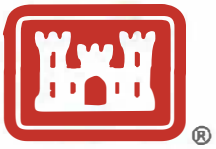
Final Site Inspection Report for RVAAP-28 Suspected Mustard Agent Burial Site

Ravenna Army Ammunition Plant
Ravenna, Ohio

Prepared for:

OHARNG
Camp Ravenna
1438 State Route 534 SW
Newton Falls, OH 44444

Prepared by:



U.S. Army Corps of Engineers, Huntsville Center
4820 University Square
Huntsville, AL 35816

April 27, 2015

John R. Kasich, Governor
Mary Taylor, Lt. Governor
Craig W. Butler, Director

July 16, 2015

Mr. Mark Leeper, P.G., MBA
Army National Guard Directorate
Environmental Programs Division
ARNGD-ILE-CR
111 South George Mason Drive
Arlington, VA 22204

Re: US Army Ravenna Ammunition Plt RVAAP
Remediation Response
Project Records
Remedial Response
Portage County
267000859025

Subject: Approval for the "Final Site Inspection Report for RVAPP-28 Suspected Agent Burial Site at the Ravenna Army Ammunition Plant, Ravenna, Ohio," Dated April 27, 2015, Ohio EPA ID # 267-000859-025

Dear Mr. Leeper:

The Ohio Environmental Protection Agency (Ohio EPA), Northeast District Office (NEDO), Division of Environmental Response and Revitalization (DERR) has received and reviewed the document entitled, "Final Site Inspection Report for RVAPP-28 Suspected Agent Burial Site at the Ravenna Army Ammunition Plant, Ravenna, Ohio," dated April 27, 2015. This document, received on May 7, 2015, was prepared for the Ohio Army National Guard/Camp Ravenna, by the U.S. Army Corps of Engineers – Huntsville District.

Ohio EPA has reviewed this documentation and has found no significant deficiencies. As a result, the "Final Site Inspection Report for RVAPP-28 Suspected Agent Burial Site" has been approved.

If you have any questions or concerns, please do not hesitate to contact me at (330) 963-1249.

Sincerely,

Andrew C. Kocher, Site Coordinator
Division of Environmental Response and Revitalization

ACK/nvr

cc: Gregory F. Moore, USACE, Louisville District
Katie Tait/Kevin Sedlak, Camp Ravenna
Haney/Harris, Vista Sciences, Newton Falls

ec: Rod Beals, NEDO, DERR
Justin Burke, CO, DERR

REPORT DOCUMENTATION PAGE

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1. REPORT DATE *(DD-MM-YYYY)*	2. REPORT TYPE	3. DATES COVERED *(From - To)*
27-04-2015	Site Inspection	From 11/6/2014 To 6/4/2015

4. TITLE AND SUBTITLE

Final Site Inspection Report for RVAAP-28 Suspected Mustard Agent Site, Ravenna Army Ammunition Plant, Ravenna, Ohio

5a. CONTRACT NUMBER
N/A

5b. GRANT NUMBER
N/A

5c. PROGRAM ELEMENT NUMBER
N/A

6. AUTHOR(S)

Amber D. Lee
Project Management Specialist

5d. PROJECT NUMBER
N/A

5e. TASK NUMBER
N/A

5f. WORK UNIT NUMBER
N/A

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

United States Army Corps of Engineers, Huntsville Center
4820 University Square
Huntsville, AL 35816

8. PERFORMING ORGANIZATION REPORT NUMBER

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

Army National Guard (ARNG-ILE Cleanup)
111 South George Mason Drive
Arlington, Virginia 22204

10. SPONSOR/MONITOR'S ACRONYM(S)
ARNG-ILE

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

12. DISTRIBUTION/AVAILABILITY STATEMENT

Reference Distribution Page

13. SUPPLEMENTARY NOTES

None

14. ABSTRACT

This Site Inspection (SI) Report was prepared for the Suspected Mustard Agent Burial Site, RVAAP-28 (SMABS) at the former Ravenna Army Ammunition Plant (RVAAP), in Portage and Trumbull counties, Ohio. The SI was conducted to evaluate the presence of sulfur mustard agent (dichlorodiethyl sulfide), which was suspected to have been buried at the SMABS after World War II and before 1950. Based on unconfirmed verbal evidence, this sulfur mustard may be in the form of Chemical Agent Identification Sets (CAIS).

15. SUBJECT TERMS

Site Inspection; RVAAP-28 Suspected Mustard Agent Burial Site

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			Amber D. Lee
UU	UU	UU	UU	59	19b. TELEPHONE NUMBER *(Include area code)* (256) 895-8282

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Standard Form 298 (Rev. 8/98)
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ARNG—Army National Guard
OHARNG—Ohio Army National Guard
Ohio EPA—Ohio Environmental Protection Agency
RVAAP—Ravenna Army Ammunition Plant
USACE—U.S. Army Corps of Engineers

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Acronyms and Abbreviations

°F	degrees Fahrenheit
AMEC	AMEC Earth and Environmental, Inc.
amsl	above mean sea level
AOC	area of concern
ARNG	Army National Guard
BRACD	Base Realignment and Closure Division
CAIS	Chemical Agent Identification Sets
Camp Ravenna	Camp Ravenna Joint Military Training Center
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CWM	chemical warfare materiel
DENIX	DOD Environment, Safety, and Occupational Health Network and Information Exchange
DGM	digital geophysical mapping
DOD	U.S. Department of Defense
DQO	data quality objective
EE/CA	Engineering Evaluation/ Cost Analysis
EQM	Environmental Quality Management, Inc.
GPO	geophysical prove-out
km	kilometer
MEC	munitions and explosives of concern
MMRP	Military Munitions Response Program
NACA	National Advisory Committee for Aeronautics
NTA	NACA Test Area
ODNR	Ohio Department of Natural Resources
OHARNG	Ohio Army National Guard
RI	Remedial Investigation
RVAAP	Ravenna Army Ammunition Plant
SAIC	Science Applications International Corporation
Shaw	Shaw Environmental & Infrastructure, Inc.
SI	Site Inspection
SpecPro	SpecPro, Inc.
SMABS	Suspected Mustard Agent Burial Site, RVAAP-28
U.S.	United States
USACE	U.S. Army Corps of Engineers
USAESC	U.S. Army Engineering & Support Center
USGS	U.S. Geological Survey
UXO	unexploded ordnance

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EXECUTIVE SUMMARY

This Site Inspection (SI) Report was prepared for the Suspected Mustard Agent Burial Site, RVAAP-28 (SMABS) at the former Ravenna Army Ammunition Plant (RVAAP), in Portage and Trumbull counties, Ohio. The SI was conducted to evaluate the presence of sulfur mustard agent (dichlorodiethyl sulfide), which was suspected to have been buried at the SMABS after World War II and before 1950. Based on unconfirmed verbal evidence, this sulfur mustard may be in the form of Chemical Agent Identification Sets (CAIS).

SI Objectives and Scope

The purpose of the SMABS SI is to determine whether the SMABS warrants further response action under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980. In general, a SI collects the maximum amount of information available to make this determination. A SI also determines the potential need for a removal action or interim measures; collects or develops additional data, as appropriate, for Hazard Ranking System scoring by the United States (U.S.) Environmental Protection Agency; and collects data, as appropriate, to characterize the release for effective and rapid initiation of the Remedial Investigation and Feasibility Study. The scope of the SI reported herein is restricted to evaluation of the presence of CAIS or chemical agent associated with their suspected burial at the SMABS. SI activities performed as part of this investigation included a summary of prior surficial soil sampling, prior geophysical surveys and groundwater sampling, a visual inspection, and a historical records review. The intent of the SI was to confirm the presence or absence of mustard agent within the SMABS area of concern (AOC) investigation areas through previous nonintrusive investigation methods.

