estimated concentration that was approximately half its reporting limit. Although dibenzofuran is considered a PBT compound, its limited presence suggests that it is unlikely to adversely affect ecological receptor populations at the Erie Burning Grounds MRS.

8.4.4 Uncertainty Analysis

A number of factors contribute to the overall variability and uncertainty inherent in ERAs. Variability is due primarily to measurement error and natural variability of chemical concentrations in environmental media. Laboratory media analyses, sampling design/methods, and receptor study design are the major sources of this kind of error. Uncertainty, on the other hand, is associated primarily with deficiency or irrelevancy of effects, exposure, or habitat data to actual ecological conditions at the MRS. Species physiology, feeding patterns, and nesting behavior are poorly predictable; therefore, all toxicity information derived from toxicity testing, field studies, or observation have uncertainties associated with them. Laboratory studies conducted to obtain MRS-specific, measured information often suffer from poor relevance to the actual exposure and uptake conditions at the MRS (i.e., bioavailability, exposure, assimilation, etc., are generally greater under laboratory conditions as compared to field conditions). Calculating an estimated value based on a large number of assumptions is often the only alternative to the accurate, albeit costly, methods of direct field or laboratory observation, measurement, and/or testing. Finally, habitat- or MRS-specific species may be misidentified if, for example, the observational assessment results are based on only one or two brief site reconnaissance surveys.

The uncertainty analysis describes many of the major assumptions made for the ERA. When discernible, the direction of bias caused by each assumption (i.e., whether the uncertainty results in an overestimate or underestimate of risk) is provided as well. Where possible, a description of recommendations for minimizing the identified uncertainties is also presented if the ERA progresses to higher level assessment phases. The most important uncertainties associated with the ERA are discussed in the following paragraphs.

8.4.4.1 Assumptions of Bioavailability

The assumption that COPECs are 100-percent bioavailable likely overestimates the potential for adverse effects. The duration that has lapsed since the chemical release affects bioavailability as the chemical becomes sequestered or transformed within the environmental media. Sequestration, transformation, and bioavailability are influenced by medium characteristics including pH, temperature, and organic carbon content. For example, in aquatic or semi-aquatic systems, metals in highly insoluble forms are not bioavailable to sediment-dwelling organisms. Metals bound to iron and manganese oxides, as well as

sulfides in anaerobic sediments, form stable complexes that are not bioavailable. Because surface water and sediment benchmark concentrations are typically developed using studies where the metal is in a dissolved or highly bioavailable form, potential toxicity for these metals is likely overestimated using the ESV comparison.

8.4.4.2 Use of Laboratory-Derived or Empirically Estimated Partitioning and Transfer Factors

The use of laboratory-derived or empirically estimated partitioning and transfer factors to predict COPEC concentrations in plants, invertebrates, and prey species, likely overestimates potential risks. As discussed previously, the incorporation of COPECs into the food chain is influenced by the characteristics of the exposure medium, which likely differs from that used in the laboratory to derive partitioning and transfer factors.

8.4.4.3 Use of Laboratory-Derived Toxicity Reference Values

The use of laboratory-derived TRVs may overestimate or underestimate the potential for adverse effects. The method of administration of the chemical in the laboratory is typically different than that experienced in the wild by the receptors. Also, laboratories typically use "naïve" organisms in their toxicity testing, which are likely to be much more sensitive to toxicants than organisms living in the wild or at the MRS, which have likely developed resistances or have otherwise adapted to ambient concentrations of chemicals in their environment.

8.4.4.4 Use of the HQ Method to Estimate Risks to Populations or Communities

The calculation of HQs also introduces uncertainty. The following limitations associated with HQs (Tannenbaum, 2005) are noted:

- HQs are not measures of risk.
- HQs are not population based.
- HQs are not linearly scaled.
- HQs are often produced that are unrealistically high and toxicologically impossible (e.g., estimated HQs greater than 1,000, such as the HQ of 1,431 for mercury that was calculated during the initial screen against the ESV).
- Trace soil concentrations of inorganic chemicals (including concentrations well below background levels) can lead to HQ threshold exceedances.

Therefore, HQs greater than 1 do not mean that adverse ecological effects are occurring or may occur in the future.

8.4.4.5 Sampling and Analytical Limitations

It is not possible to completely characterize the nature and extent of chemical contamination at any MRS. Uncertainties arise from limits on the number of locations that can be sampled. The sampling protocol used at the Erie Burning Grounds MRS, however, was designed to optimize efficiency of the sampling effort and reduce uncertainty by providing coverage of the affected area at the MRS.

8.4.5 Level III Baseline Conclusions and Recommendations

Two COPECs in surface water (copper and iron) and 10 COPECs in wet sediment samples (antimony, barium, cadmium, copper, iron, lead, mercury, nitrocellulose, Aroclor-1254, and dibenzofuran) were identified as COPECs in the Level II Screening. Of these COPECs, mercury, Aroclor-1254, and dibenzofuran were PBT chemicals, and recommended for further evaluation in the Level III Baseline due to concerns about food chain effects. All other COPECs in surface water and wet sediment (except nitrocellulose, which lacked uptake and toxicity information, and was deemed unlikely to contribute to modeled hazard estimates) were included in the Level III Baseline food chain modeling exercise for direct contact (i.e., direct ingestion of the affected medium) only. Food chain modeling was used to estimate ecological hazards to two avian and two mammalian representative species to address assessment endpoints designed to be protective of aquatic and semi-aquatic receptors likely to be present at the MRS (the protection of aquatic biota and benthic invertebrates were assessment endpoints that were previously addressed during the Level II Screening). The maximum detected concentrations for surface water COPECs were used as the EPCs for the food chain modeling due to a low sample size, but 95-percent UCLs were calculated and used as the EPCs for wet sediment COPECs. No receptor had HQs exceeding 1; although, the HQs could not be calculated for iron, dibenzofuran, or antimony (avian receptors only). However, the limited magnitude and distribution of samples with detectable levels of these chemicals suggests that significant impacts to populations of mammalian and avian receptors are unlikely. Therefore, the potential hazard associated with food chain effects was considered to be minimal for all COPECs.