RVAAP and SMABS

The former Ravenna Army Ammunition Plant (RVAAP) is located in northeastern Ohio within Portage and Trumbull counties, approximately one (1) mile northwest of the city of Newton Falls and three (3) miles east-northeast of the city of Ravenna. The installation is a parcel of property approximately 11 miles long and 3.5 miles wide bounded by State Route 5, the Michael J. Kirwan Reservoir, and the CSX System Railroad on the south; Garret, McCormick, and Berry roads on the west; the Norfolk Southern Railroad on the north; and State Route 534 on the east.

In September 1940, construction of the facility started. In August 1941, munitions production started. The primary missions of the facility included loading, assembling, and packaging of large-caliber ammunition and depot storage. The facility changed names several times during its history before being designated as the RVAAP in 1961. In 1992, the status of the former RVAAP changed from inactive- maintained to modified caretaker. In 1992, the only activities still being carried out from the wartime era were the storage of bulk explosives and propellants and the infrequent demolition of unexploded ordnance found at the installation.

As of September 2013, administrative accountability of the entire 21,683-acre former RVAAP has been transferred to the United States Property and Fiscal Officer for Ohio. The installation has been licensed to the Ohio Army National Guard (OHARNG) for use as a

military training site known as the Camp Ravenna Joint Military Training Center (Camp Ravenna). Subsequent references in this document to RVAAP, or the former RVAAP, relate to previous activities at the installation as related to former munitions production activities or to activities being conducted under the restoration/cleanup program.

During former RVAAP's operational years, the entire 21,683-acre property was a government-owned, contractor-operated industrial facility. The RVAAP Installation Restoration Program (IRP) encompasses investigation and cleanup of past activities over the entire 21,683 acres of the former RVAAP.

The SMABS AOC is located in the south center of Camp Ravenna and encompasses approximately 1.8 acres. The AOC is situated both north and south of Hinkley Creek and contains three investigation areas.

In 1969, the United States (U.S.) Army excavated a possible mustard agent burial site west of the National Advisory Committee for Aeronautics (NACA) Test Area. One 50-gallon drum and seven small rusted cans were discovered. All recovered items were empty and no contamination was discovered, according to documentation which cites the results of these reports (Environmental Quality Management, Inc. [EQM], 2008). It should be noted, however, that the original documentation regarding the excavation is no longer available, so it is unknown what exactly occurred during the investigation. An unidentified and undocumented source reported that the first site excavated in 1969 was incorrectly identified, and that the mustard agent was buried in the wooded area approximately 500 feet south of Hinkley Creek, along an abandoned power line right-of-way (Science Applications International Corporation [SAIC], 1996). This second suspected site, measuring 270 square feet, was marked and fenced. However, only remnants of the fence existed in 2006 and the area has since been marked with Seibert stakes.

In July 2006, stakeholders, which included members from the OHARNG, the Ohio Environmental Protection Agency, BRACD, and the U.S. Army Corps of Engineers (USACE) conducted an interview with three local members of the public who formerly worked at the RVAAP and claimed to have knowledge of suspected mustard agent burial areas at the facility. One of the former workers interviewed identified a new area adjacent to the concrete pad at the west end of the NACA crash strip. This location encompasses the 1969 excavation area and is nonforested and flat (EQM, 2008).

The previous study areas at the SMABS were performed in the more heavily wooded area approximately 1,000 feet to the west of the NACA Test Area and adjacent to the west of the concrete pad at the west end of the NACA crash strip. These studies were conducted between 1996 and 2010, as discussed below.

In 1996, two surface soil samples were collected at the second identified burial location from along the abandoned power line right-of-way located 500 feet south of Hinkley Creek as part of the Relative Risk Site Evaluation (U.S. Army Center for Health Promotion and Preventive Medicine, 1996). This investigation was conducted for the Hazardous and Medical Waste Study conducted at the former RVAAP. No attempts were made to collect subsurface samples due to the potential hazards associated with mustard agent. The surface soil samples

were tested for thiodiglycol, a mustard agent decomposition product, and no concentrations were detected.

In 1998, SAIC conducted a digital geophysical mapping (DGM) survey at an approximately 270-square-foot area along the abandoned power line right-of-way where the soil samples were collected. Several geophysical anomalies were identified, which may have been the result of metallic objects or cultural features located at or near ground surface; however, the results determined that it was difficult to discriminate these interferences from any potential buried waste containers (SAIC, 1998).

Between 2004 and 2005, SpecPro, Inc. conducted a groundwater investigation at the AOC at the suspected area along the abandoned power line right-of-way that included the installation of six monitoring wells. The wells were placed along the perimeter of the site and not within the suspect area. Mustard agent breakdown products (thiodiglycol, 1,4-dithiane, and 1,4-oxathiane) were not detected in any of the groundwater samples collected during the sampling events (SpecPro, Inc., 2006).

EQM conducted a series of DGM surveys at the AOC in 2006 using various methodologies (EQM, 2008). The objective of the project was to determine if mustard agent had been buried in an approximate one-acre area located at the west end of the NACA crash strip, as reported in 2006 by the former employee. The 2006 geophysical investigation showed anomalies in the area where mustard agent was reportedly buried, but the extent of the area potentially affected had not been delineated.

In 2010, Shaw Environmental & Infrastructure, a CB&I company, conducted a DGM survey to further evaluate the suspected burial area around the test pad at the NACA crash strip. The DGM data for SMABS suggest anomalies are present that have characteristics similar to single items of interest (including CAIS PIGs), but do not have the characteristics of trench or pit type burial features (U.S. Army Engineering & Support Center [USAESC], 2013).

In 2013, the USAESC prepared a Probability Assessment for the SMABS to document the probability of encountering chemical warfare materiel (CWM) prior to conducting ground-disturbing (i.e., construction) or other intrusive activities (USAESC, 2013). In addition to the geophysical testing results, the Probability Assessment evaluated results of archived records searches. An Archive Search Report prepared for the former RVAAP in 2004 indicated that, "no records were found during the records search of any CWM at this installation." Furthermore, in a follow-up records review in 2012 of all documents available at the former RVAAP, there was no indication that any shipment of CWM had passed through the former RVAAP. However, historical documentation is most likely incomplete due to potential disposal of some archived documents over the years. Therefore, results should not rely solely on archived documentation but should consider sampling and geophysical results. Based on the Probability Assessment (USAESC, 2013) findings, the possibility of encountering CWM or CAIS at the SMABS is "seldom", meaning remotely possible.

To date, no CAIS have been identified at any portions of the AOC that have been investigated since 1969. In addition, no mustard agent degradation compounds have been detected in surface soil samples collected at the AOC south of Hinkley Creek or in

groundwater samples collected from monitoring wells proximate to the AOC south of Hinkley Creek.

Based on the exposure pathways evaluation up to this point, the SMABS AOC represents an unlikely exposure potential for human or environmental receptors. However, there is an uncertainty as to whether sulfur mustard is in the subsurface, due to lack of investigation of subsurface anomalies that have the characteristics of potential items of interest. As presented in the Preliminary Assessment report for the RVAAP (Science Applications International Corporation [SAIC], 1996), and supported by subsequent SI activities, the SMABS AOC was scored as a low relative risk designation under the Department of Defense's relative risk site evaluation methodology. This methodology is similar to the U.S. Environmental Protection Agency's Hazard Ranking System Prioritization Model (SAIC, 1996).

SI Summary and Recommendations

To date, investigations at the SMABS AOC have been limited to one discrete soil excavation, collection of two surface soil samples, geophysical mapping, and historical records review. In addition, groundwater monitoring has been conducted in the vicinity of one of the SMABS AOC investigation areas as part of facility-wide activities. No compounds related to mustard agent were detected in these surface soil and groundwater samples. The results of the geophysical investigations indicate that subsurface anomalies are present in the SMABS AOC. Many of the anomalies were identified as possible cultural and anthropogenic features based on location, size, length, position, and/or historical practices at the facility. The identified anomalies included former fencing/fence posts, subsurface utilities, and steel mill slag, and were not indicative of mustard agent burial containers as were described to have been buried. Although CAIS have been indicated to have been buried based on anecdotal interviews, the type and kind has not been clearly defined, and the investigation activities conducted to date have not confirmed the presence of metallic or glass CAIS containers. Based on the Probability Assessment, the possibility of encountering CWM or CAIS is "seldom"- meaning remotely possible. According to the geophysical data available, there are anomalies present which could be caused by metallic items the size of items of potential concern. This potentiality cannot be ruled out without an intrusive investigation of the anomalies. Therefore, this SI Report recommends an Engineering Evaluation/ Cost Analysis (EE/CA) and Action Memorandum to determine the cost of investigation verses the cost of evaluating and selecting remedial alternatives (i.e. Land Use Controls), such as fencing the site off. In accordance with the Probability Assessment (USAESC, 2013) and as a common-sense safety measure, a site-specific contingency plan for encountering items with unknown liquid fill has been developed and finalized for SMABS for potential emergency response actions in the remote event that CWM is encountered. Users and planners of activities in these areas should remain aware of the possibility of contamination and be alert to what actions to take in the event of encountering potential indications of such. The site-specific contingency plan will be integrated into installation standard operation plans.

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1.0 INTRODUCTION

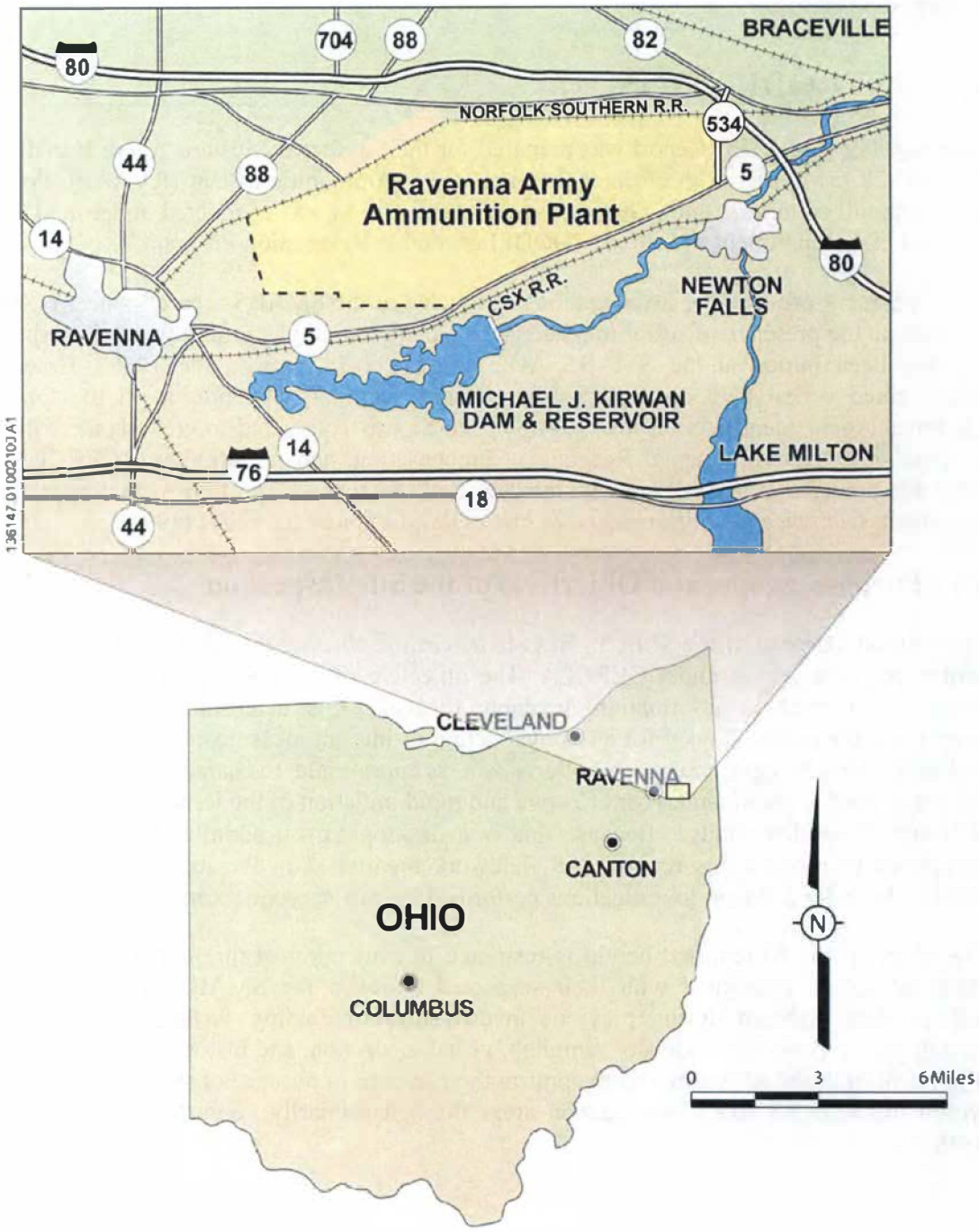
This Site Inspection (SI) Report was prepared for the Suspected Mustard Agent Burial Site, RVAAP-28 (SMABS) at the former Ravenna Army Ammunition Plant (RVAAP), Portage and Trumbull counties, Ohio (**Figures 1-1** and **1-2**). The SI was conducted under the United States (U.S.) Department of Defense (DOD) Installation Restoration Program.

This document presents the investigations conducted at the SMABS area of concern (AOC) to evaluate the presence of sulfur mustard agent (dichlorodiethyl sulfide), which is suspected to have been buried at the SMABS AOC (**Figure 1-3**) prior to the 1950s. Based on unconfirmed verbal evidence, this sulfur mustard agent may be present in the form of Chemical Agent Identification Sets (CAIS). The SI was conducted in compliance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980 and prepared in accordance with the U.S. Environmental Protection Agency's guidance document, *Guidance for Performing Site Investigations Under CERCLA* (1992).

1.1 Purpose, Scope, and Objectives of the Site Inspection

The primary purpose of the SMABS SI is to determine whether the SMABS AOC warrants further response action under CERCLA. The objective of the desktop SI is to collect the maximum amount of information available to make this determination. The SI also determines the potential need for a removal action or interim measures; collects or develops additional data, as appropriate; and collects data, as appropriate, to characterize the release of the site-related contaminant(s) for effective and rapid initiation of the Remedial Investigation (RI) and Feasibility Study. Because this is a desktop SI, no additional field work was completed to prepare this report. All fieldwork mentioned in the report was conducted previously under different investigations performed by various contractors.

The scope of the SI reported herein is restricted to evaluation of the presence of CAIS or chemical agents associated with their suspected burial at the SMABS. This desktop SI utilized data gathered during previous investigations, including surficial soil sampling, geophysical surveys, groundwater sampling, visual inspection, and historical records review. The intent of the SI activities was to confirm the presence or absence of sulfur mustard agent within the SMABS AOC investigation areas through primarily nonintrusive investigation methods.