In summary, the results of multiple chemicals with elevated HQs in the Level II Screening suggested further evaluation in the Level III Baseline for potential localized impacts to organisms at the base of the food chain (e.g., aquatic biota, including plants and invertebrates). However, with the exception of antimony, all HQs were below 10. Also, the conservative assumptions used in the Level II Screening (e.g., use of the maximum detected concentration as the EPC, the assumption that chemicals are 100-percent bioavailable, etc.), tolerances that nonlaboratory organisms may develop to chemicals in their surrounding environment, and population dynamics for these types of species that typically allow for rapid recolonization and replacement of individuals, reduce the concerns of the Level II

Screening results. Evaluation of the selected COPECs in the Level III Baseline suggested that impacts to upper level trophic receptors are minimal, and adverse effects to populations of these receptors are not expected.

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9.0 REVISED CONCEPTUAL SITE MODELS

This section presents the revised CSMs for MEC and MC at the Erie Burning Grounds 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 Erie Burning Grounds 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 CSMs, 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 Erie Burning Grounds MRS. As discussed in Section 2.1, "Preliminary CSM and Project Approach," each pathway includes a source, activity, access, and receptor, with complete, potentially complete, and incomplete exposure pathways identified for each receptor. A pathway is considered complete when a source (MEC) is known to exist and when receptors have access to the MRS while engaging in some activity which results in contact with the source. A pathway is considered potentially complete when a source (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 Erie Burning Grounds MRS was used to thermally treat bulk, obsolete, off-specification propellants, conventional explosives, rags, and large explosive contaminated items (e.g., railcars) by open burning on the ground surface. During operations, open boxcars were staged at the end of Track 49 and items were tipped out of the car in order to be burned. Ash residue from open burn activities was left at the MRS after the burn. In addition to open burn activities, bomb bodies were transported to Erie Burning Grounds for flashing after they were cleaned out. Since activities ceased at Erie Burning Grounds, the areas where the open burn activities occurred have become inundated with water due to seasonal flooding and beaver dam activity. The locations at the MRS where the munitions activities occurred represent potential source areas for MEC.

A DGM survey was successfully completed at the MRS during the RI, and a total of 3,824 anomalies were identified. A total of 1,719 clusters of high-density anomalies were recommended for intrusive investigation at 15 exploratory trench locations. Outside of these high-density anomaly areas, 1,052 point-source anomalies were recommended for intrusive investigation at both the terrestrial and underwater portions of the MRS. The intrusive investigations were successfully completed at 14 of the 15 exploratory trench locations and at 350 of the identified 1,052 point-source anomalies.

No MEC was found during the intrusive investigations; however, numerous MD items were identified. A total of 910 lbs of MD was found at 5 of the 14 trenches at a maximum depth of 48 inches bgs and 385 lbs of MD was found at 29 point-source anomaly locations at a maximum depth of 6 inches bgs. The MD items were solid and/or inert, and posed no explosives safety hazard.

9.1.2 Activity

Activity describes ways that receptors come into contact with a source. Current activities at the Erie Burning Grounds MRS include maintenance and natural resource management activities. Most of these activities involve foot traffic only; however, periodic beaver dam removal as part of maintenance at the MRS may require intrusive activities. Biota activities at the MRS may include foot traffic or burrowing activities. Due to the high quality wetland and inundation, it is unlikely that the Erie Burning Grounds MRS will be used for training; therefore, activities at the MRS will be similar to those currently being conducted. The MRS may also be used for hunting/trapping and fire suppression activities.

9.1.3 Access

Access is the degree to which a MEC source or environment containing MEC is available to potential receptors. The Erie Burning Grounds MRS is currently managed as an “Authorized Access” area due to the high-quality wetlands that are present and the potential for MEC (SAIC, 2007). Siebert stake and signs are currently present along the perimeter of the MRS identifying the presence of the MRS and restricting access; however, these mechanisms do not physically restrict receptors from being able to enter the MRS. Once on the MRS, receptors would have access to any MEC in surface soil or sediment. Future access to this MRS is expected to remain similar to current access conditions.

9.1.4 Receptors

A receptor is an organism (human or ecological) that comes into physical contact with MEC. Human receptors identified for the Erie Burning Grounds 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 current receptors identified at the Erie Burning Grounds MRS include facility personnel, contract workers, regulatory personnel, hunters and trespassers (e^2M, 2008). The Security Guard/Maintenance Worker, Hunter/Trapper, and Fire/Dust Suppression Worker have been identified as the potential receptors for the future land use at the MRS (USACE, 2005a).

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).