Note:
The scale is for the Upper Map Only
Showing the RVAAP Location

U.S. ARMY
CORPS OF ENGINEERS
LOUISVILLE DISTRICT

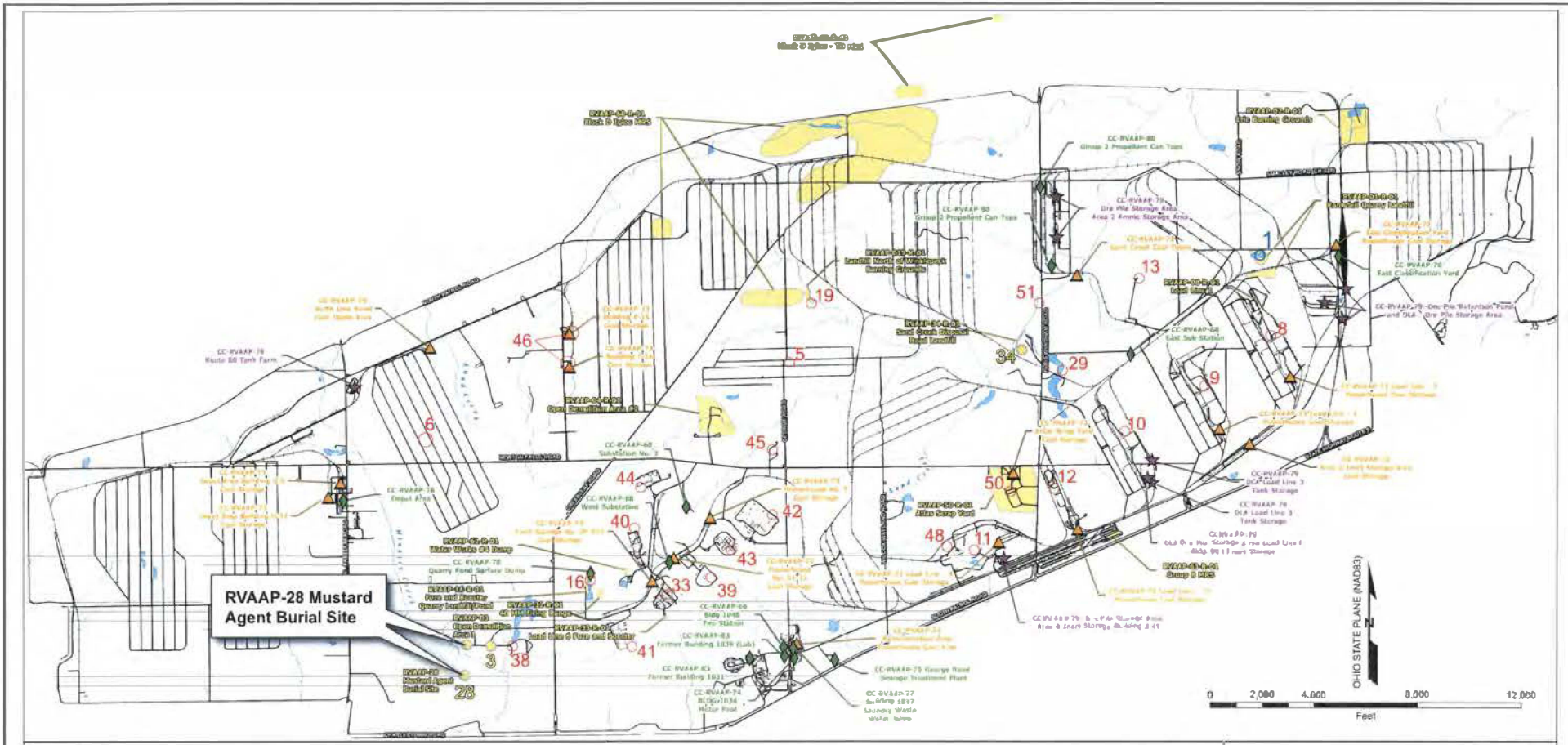
INSTALLATION RESTORATION PROGRAM

RAVENNA ARMY AMMUNITION PLANT
RAVENNA, OHIO

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

H:\AMMS\Ravenna\GIS Documents\Project Maps\AEIS\RVAAP28 MustardAgent\RVAAP 001 Fig1-1 InstallationMap SI.mxd Analyst: Date: 8/15/2013 2:53:41 PM

FIGURE 1-1 RVAAP INSTALLATION LOCATION MAP



LEGEND OF SITES

RVAAP SITES (28 SITES)

- RVAAP-01 — RAVENNA QUARRY LANDFILL
- RVAAP-02 — OPEN DEMOLITION AREA 1
- RVAAP-06 — WINKLEPECK BURNING GROUNDS
- RVAAP-07 — C BLOCK QUARRY
- RVAAP-08 — LOAD LINE 1
- RVAAP-09 — LOAD LINE 2
- RVAAP-10 — LOAD LINE 3
- RVAAP-11 — LOAD LINE 4
- RVAAP-12 — LOAD LINE 12
- RVAAP-13 — BLDG. 1036 AND CELL/TANK SETTLING POND
- RVAAP-14 — FUZE AND BOOSTER QUARRY LANDFILL/PONDS
- RVAAP-15 — LANDFILL NORTH OF WINKLEPECK BURNING GROUND
- RVAAP-16 — WASTE/DEBRIS BURIAL SITE
- RVAAP-17 — UPPER AND LOWER COBBS POND
- RVAAP-18 — LOAD LINE 5
- RVAAP-19 — SAND CREEK DISPOSAL ROAD LANDFILL
- RVAAP-20 — MAGAZINE AREA
- RVAAP-39 — LOAD LINE 9
- RVAAP-40 — LOAD LINE 7
- RVAAP-41 — LOAD LINE 8
- RVAAP-42 — LOAD LINE 6
- RVAAP-43 — LOAD LINE 10
- RVAAP-44 — LOAD LINE 11
- RVAAP-45 — WEST BARRAGE AREA
- RVAAP-46 — BURNING PAD AREA
- RVAAP-47 — ANIMAL TEST AREA
- RVAAP-48 — MUNITIONS SCRAP YARD
- RVAAP-49 — DUMP ALONG PARSONS ROAD
- RVAAP-50 — FACILITY-WIDE GROUNDWATER

MMRP SITES (14 SITES)

- MW-03-R-01 — FACILITY-WIDE SEWERS
- MW-03-R-02 — ELECTRIC SUBSTATIONS (EIGHT)
- MW-03-R-03 — BUILDING 1048 - FIRE STATION
- MW-03-R-04 — EAST CLASSIFICATION YARD
- MW-03-R-05 — FACILITY-WIDE LISTS (45 SITES)
- MW-03-R-06 — FACILITY-WIDE COAL STORAGE
- MW-03-R-07 — BUILDING 1026 HOTSHOT POOL HYDRAULIC LIFT
- MW-03-R-08 — GEORGE ROAD SEWAGE TREATMENT PLANT
- MW-03-R-09 — DEPOT AREA
- MW-03-R-10 — BUILDING 1037 LAUNDRY WASTE WATER SUMP
- MW-03-R-11 — QUARRY POND SURFACE RUNOFF
- MW-03-R-12 — OLA PITS / STORAGE SITES
- MW-03-R-13 — GROUP 2 PROPELLANT PLANT OPS
- MW-03-R-14 — FORMER SUBSTATION (BUILDING 1039)
- MW-03-R-15 — RAVENNA QUARRY LANDFILL (MW)
- MW-03-R-16 — OPEN DEMOLITION AREA 2 (MW)
- MW-03-R-17 — LOAD LINE 1 (MW)
- MW-03-R-18 — FUZE AND BOOSTER QUARRY (MW)
- MW-03-R-19 — LANDFILL NORTH OF WINKLEPECK (MW)
- MW-03-R-20 — FIRESTONE TEST FACILITY (MW)
- MW-03-R-21 — SAND CREEK DISPOSAL ROAD (MW)
- MW-03-R-22 — ATLAS SCRAP YARD (MW)
- MW-03-R-23 — BLOCK D/CELL BLOCK 2
- MW-03-R-24 — BLOCK D/CELL BLOCK 1 (MW)
- MW-03-R-25 — WATER WORKS SUMP (MW)
- MW-03-R-26 — GROUP 1 (MW)

- CERCLA
- RRPA
- MMRP SITES
- MUNITIONS RESPONSE SITES - APPROVED
- OLA PITS / STORAGE AREAS (17 SITES)
- COAL STORAGE AREAS (3 SITES)
- ACC UNDER RESPONSE CONTRACT

RAVENNA ARMY AMMUNITION PLANT
RAVENNA, OHIO

Figure 1-2
RVAAP
Facility Map

US Army Corps of Engineers
Louisville District

Ohio

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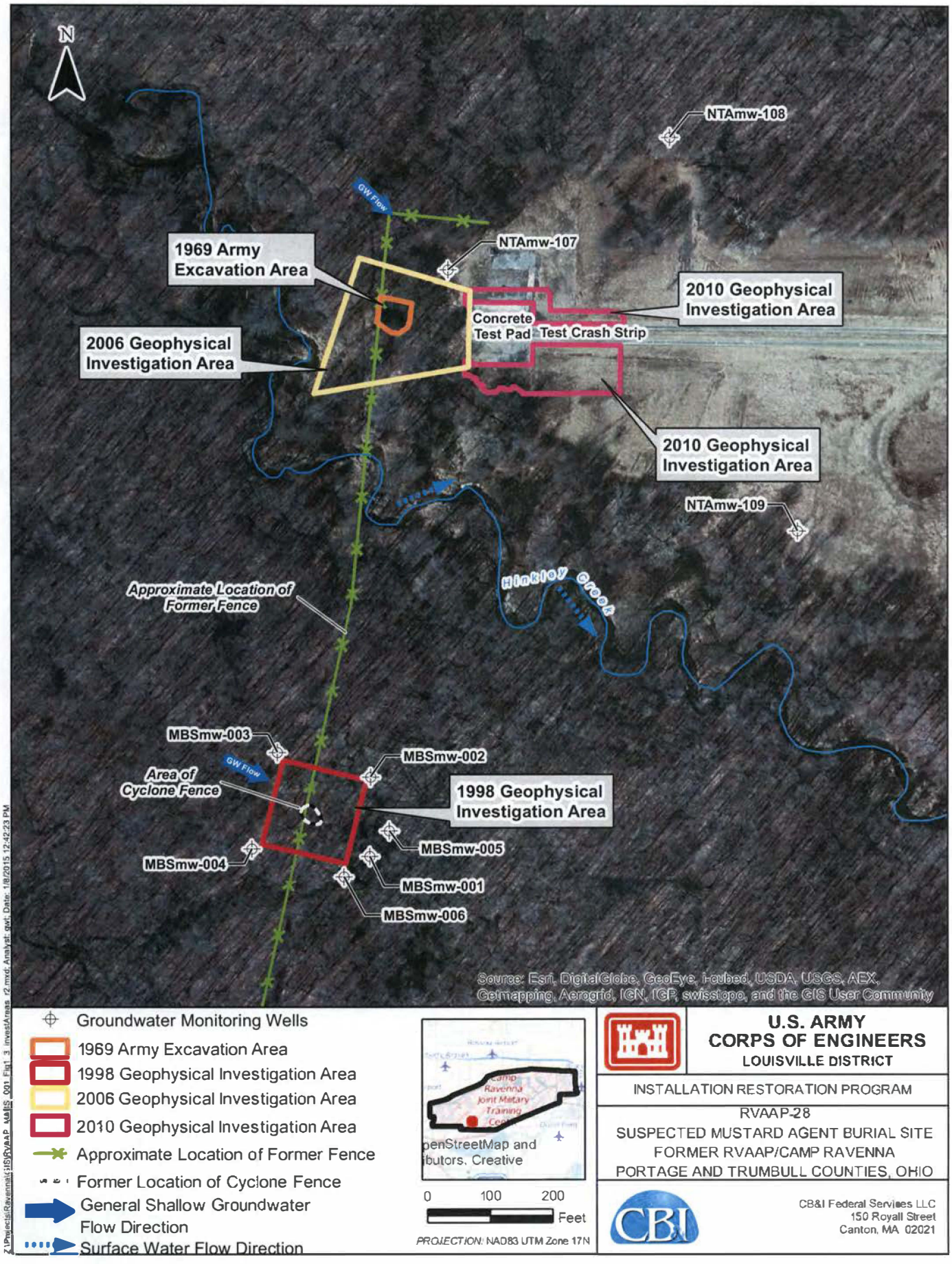

FIGURE 1-3 MUSTARD AGENT BURIAL SITE

As presented in the Preliminary Assessment report for the RVAAP (Science Applications International Corporation [SAIC], 1996), and supported by subsequent investigation activities described in this SI report, the SMABS AOC was scored as a low relative risk designation under the DOD's relative risk site evaluation methodology. This methodology is similar to the U.S. Environmental Protection Agency's Hazard Ranking System Prioritization Model (SAIC, 1996). This risk investigation was limited, however, as only two surface soil samples were collected, and mustard agent buried at depth is unlikely to exhibit a surface expression of agent breakdown products.

1.2 Report Organization

The report is organized into six sections as follows:

- Section 1.0, Introduction—This section presents the introduction, purpose, scope, objectives, and organization of this SI report.
- Section 2.0, Site Description and History—This section describes the installation's location and operational history, as well as the AOC site description, operational history, and environmental setting.
- Section 3.0, Previous SI Activities and Findings—This section details the scope and findings of previous investigations performed at the AOC.
- Section 4.0, SMABS Exposure Pathway Evaluation and Conceptual Site Model—This section presents the exposure pathways for contaminants at the AOC.
- Section 5.0, Summary, Conclusions, and Recommendations—This section presents the summary, conclusions, and recommendations for the SMABS based upon the results of the SI.
- Section 6.0, References—This section contains a list of references for this document.

2.0 SITE DESCRIPTION AND HISTORY

This section describes the location and general background of the former RVAAP applicable to the SI activities and the history and operations specific for the SMABS AOC. The environmental setting for the former RVAAP and the SMABS AOC is provided at the end of this section. The descriptions presented in this SI report were obtained from the following previously issued documents:

- *Final RVAAP Geophysical Survey Results, Suspected Mustard Agent Burial Site (RVAAP-28)* (SAIC, 1998);
- *Final Report on the Geophysical Investigation of RVAAP-28 the Suspected Mustard Agent Burial Site* (Environmental Quality Management, Inc. [EQM], 2008);
- *Final Data Quality Objectives for the RVAAP-28 Mustard Agent Burial Site at Ravenna Army Ammunition Plant* (DQO Report; Shaw, 2009);
- *Final Geophysical Prove-Out Report for Environmental Services at RVAAP-34 Sand Creek Disposal Road Landfill, RVAAP-03 Open Demolition Area #1, and RVAAP-28 Mustard Agent Burial Site* (GPO Report; Shaw, 2010);
- *Final Digital Geophysical Mapping Report for the RVAAP-34 Sand Creek Disposal Road Landfill, RVAAP-03 Open Demolition Area #1, and RVAAP-28 Mustard Agent Burial Site* (DGM Report; Shaw, 2011); and
- *Final Probability Assessment for the Mustard Agent Burial Site at the Ravenna Army Ammunition Plant, Ravenna, Ohio* (Probability Assessment; U.S. Army Engineering & Support Center [USAESC], 2013).