9.1.5 MEC Exposure Conclusions

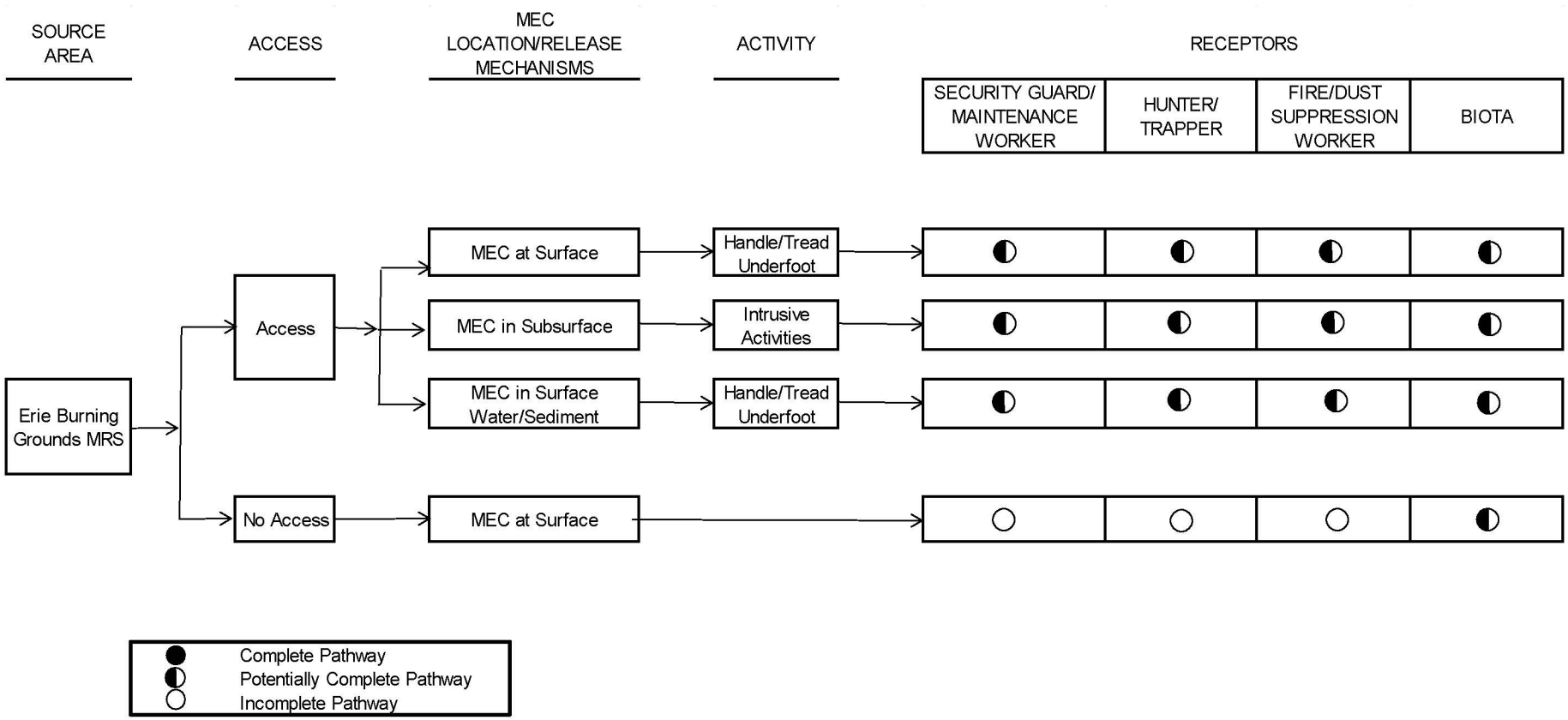
The information collected during the RI was used to update the preliminary MEC CSM for the Erie Burning Grounds MRS and to identify all complete, potentially complete, or incomplete source-receptor interactions for the MRS for current and anticipated future land uses. Evaluation of the end use receptors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

A statistical approach using the UXO Estimator® module was taken for the investigation at the Erie Burning Grounds MRS and portions of the MRS were investigated by visual survey, DGM survey, and intrusive investigation. No MEC was identified during the RI field activities; however, numerous MD items were encountered at depths ranging from ground surface to 48 inches bgs. The MD items were solid and/or inert, and posed no explosives safety hazard.

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

9.2 MC Exposure Analysis

MC is defined as any material originating from MPPEH or munitions, or other military munitions including explosive and non-explosive material, and emission degradation, or breakdown elements of such ordnance and munitions (10 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 Erie Burning Grounds MRS is presented in **Figures 9-2** and **9-3** for the terrestrial and aquatic environments, respectively.



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MILITARY MUNITIONS RESPONSE PROGRAM

ERIE BURNING GROUNDS MRS
RAVENNA ARMY AMMUNITION PLANT
RAVENNA, OHIO

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

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FIGURE 9-1 REVISED MEC CONCEPTUAL SITE MODEL