2.1 General Facility Site Description

The former RVAAP is located in northeastern Ohio within Portage County and Trumbull County, approximately 1.6 kilometers (km) (1 mile) northwest of the city of Newton Falls and 4.8 km (3 miles) east-northeast of the city of Ravenna (**Figure 1-1**). The installation is surrounded by several communities: Windham to the north; Garrettsville 1 mile to the northwest; Newton Falls 1 mile to the east; Charlestown to the southwest; and Wayland 3 miles southeast. The facility is a parcel of property approximately 17.7 km (11 miles) long and 5.6 km (3.5 miles) wide bounded by State Route 5, the Michael J. Kirwan Reservoir, and the CSX System Railroad on the south; Garret, McCormick, and Berry Roads on the west; the Norfolk Southern Railroad on the north; and State Route 534 on the east (**Figure 1-1**).

As of September 2013, administrative accountability of the entire 21,683-acre former RVAAP has been transferred to the United States Property and Fiscal Office for Ohio. The installation has been licensed to the Ohio Army National Guard (OHARNG) for use as a military training site known as the Camp Ravenna Joint Military Training Center (Camp

Ravenna). Camp Ravenna did not exist when the former RVAAP was operational, and the entire 21,683-acre parcel was a government-owned, contractor-operated industrial facility.

2.1.1 RVAAP Ownership and Operational History

In August 1940, the U.S. Government purchased approximately 25,000 acres from private landowners in Portage County and Trumbull County located in northeastern Ohio. In September 1940, construction of the facility started. In August 1941, munitions production started. In 1940 and 1941, the primary missions of the former RVAAP included depot storage and ammunition loading during World War II. The facility changed names several times during its history before being designated the RVAAP in 1961. 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 trinitrotoluene and Composition B into large-caliber shells and bombs. The operations on the load lines produced explosive dust, spills, and vapors that collected on the floors and walls of each building. Periodically, the floors and walls would be cleaned with water and steam. The liquid, containing trinitrotoluene and Composition B, was known as "pink water" for its characteristic color. Pink water was collected in concrete holding tanks, filtered, and pumped into unlined ditches for transport to earthen settling ponds. Load Lines 5 through 11 were used to manufacture fuzes, primers, and boosters. From 1946 to 1949, Load Line 12 was used to produce ammonium nitrate for explosives and fertilizers.

In 1950, the facility was placed on standby status and operations were limited to renovation, demilitarization, and normal maintenance of equipment, along with the 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, and 12. Demilitarization activities included disassembly of munitions and explosives melt-out and recovery operations using hot water and steam processes. Periodic demilitarization of various munitions continued through 1992.

In addition to production and demilitarization activities at the load lines, other facilities at the former RVAAP include sites that were used for burning, demolition, and testing of munitions. These burning and demolition grounds consist of large parcels of open space or abandoned quarries.

In 1992, the status of the former RVAAP changed from inactive-maintained to modified caretaker. In 1992, the only activities still being carried out from the wartime era were the storage of bulk explosives and propellants and the infrequent demolition of unexploded ordnance (UXO) found at the installation. As of 2013, the only activities still being performed at the former RVAAP, besides military training, include environmental restoration, ordnance clearance, and infrequent demolition of any UXO during investigation and remediation activities.

2.1.2 Demography and Land Use

The 2010 Census (U.S. Census Bureau, 2010) lists the total populations of Portage County and Trumbull County as 161,419 and 210,312, respectively. Population centers closest to the former RVAAP are Ravenna, with a population of 11,724, and Newton Falls, with a population of 4,795.

The former RVAAP facility is located in a rural area and is not close to any major industrial or developed areas. Approximately 55 percent of Portage County, in which the majority of the former RVAAP is located, consists of either woodland or farm acreage. The Michael J. Kirwan Reservoir (also known as West Branch Reservoir) is the closest major recreational area and is located adjacent to the western half of the former RVAAP, south of State Route 5.

The former RVAAP is a federal facility that is operated by the OHARNG. The ARNG/OHARNG manages the restoration and cleanup activities at the facility. The facility is currently used for military training.

2.2 SMABS Site Background and Description

CAIS test kits were sets of glass vials or bottles that contained small amounts of chemical agents. They were employed by all branches of the U.S. Armed Forces from 1928–1969 for the purpose of training in detection, handling, and familiarization with chemical warfare. Most CAIS were destroyed in the 1980s, but the U.S. Army Chemical Materials Agency still occasionally demilitarizes CAIS that are found buried.

The SMABS AOC is a location where sulfur mustard agent (dichlorodiethyl sulfide) is suspected to be buried, possibly in the form of CAIS. The depth at which the mustard agent may have been buried is not known. Of the various types of CAIS glass containers that have been identified as potentially containing mustard agent, all are believed to have been packed in metal--either metal paint/coffee type cans, 55-gallon drums, or steel shipping cylinders called PIGs (EQM, 2008).

According to UXO safety information on the DOD Environment, Safety, and Occupational Health Network and Information Exchange (DENIX) website (https://www.denix.osd.mil/), prior to the early 1970s, one of the approved procedures for disposing of CAIS was burial on training ranges or areas. When buried, CAIS were either buried in their original containers (PIGs) or loose. Normally, CAIS vials were broken before burial and decontaminant was used to neutralize any chemical agent present. Note that the DENIX website references wooden containers. Based on the *Description of Chemical Agent Identification Set Types, 2004*, the only CAIS packed in nonmetallic (wooden) containers was K945; however, all K945 kits were accounted for by the U.S. Army and destroyed (EQM, 2008). There is no definitive documentation of whether or not CAIS was onsite, so the procedures mentioned above are generic and purely speculative based on the methods usually used prior to burying CAIS.

According to the former RVAAP files, in 1969, the U.S. Army excavated a suspected mustard agent burial site within the old demolition grounds in an area west of the current National Advisory Committee for Aeronautics (NACA) Test Area (NTA) (EQM, 2008). One 50-gallon drum and seven small rusted cans were discovered. All recovered items were empty and no contamination was discovered, according to documentation which cites the results of these reports (EQM, 2008). It should be noted, however, that the original documentation regarding the excavation is no longer available, so it is unknown what exactly occurred during the investigation.

The SMABS AOC is located in the southwestern portion of the former RVAAP in Portage County as shown in **Figure 1-2** and consists of three investigation areas as shown in **Figure 1-3**. The 1969 Army Excavation Area and 2006 Geophysical Investigation Area are considered to be one area for the purposes of this report. The Universal Transverse Mercator coordinates for the SMABS AOC are 4557923.53 meters north, 489003.15 meters east, Zone 17T (based on the approximate location of the 1969 U.S. Army excavation area described below). The three investigation areas, located both north and south of Hinkley Creek, cover approximately 1.8 acres.

Currently, Camp Ravenna has placed precautionary restrictions at SMABS due to the suspected presence of mustard agent, per Army Military Munitions Response Program (MMRP) guidance. These current restrictions for SMABS prohibit access (i.e., Siebert stakes, signage, and fencing) and intrusive activities.