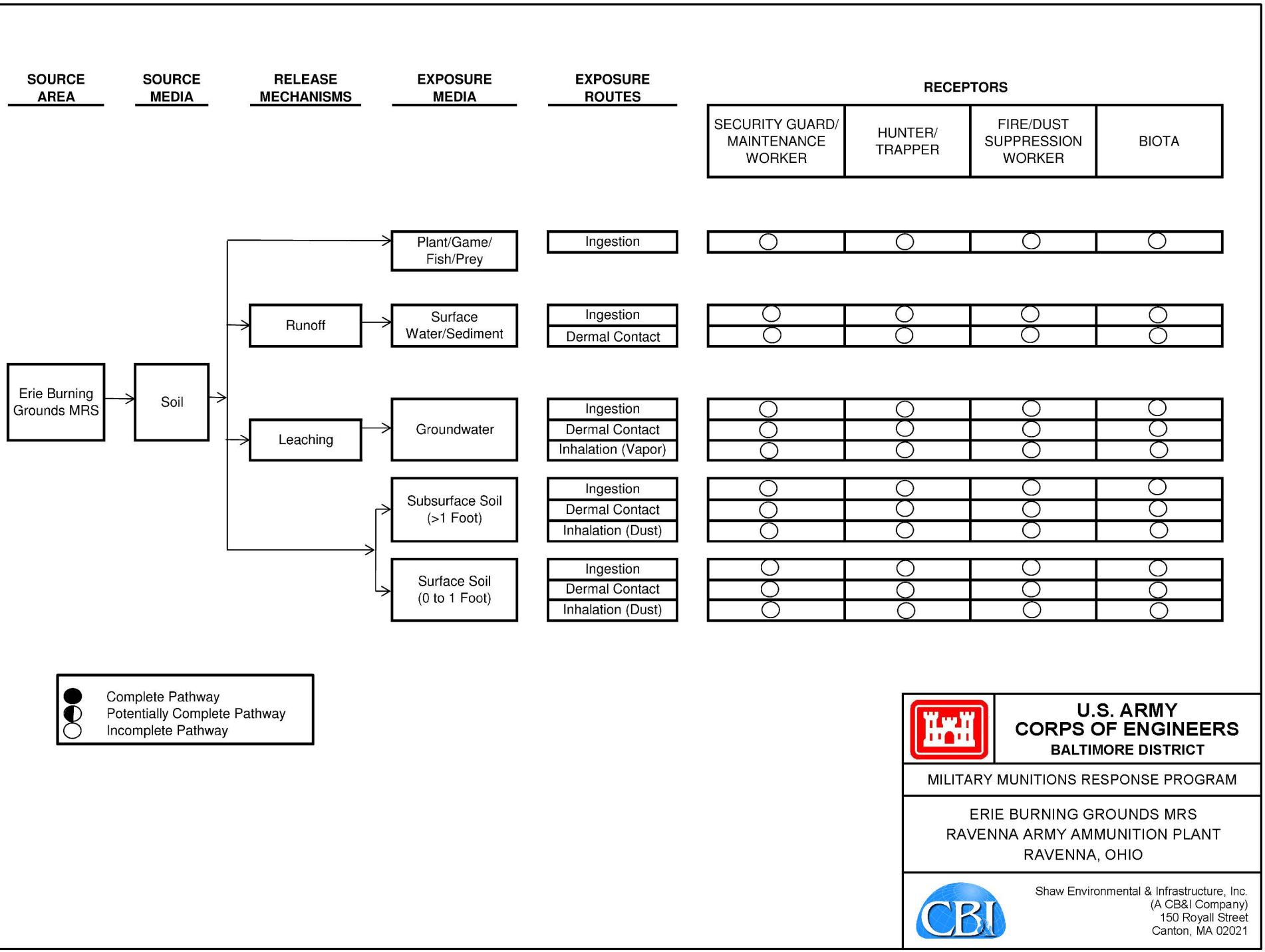
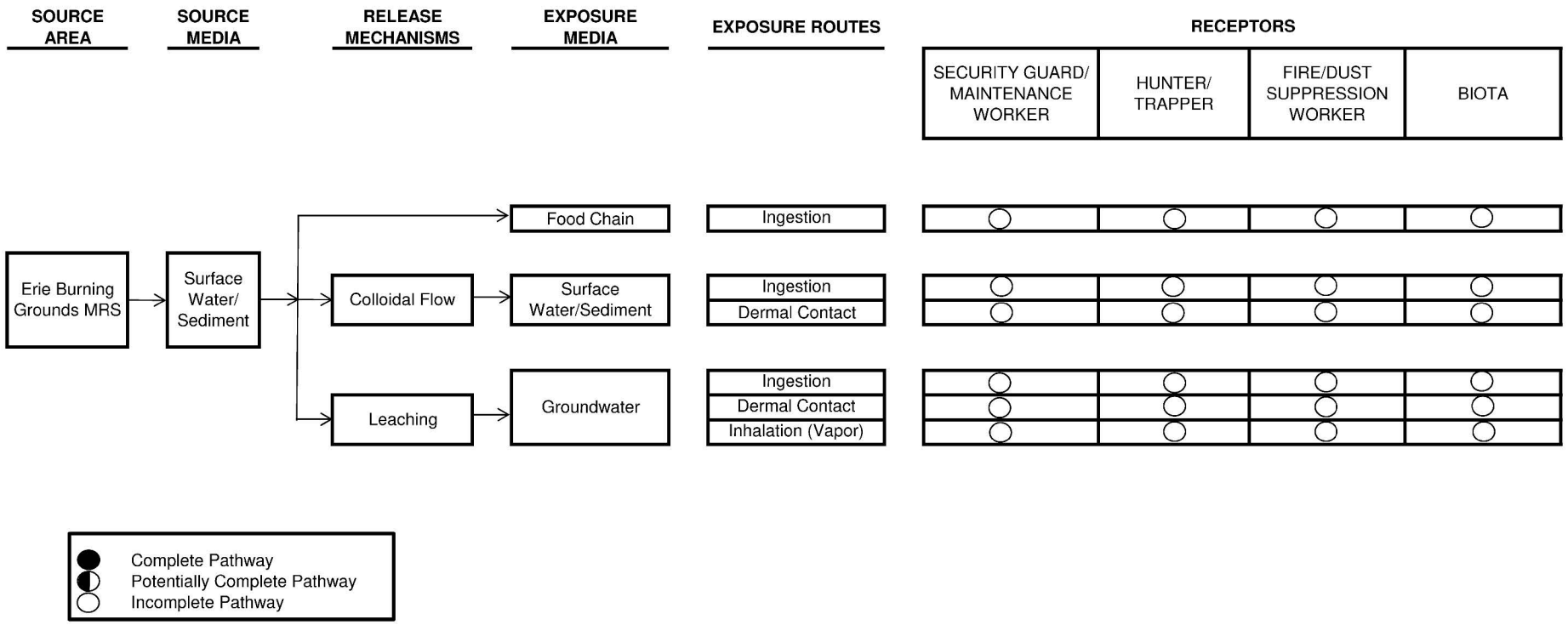


FIGURE 9-2 REVISED MC CONCEPTUAL SITE MODEL, TERRESTRIAL ENVIRONMENT



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MILITARY MUNITIONS RESPONSE PROGRAM

ERIE BURNING GROUNDS MRS
RAVENNA ARMY AMMUNITION PLANT
RAVENNA, OHIO

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

Project Number: 136147 Generated By: gwt Date: 10/16/13 File: H:\WAMMS\Ravenna\GIS Documents\Project Maps\MMRP\RIFS\RIFS_ErieBurningGrounds\Sept 2013\RVAAP EBG 032 Fig9 3 Revised Aquatic MC CSM rev1.mxd

FIGURE 9-3 REVISED MC CONCEPTUAL SITE MODEL, AQUATIC ENVIRONMENT

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 Erie Burning Grounds MRS was the thermal treatment of bulk, obsolete, off-specification propellants, conventional explosives, rags, and large explosive contaminated items (e.g., railcars) by open burning on the ground surface. 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. The MRS has become inundated with water since the open burn activities ceased and any MC distributed to surface soil may have since leached to subsurface soil, sediment, surface water, and groundwater.

The determination as to whether MC characterization was required at the MRS was made based on historical activities that occurred at the MRS and the results of the RI intrusive investigation. In accordance with the Work Plan Addendum (Shaw, 2011), three surface water samples and six ISM wet sediment samples were collected from the three primary water basins at the MRS. Additional samples were proposed in areas with concentrated MEC/MD and two additional ISM soil samples were collected from the bottom of the trenches where buried MD was encountered at the MRS. The trench sample were evaluated as subsurface soils in the HHRA.

The detected chemicals were evaluated in accordance with the facility data use evaluation process to identify SRCs. In all, 7 SRCs were identified in surface water, 22 SRCs were identified in wet sediment, and 2 SRCs were identified in the trench soil samples.

A HHRA was conducted for the surface water, wet sediment, and the subsurface soil samples to determine if the identified SRCs were COPCs and COCs that may pose a risk to future human receptors. The MRS is unlikely to be used for military training due to the high-quality wetlands that are present. Therefore, the most Representative Receptor at the MRS is the Security Guard/Maintenance Worker. The future land use at the MRS may also include hunting/trapping and fire suppression activities. Therefore, the Hunter/Trapper and Fire/Dust Suppression Worker were identified as potential receptors as well. The anticipated future land use in conjunction with the evaluation of Unrestricted Land Use form the basis for identifying COCs in the RI. For the facility, the Resident Receptor (Adult and Child) is evaluated for COCs for Unrestricted Land Use at the MRS in accordance with the CERCLA process to evaluate for baseline conditions and the no action alternative and as outlined in the HHRAM (USACE, 2005a).

The facility exposure scenarios for the potential receptors assumes no exposure to surface water and wet sediment for the Security Guard/Maintenance Worker and no exposure to

subsurface soil (i.e., greater than 1 foot bgs) for the Security Guard/Maintenance Worker, Hunter/Trapper, and Fire/Dust Suppression Worker (SAIC, 2010). The exposure scenario for the environmental receptors in the ERA is 0 to 1 foot bgs.

The HHRA and ERA determined that SRCs in surface water, wet sediment, and subsurface soil are not present at concentrations great enough to pose risks to the human and ecological receptors. These results are consistent with the previous investigations under the IRP that determined that detected contaminants in soil and dry sediment also do not pose risks to likely human or ecological receptors (SAIC, 2007). Although MD was verified during the RI field activities, given the extent of environmental media coverage achieved for the sampling activities for the RI and the results for the MC characterization, it is unlikely that SRCs will leach from the MD. The CSM for MC has been updated to reflect incomplete pathways for all receptors in the terrestrial and aquatic environments.

Groundwater beneath the former 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 at depths that were at or just beneath the soil and groundwater interface (3 to 4 feet bgs). Although SRCs were detected in environmental media that was sampled during the RI field work, evaluation for fate and transport of the chemicals and review of the Phase II RI (SAIC, 2005) indicate that that groundwater has not been significantly impacted from past activities at the MRS. Additionally, it is unlikely that the human or ecological receptors will come into contact with groundwater at the MRS. No groundwater samples were collected at the Erie Burning Grounds 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 Erie Burning Grounds MRS; however, the process does not remove all uncertainty associated with the MRS. The primary uncertainty at the Erie Burning Grounds MRS is whether the RI activities adequately characterized for MEC in accordance with the DQOs. The DGM survey coverage for the RI was designed based on the UXO Estimator® program that at a 95-percent confidence level, a MEC density of 0.5 MEC per acre was expected to be found at the MRS. Although no MEC was found during the intrusive and underwater investigation activities and the area of actual DGM coverage (6.8 acres) exceeded the proposed area of coverage (5.2 acres), nearly two-thirds of the detected point-source anomalies were inaccessible for investigation. Based on the number of anomalies that were able to be successfully investigated, the UXO Estimator® program calculated the statistical

upper bound density of MEC to be 0.442 MEC per acre at a 95-percent confidence which is below the minimum density assumed for the DQOs. However, the program assumes that 100 percent of the detected anomalies are investigated and due to the limited number of anomalies that were accessible for the intrusive investigation activities at the terrestrial and underwater areas of the MRS, the results of the module cannot accurately determine if the performance criteria has been satisfied. No direct evidence of an explosive hazard exists for the MRS; however, the results of the RI field activities create statistical uncertainty regarding the potential for remaining MEC.

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 revised MRSPP worksheets for the Erie Burning Grounds MRS are included in **Appendix K** for reference only.

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10.0 SUMMARY AND CONCLUSIONS

This section summarizes the results of the RI field activities conducted at the Erie Burning Grounds MRS. The purpose of the RI was to determine whether the Erie Burning Grounds MRS warranted 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 likely human and environmental receptors by MEC and MC. Additional data was also presented in this RI Report to support the identification and evaluation of alternatives in a FS, if required. A summary of the RI results for the Erie Burning Grounds 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
Erie Burning Grounds	5.2	6.8	MD	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 Erie Burning Grounds 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^2M, 2007), and the SI Report (e^2M, 2008).

The preliminary MEC and MC 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 DQOs outlined in the Work Plan Addendum (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 Erie Burning Grounds 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.
- Collect surface water and wet sediment samples at predetermined locations to characterize the nature and extent of contamination associated with previous activities at the MRS.
- Collect additional samples in areas of concentrated MEC/MD, if necessary.
- Process the information to evaluate whether there are unacceptable risks to human health and the environment associated with MEC/MC and make a determination if further investigation is required under the CERCLA process.

10.1.1 Geophysical Investigation

In January and February of 2012, CB&I performed a DGM investigation to identify potential subsurface areas of MEC and/or MD at the Erie Burning Grounds MRS. The DGM data were collected in all accessible areas within the MRS, and the spatial coverage was calculated to be 6.8 acres, which represents an MRS coverage of 20 percent and exceeds the proposed sampling coverage of 5.2 acres presented in the Work Plan Addendum (Shaw, 2011). The 6.8 acres equates to a total transect distance of 17 miles where each transect width covered was 1 meter wide.

10.1.2 Anomaly Selection

A total of 3,824 anomalies were identified at the entire MRS through the DGM process. The anomalies ranged in intensity from 5 to 11,401 mV (Channel 2). The Work Plan Addendum (Shaw, 2011) specified that the anomaly selection criteria would be the 8-mV (Channel 2) threshold; however, the 5-mV threshold (Channel 2) was considered appropriate for anomaly selection in the areas of the MRS covered by water in order to compensate for the variable water depth at the MRS. The more stringent 5-mV threshold was also used to evaluate for targets at the terrestrial high-density anomaly areas. The 8-mV threshold was still used for selection of point-source anomalies in the terrestrial areas of the MRS. Since complete DGM coverage was not performed at the MRS, the intrusive investigation activities required 100-percent reacquisition of individual non-culturally related anomalies that exceed the 8-mV threshold in the terrestrial portion of the MRS and the 5-mV threshold in the underwater portions of the MRS.

A high-density anomaly area that consisted of 2,233 clusters of anomalies above 5 mV was found at the terrestrial areas of the MRS. Two hundred anomaly clusters were within approximately 3 feet of one another and were merged together to form one target location

south of Burn Area D. Forty-nine anomaly clusters were located outside of the high-density anomaly area and were found to be either related to cultural features identified by the DGM team during field operations or nails placed by the DGM team for QC purposes for the DGM activities. Another 266 anomaly clusters were identified to be slightly outside of the MRS boundary. In all, 1,719 clusters of anomalies above 5 mV were identified in the high-density anomaly areas, and a total of 15 trenches were proposed for intrusive investigation. The proposed length of the trenches in the high-density anomaly areas was 20 feet to adequately investigate the detected subsurface anomalies; however, some of the trenches were shorter in length where the DGM survey identified areas of density that were not as large.