2.3 Physical Setting

This section presents the physical characteristics of the former RVAAP, the SMABS, and the surrounding environment that are factors in understanding fate and transport, receptors, and exposure scenarios for potential human health and ecological risks. The physiographic setting, hydrology, climate, and ecological characteristics of the former RVAAP were compiled primarily from information originally presented in the Final RVAAP Military Munitions Response Sites SI report (engineering-environmental Management, Inc., 2008), the *Integrated Natural Resources Management Plan* that was prepared for the OHARNG by AMEC Earth and Environmental, Inc. (AMEC) in 2008, and the DQO Report (Shaw, 2009). The following section addresses the general setting of the former RVAAP property as a whole with details regarding the SMABS AOC where relevant.

2.3.1 Topography and Vegetation

Overall, the installation is relatively flat with occasional broad ranging hills, although there are occasional steep slopes. Many of the steep slopes are due to modifications of the landscape from cut-and-fill operations during the construction of the ammunition plant in the 1940s. The elevation ranges across the facility from approximately 930 feet above mean sea level (amsl) to approximately 1,200 feet amsl.

The SMABS is situated in the southwestern quadrant of the former RVAAP facility, as shown on **Figure 1-2**. Topography across the SMABS is relatively flat (see **Figure 2-1**), with the AOC areas located approximately 1,080 feet amsl. The portion of the SMABS AOC

located south of Hinkley Creek is in a wooded area along an abandoned power line right-of-way (SAIC, 1998). The portion of the SMABS AOC located near the NACA crash strip is relatively flat, sloping gently towards Hinkley Creek to the west and south. The area around the concrete pad is nonforested. However, the area to the west of the concrete pad is heavily vegetated with scrub brush and trees, some of them greater than 10 inches in diameter.

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 former RVAAP, including the SMABS AOC. Wetlands were mapped as being located in the western portion of the AOC area west of the NACA crash strip (AMEC, 2008), along the southwestern portion of the 2006 study area and nearest Hinkley Creek (EQM, 2008).

In June 2012, the US Army Corps of Engineers, Pittsburgh District conducted a wetland delineation and stream assessment on the former RVAAP Western access route leading to the SMABS (USACE, 2013). The investigation identified four palustrine emergent wetlands, totaling 6852.25 square feet and a single intermittent stream channel within the study area. One wetland (2188.24 square feet) directly abuts an unnamed tributary to Hinkley Creek making it a Water of the United States, while the other three wetlands, totaling 4664.01 square feet, are hydrologically isolated.

2.3.2 Climate

The general climate of the former RVAAP area is continental and is characterized by moderately warm and humid summers, reasonably cold and cloudy winters, and wide variations in precipitation from year to year. The following climatological data were obtained from the Midwest Regional Climate Center at the Youngstown-Warren Regional Airport located in Trumbull County and are based on a 30-year average between 1971 and 2000 (Midwest Regional Climate Center, 2000).

Total annual rainfall in the former RVAAP area is approximately 38.2 inches, with the greatest monthly average occurring in July (4.10 inches) and the lowest monthly average occurring in February (2.03 inches). Average annual snowfall totals approximately 55 inches, with the greatest monthly average occurring in January (14.3 inches). It should be noted that due to the influence of lake-effect snowfall events associated with Lake Erie, located approximately 35 miles to the northwest of the former RVAAP, snowfall totals vary widely throughout northeastern Ohio.

The average annual daily temperature in the former RVAAP area is 48.3 degrees Fahrenheit (°F), with an average daily high temperature of 58.2°F and an average daily low temperature of 38.8°F. The prevailing wind direction at the former RVAAP is from the southwest. Severe weather, in the form of thunder and hail in summer and snowstorms in winter, is common. Tornadoes are infrequent in Portage County; however, minor structural damage to several buildings on facility property occurred as the result of a tornado in 1985.

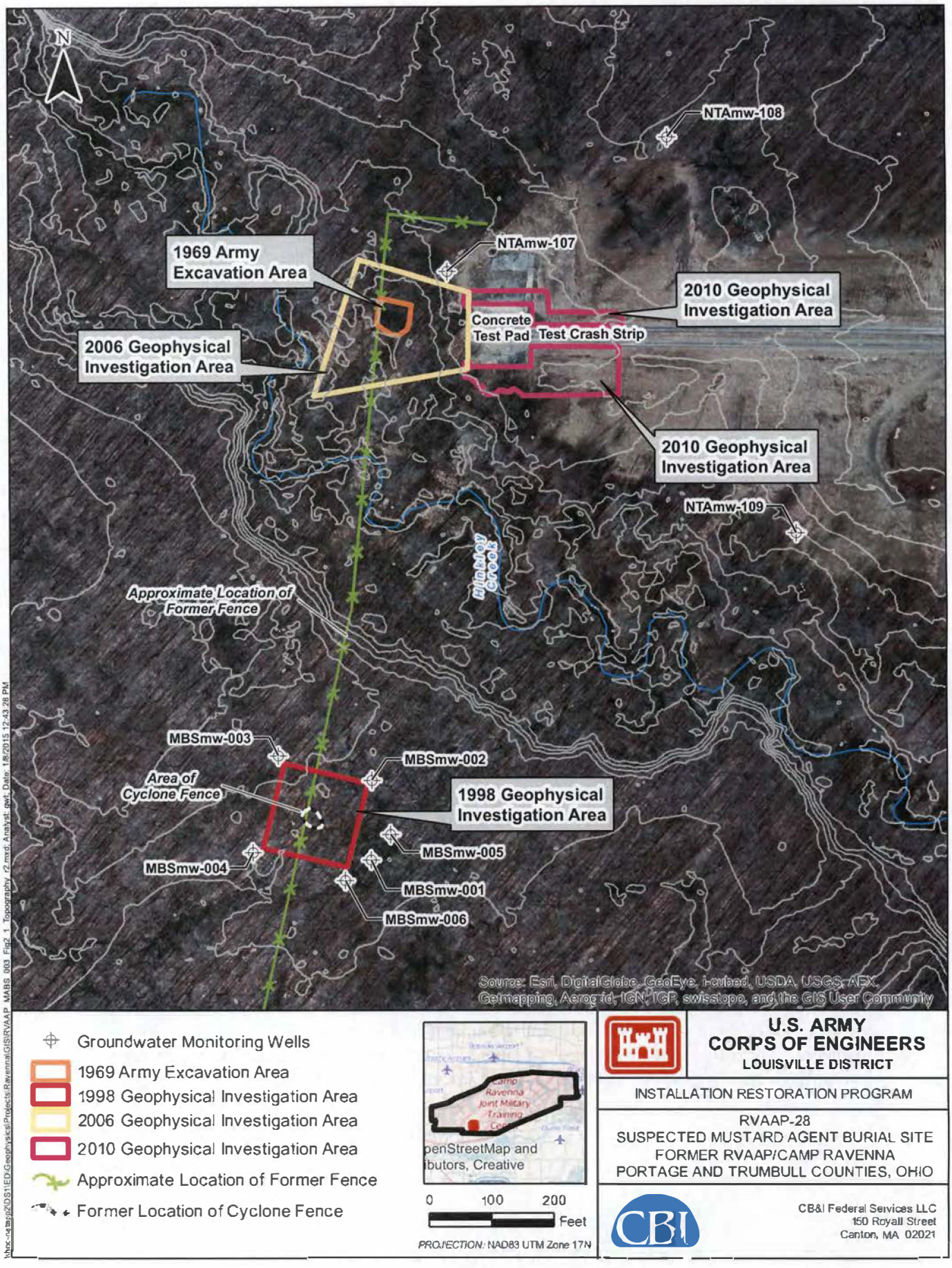

FIGURE 2-1 TOPOGRAPHY

2.3.3 Hydrology

The former RVAAP is located in the Mahoning River Basin (AMEC, 2008). Three major streams (South Fork Eagle Creek, Sand Creek, and Hinkley Creek) drain approximately 65 percent of the facility. The northern and central portions of the property are drained by Sand Creek, with a total drainage area of 13.5 square miles (8,640 acres). Sand Creek subsequently drains to South Fork Eagle Creek, which has a drainage area of 30.7 square miles (19,648 acres) and runs into Eagle Creek, and finally the Mahoning River. The western portions of the former RVAAP (including the SMABS) drain to Hinkley Creek, a 7.2-square-mile (4,608-acre) drainage basin, and subsequently to the West Branch of the Mahoning River. The eastern-most portion of the installation drains to the West Branch of the Mahoning River near its confluence with the main trunk of the Mahoning River. The southern areas drain directly into Michael J. Kirwan Reservoir. A number of smaller, unnamed creeks drain other areas of the facility (AMEC, 2008). Surface water flow directions in the vicinity of the SMABS AOC are shown on **Figure 2-2**.