With regards to the 266 clusters of anomalies along the MRS boundary, approximately 25 to 30 percent of the clusters were on one transect along the portion of Blackberry Lane that bounds the northern portion of the MRS. Blackberry Lane forms both the north and east boundaries of the MRS that is itself bound by a fence that existed when the MRS was in operation. Surface water and wetland areas are present to the north of the Blackberry Lane fence line, and an operational range is situated to the east of the fence line adjacent to the east of Blackberry Lane. The south and west portions of the MRS are bound by former elevated railroad beds in relation to the MRS that are covered with ballast material. A majority of the remaining portions of the 266 anomaly clusters were identified at the southwest and western edges of the MRS along the slopes of the former railroad beds. Based on the distinct boundaries that are presented by Blackberry Lane and the former elevated railroad beds, the extent of the DGM survey along the edges of the MRS are considered to be adequately characterized.

Outside of the high-density anomaly areas, a total of 1,076 point-source anomalies remained at the terrestrial and underwater portions of the MRS that were detected at intensities greater than 5 mV. Following the evaluation of the DGM survey results, 186 of 214 targets within the terrestrial zone were greater than 8 mV and were recommended for intrusive investigation. Within the underwater areas, 862 targets greater than 5 mV were recommended for investigation. Four anomalies that were located in a high-density anomaly area west of Burn Area D were recommended for intrusive investigation as point-source anomalies by the USACE geophysicists following review of the proposed investigation locations. In all, a total of 1,052 point-source anomalies were identified as requiring intrusive investigation at both the terrestrial and underwater areas of the MRS.

10.1.3 Intrusive Investigation Activities

Intrusive investigation activities were conducted at the terrestrial and underwater areas of the MRS between April and May 2012, at the locations recommended following the DGM survey. A total of 14 of the 15 proposed exploratory trench locations were successfully

investigated. One trench (EBG-04) was underwater at the time of the intrusive investigation activities and was considered inaccessible. Only 350 of the proposed 1,052 combined terrestrial and underwater point-source anomalies were accessible for exploration, since many of the point-source anomalies at the underwater areas were found to be buried deep in the sediment and could not be safely investigated.

No MEC was identified during the intrusive investigation activities; however, MD items were found at the various trenches and point-source anomaly locations that were able to be investigated. A total of 33 MD items, weighing approximately 910 lbs, were identified at 5 of the exploratory trenches, and a total of 29 MD items that weighed approximately 385 lbs were identified at the point-source anomaly locations. All of the MD items found in the trenches and at most of the point-source anomaly locations were various parts associated with the AN-M64A1-series 500-lb GP bomb. MD items associated with the M48-series 75mm HE projectile and the M309-series 75mm projectile were encountered at several of the point-source anomaly locations.

10.1.4 MC Sampling

Sampling for MC was predetermined during the DQO decision-making process to further characterize the nature and extent of contamination associated with previous activities at the MRS. Three surface water samples and six ISM wet sediment samples were collected at the MRS during the RI field activities. Surface water samples were collected at each of the main surface water areas at the MRS: the North Surface Water Basin, the South Surface Water Basin, and the East Surface Water Basin. The wet sediment samples were collected at sampling units of approximately the same size and from the same basin areas as where the surface water samples were collected. Three ISM sediment samples were collected from the North Surface Water Basin (2.8 acres each), two ISM sediment samples were collected from the South Surface Water Basin (3.2 acres each), and one ISM sediment sample was collected from the East Surface Water Basin (1.5 acres). Additional samples were proposed in areas with concentrated MEC/MD, and two additional ISM soil samples were collected from the bottom of two trenches at depths between 3 to 4 feet bgs where buried MD was encountered during the intrusive investigation activities.

10.2 Nature and Extent of SRCs

The SRCs for the Erie Burning Grounds MRS were determined for surface water, wet sediment, and subsurface soil collected during the RI field activities through the facility data screening process as presented in the FWCUG guidance (SAIC, 2010). All surface water, wet sediment, and subsurface soil samples were analyzed for the identified MC associated with historical munitions-related activities at the MRS. The identified MC included metals (aluminum, antimony, barium, cadmium, chromium [total and hexavalent], copper, iron,

lead, mercury, strontium, and zinc), explosives, SVOCs, nitrocellulose, and pH. The wet sediment and soil samples were also analyzed for PCBs and TOC. The detected chemicals that were retained as SRCs following the screening process included the following:

- **Surface Water (1.5 feet below water surface)**
  - *Metals:* barium, chromium (as Cr^{+3}), copper, iron, lead, strontium, and zinc
- **Wet Sediment (0 to 0.5 feet below sediment surface)**
  - *Metals:* aluminum, antimony, barium, cadmium, chromium (as Cr^{+3}), copper, iron, lead, mercury, and strontium
  - *Explosives:* TNT and 4-amino-2,6-DNT
  - *SVOCs:* benzo(b)fluoranthene, benzoic acid, chrysene, dibenzofuran, fluoranthene, phenanthrene, and pyrene
  - *PCBs:* Aroclor-1254
  - *General Chemistry:* Nitrocellulose and Cr^{+6}
- **Subsurface Soils (3 to 4 feet bgs)**
  - *Metals:* Cadmium and strontium

No explosives, propellants, or SVOCs were detected in the surface water and subsurface soil samples. PCBs were also analyzed for the subsurface soil samples and none were detected.

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. Numerous MD items were encountered at various depths at the Erie Burning Grounds MRS during the RI field activities. 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. Although the future activities at the MRS are expected to continue as those that are currently being conducted, intrusive activities associated with the periodic removal of beaver dams or other maintenance activities

in the surface water areas 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 SRCs consisting of metals have a tendency to adsorb to soil with a pH of 4 or greater, depending on the specific analyte. Much of the inundated areas of the MRS were primarily dry until the 1990s when beaver dam activity flooded the MRS; therefore, the makeup of the current underwater sediment at much of the MRS consists of the previous terrestrial soil conditions. The soils at the MRS consist primarily of the Sebring variant and silty loams with high clay content that are, for the most part, very poorly drained soils with low permeabilities and susceptible to flooding (USDA et al., 1978). The similarities between the soils and the underwater sediment are also supported by moderately analogous pHs of approximately 6.7 and 6.4 for the terrestrial soil and underwater sediment, respectively. The low permeable soil conditions and moderate pH results indicate that metal SRCs would be expected to be found in the top several inches where they were released, with only limited downward migration. Several of the detected metals in sediment have a tendency to mobilize or redissolve in aquatic environments (in particular antimony, barium, cadmium, and Cr^{+6}); however, of these metals only barium was identified as an SRC in surface water and was detected at low estimated concentrations. However, periodic and/or constant inundation, recurring anaerobic conditions, and accumulation and retention of organic matter may result in more limited downward migration of metals from wet sediment than soil. The surface water results provide supporting evidence that metal SRCs in sediment have not mobilized.

One of the principal migration pathways at the Erie Burning Grounds MRS is infiltration through the unsaturated soil, sediment, and surface water to groundwater. The water table at the Erie Burning Grounds MRS is shallow, typically 2 to 3 feet bgs, and groundwater flow is generally from north to south across the MRS, which is consistent with surface drainage patterns. The inorganic SRCs in subsurface soil were cadmium and strontium in samples that were collected at the approximate soil and groundwater interface. Strontium in soils is moderately mobile, while the mobility of cadmium in soils and sediment is more strongly influenced by pH, organic content, and clay minerals (EPA, 1979). Based upon the pH and heavy clay contents in the soils at the MRS, strontium and cadmium would be expected to bind to soils close to a source. Because of the extensive wetland areas within the MRS, a high degree of interaction exists between groundwater and surface water (SAIC, 2007). Antimony, barium, cadmium, and Cr^{+6} in sediments have a potential to migrate to groundwater due to their tendency to mobilize or redissolve in aquatic environments. Inorganic SRCs consisting of barium, chromium (as Cr^{+3}), copper, iron, lead, and strontium were identified in both the sediment and surface water samples collected at the MRS. The presence of metals in both the surface water and sediment, when combined with the high degree of interaction between surface water and groundwater, may potentially result in the

migration of inorganic SRCs to groundwater. However, high dilution/attenuation factors would be presumed to result in few groundwater concentrations above background (SAIC, 2005).

Inorganic SRCs were detected in groundwater as part of the Phase II RI and included potential MC consisting of antimony, barium, copper, lead, nickel, and zinc. These inorganic SRCs were considered consistent with upgradient background concentrations in groundwater outside of the Erie Burning Grounds MRS (SAIC, 2005). The antimony, barium, copper, and lead SRCs identified in groundwater are consistent with the SRCs identified between the wet sediment and surface water media that have interaction with groundwater. The concentrations of the inorganic SRCs in groundwater were relatively low and were detected at isolated well locations, with the exception of barium that was detected at all eight monitoring wells installed under the IRP (SAIC, 2005). These results suggest that there is minimal leaching of the inorganic SRCs detected in sediment and surface water during the RI field activities, that the occurrence of the detected inorganics in groundwater may be naturally occurring, or that dilution factors are high.

Because of their low solubility and high affinity for organic carbon, the detected PCBs and SVOCs that include PAHs in aquatic systems, such as in the sediment at the MRS, are primarily found sorbed to particles that either have settled to the bottom or are suspended in the water column. When found in soil or sediment, these chemicals will tend to stay bound to the organic fraction of the soil/sediment instead of leaching into groundwater or surface water runoff, or volatilizing to the atmosphere (EPA, 1981). Based on the same principle, volatilization from surface water to the atmosphere is also not anticipated to occur, as PCBs will adsorb to sediment and suspended particles in the water column. Two low concentrations of SVOCs consisting of bis(2-ethylhexyl)phthalate and di-n-butyl phthalate were detected in groundwater during the Phase II RI. These SVOCs were found between two well locations that are located at the central portion of the MRS near the former burn areas (SAIC, 2005). Neither of these SVOCs were identified as SRCs in the soil, sediment, or surface water samples collected for the RI, and these results indicate that SVOCs and PCBs in sediments are relatively immobile.

The TNT concentration that was detected in wet sediment is not expected to sorb to the organic fraction of soil and will tend to leach into the groundwater. Biodegradation is the most probable degradative process that may occur for TNT in the sediment at the MRS. The presence of 4-amino-2,6-DNT in the sediment provides evidence that biodegradation is occurring. Unlike TNT, 4-amino-2,6-TNT can bind to the organic fractions of soil and sediment is thereby immobilized (Walker and Kaplan, 1992). No explosives were identified as SRCs in groundwater as part of the Phase II RI, indicating that potential leaching to groundwater is minimal or that dilution factors are high (SAIC, 2005).

10.4 MEC Hazard Assessment

The MEC HA Methodology (EPA, 2008a) 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 will include the information available for the MRS up to and including the RI field activities and will provide a scoring summary for the current and future land-use activities. If no explosive hazard is found at the MRS, then there is no need to calculate a MEC HA score, since there are no human health safety concerns. No MEC items were identified at the MRS during the RI field activities. These results indicate that no MEC source or explosive safety hazard is present at the MRS. Therefore, calculation of a MEC HA was not warranted for the Erie Burning Grounds MRS.

10.5 MC Risk Assessment Summary

Following the identification of the SRCs at the Erie Burning Grounds MRS through the facility data screening process, the SRCs were then carried through the human health and ecological risk assessments process to evaluate for potential receptors. The risk assessments resulted in the following conclusions.

10.5.1 Human Health Risk Assessment

A HHRA was conducted for surface water, wet sediment, and subsurface soil samples collected at the Erie Burning Grounds MRS to determine if the SRCs identified were COPCs or COCs that may pose a risk to current or future human receptors. The MRS is located within a larger area where the anticipated future land use will be military training; however, since the MRS is a high-quality wetland, training activities are unlikely to occur there (OHARNG, 2008). Therefore, the Security Guard/Maintenance Worker, the Hunter/Trapper, and the Fire/Dust Suppression Worker have been identified as potential receptors. The anticipated future land use in conjunction with the evaluation of Unrestricted Land Use form the basis for identifying COCs in the RI. For the facility, the Resident Receptor (Adult and Child) is evaluated for COCs for Unrestricted Land Use at the MRS in accordance with the CERCLA process to evaluate for baseline conditions and the no action alternative and as outlined in the HHRAM (USACE, 2005a).

Iron was identified as a COC for the Resident Receptor (Adult and Child) in wet sediment; however, weight of evidence suggests that the one elevated iron concentration is most likely associated with background and does not pose a hazard. No other COCs were identified in surface water, wet sediment, or soil for any of the receptors. Since no COCs were identified for the Resident Receptor, Unrestricted Land Use was achieved for MC.

10.5.2 Ecological Risk Assessment

Two COPECs in surface water (copper and iron) and 10 COPECs in sediment samples (antimony, barium, cadmium, copper, iron, lead, mercury, nitrocellulose, Aroclor-1254, and dibenzofuran) were recommended to be evaluated in the Level III Baseline following the Level II Screening. The COPECs are determined in the ERA and may differ from COPCs. Evaluation of the selected COPECs in the Level III Baseline suggested that impacts to upper trophic-level receptors are minimal, and adverse effects to populations of these receptors are not expected. These findings are supported by the FWBWQS that was performed at the facility in 2003. This study included the evaluation of several reaches of the West Branch of the Mahoning River downstream of the Erie Burning Grounds MRS and found no biological impacts associated with chemical contamination (USACE, 2005b).

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 Erie Burning Grounds 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 investigation at the Erie Burning Grounds MRS; and portions of the MRS were investigated by visual survey, DGM survey, and intrusive investigation. No MEC was identified during the RI field activities; however, numerous MD items were encountered at depths ranging from ground surface to 48 inches bgs. The MD items were solid and/or inert and posed no explosives safety hazard.

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

10.6.2 MC Exposure Analysis

The Security Guard/Maintenance Worker, Hunter/Trapper, and Fire/Dust Suppression Worker have been identified as the potential receptors for the future land use at the MRS. The facility-wide exposure scenarios for the future land-use receptors assumes no exposure to surface water and wet sediment for the Security Guard/Maintenance Worker and no exposure to subsurface soil (i.e., greater than 1 foot bgs) for the Security Guard/Maintenance

Worker, Hunter/Trapper, and Fire/Dust Suppression Worker (SAIC, 2010). The exposure scenario for the environmental receptors in the ERA is 0 to 1 foot bgs.

The HHRA and ERA determined that SRCs in surface water, wet sediment, and subsurface soil are not present at concentrations great enough to pose risks to the human and ecological receptors. These results are consistent with the previous investigations under the IRP that determined that detected contaminants in soil and dry sediment also do not pose risks to likely human or ecological receptors (SAIC, 2007). Although MD was verified during the RI field activities, given the extent of environmental media coverage achieved for the sampling activities for the RI and the results for the MC characterization, it is unlikely that SRCs will leach from the MD. The CSM for MC has been updated to reflect incomplete pathways for all receptors in the terrestrial and aquatic environments.

Groundwater beneath the former 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 at depths that were at or just beneath the soil and groundwater interface (3 to 4 feet bgs). Although SRCs were detected in environmental media that was sampled during the RI field work, evaluation for fate and transport of the chemicals and review of the Phase II RI (SAIC, 2005) indicate that that groundwater has not been significantly impacted from past activities at the MRS. Additionally, it is not expected that the likely human or ecological receptors will come into contact with groundwater at the MRS. No groundwater samples were collected at the Erie Burning Grounds 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 at the Erie Burning Grounds MRS is whether the RI activities adequately characterized for MEC in accordance with the DQOs. The DGM survey coverage for the RI was designed based on the UXO Estimator® program that at a 95-percent confidence level, a MEC density of 0.5 MEC per acre was expected to be found at the MRS. Although no MEC was found during the intrusive and underwater investigation activities and the area of actual DGM coverage (6.8 acres) exceeded the proposed area of coverage (5.2 acres), nearly two-thirds of the detected point-source anomalies were inaccessible for investigation. Based on the number of anomalies that were able to be successfully investigated, the UXO Estimator® program calculated the statistical upper bound density of MEC to be 0.442 MEC per acre at a 95-percent confidence, which is below the minimum density assumed for the DQOs. However, the program assumes that 100 percent of the detected anomalies are investigated, and due to the limited number of anomalies that were

accessible for the intrusive investigation activities at the terrestrial and underwater areas of the MRS, the results of the module cannot accurately determine if the performance criteria have been satisfied. No direct evidence of an explosive hazard exists for the MRS; however, the results of the RI field activities create statistical uncertainty regarding the potential for remaining MEC.

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 likely receptors. The following statements can be made for the Erie Burning Grounds MRS based on the results of the RI field activities:

- A total of 6.8 acres were investigated at the MRS during the RI, which exceeded the proposed spatial coverage of 5.2 acres.
- Intrusive investigation activities identified the vertical extent of buried MD at the MRS to range between ground surface and 4 feet bgs.
- The detected SRCs that were evaluated as MC in surface water, wet sediment, and subsurface soil do not pose potential risks to human or ecological receptors at the MRS; therefore, no further action is required for MC at this MRS.

The RI included risk assessments for explosives hazards and MC that may pose threats to likely receptors. The field work results suggest it is statistically possible that MEC may be present at the MRS, although confirmed discoveries have not been made to date. Even though MD was recovered during the field activities, the items were solid and/or inert and posed no explosives safety hazard. An FS is recommended as the next course of action for the MRS under the MMRP to assess possible response action alternatives because MD has been found and some statistical uncertainty remains for MEC.

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Appendix A
Digital Geophysical Mapping Report

Appendix B
Field Documentation

Appendix C
Data Evaluation Report

Appendix D
Summary of Laboratory Analytical Results

Note: Laboratory data packages prepared by CT Laboratories are submitted on a separate compact disc.

Appendix E
Investigation-Derived Waste Management Report

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Note: This is a placeholder page. CB&I Federal Services LLC will supply a signed authorization page to be inserted into the final hard copy document as soon as it becomes available. Replacement CDs that include the signed authorization page will also be supplied.

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