2.3.4 Area Water Supply

According to the 2012 *Portage County Water Quality Report* (Portage County Water Resources Department, 2012), area water supply includes both surface water and groundwater sources. The City of Ravenna's water supply is Lake Hodgson, which is located approximately 5.5 miles southwest of the former RVAAP. Other nearby municipalities use groundwater supply wells. Based on the Ohio Department of Natural Resources (ODNR) *Ground-Water Resources of Portage County* map (1979), the nearest municipal groundwater well to the SMABS AOC is located approximately 9 miles to the north. Potable water at the former RVAAP is pumped from three wells, though the City of Newton Falls provides potable water and sewage services for the east side of the former RVAAP in Trumbull County (U.S. Geological Survey [USGS], 2003).

2.3.5 Geologic and Hydrogeologic Setting

This section includes a discussion of regional geology, soil types, and hydrogeologic setting of the former RVAAP and SMABS.

2.3.5.1 Regional Geology and Physiography

The regional geology at the former RVAAP consists of horizontal to gently dipping bedrock strata of Mississippian and Pennsylvanian age overlain by varying thickness of unconsolidated glacial deposits. The former RVAAP is situated within the glaciated Allegheny Plateau section of the Appalachian Plateaus Province. The general terrain is gently rolling, which is characteristic of postglacial moraine formations. Glacial till deposits from the Wisconsinan glacial period mark surficial geology at the former RVAAP, with occasional outcrops of bedrock of the Pottsville formation.

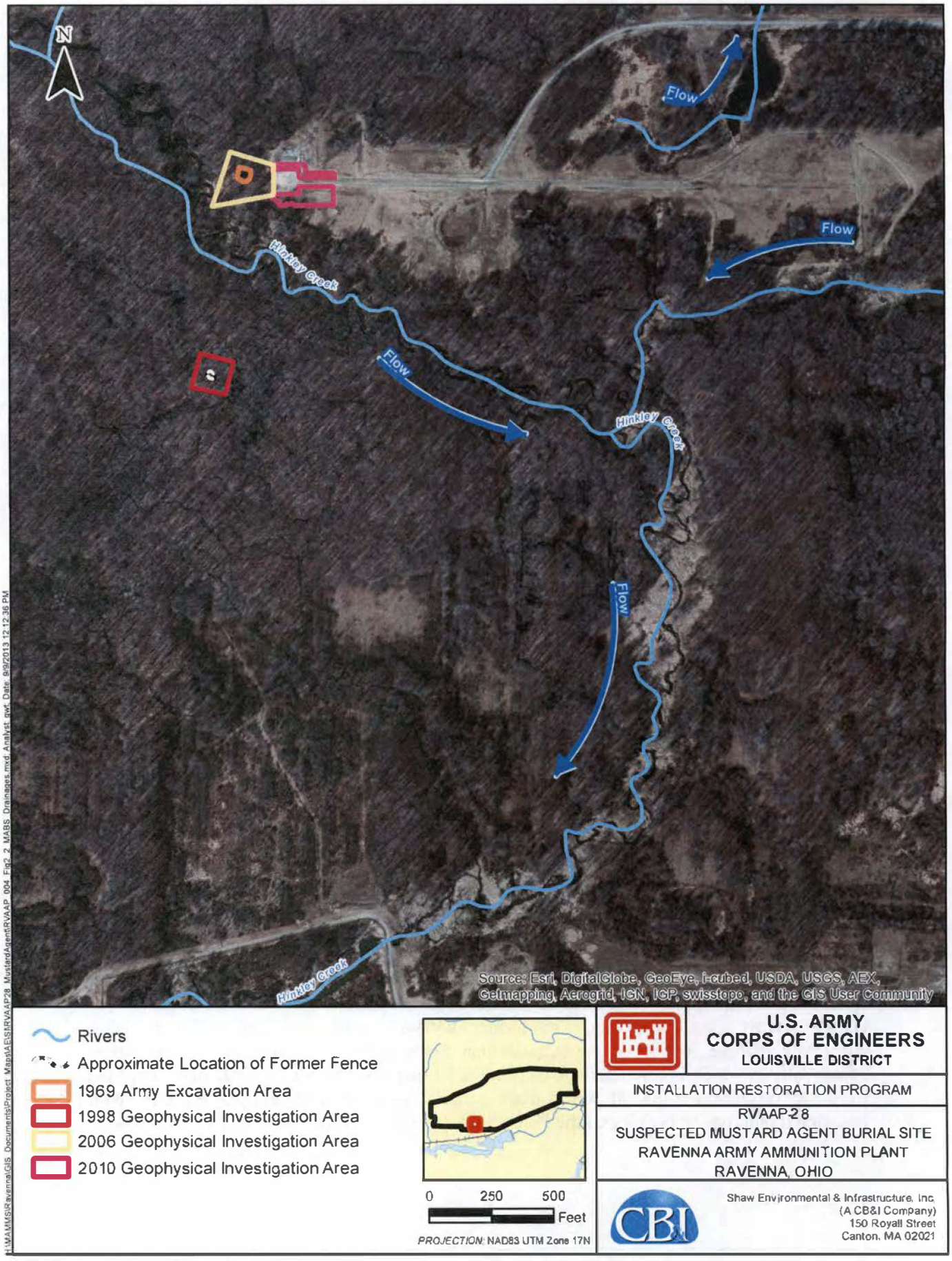

FIGURE 2-2 SURFACE WATER DRAINAGE FEATURES

The Pennsylvanian-age Pottsville sandstone formation, composed of coarse, permeable sandstones to impermeable shales, is the uppermost bedrock unit underlying the former RVAAP. The Pottsville formation is underlain by Mississippian-age shale of the Cuyahoga formation.

The former RVAAP is located within the Southern New York section of the Appalachian Plateaus physiographic province. Rolling topography containing incised streams and dendritic drainage patterns are prevalent in the province. Rounded ridges, filled major valleys, and areas covered with glacially derived unconsolidated deposits were the product of glaciation in the Southern New York section. In addition, bogs, kettle lakes, and kames are evidence of past glacial activity in the province. Old stream drainage patterns were disturbed and wetlands were created within the province as a result of past glacial activity (engineering-environmental Management, Inc., 2008).

2.3.5.2 Soils

Soil types at the former RVAAP exist as a glacial veneer, and for the most part were formed in glacial till ground moraines on upland areas. Small pockets of end moraine material also exist throughout the installation. The soils covering the majority of the installation have a thin layer of topsoil, are heavily textured, seasonally wet, strongly acidic, and limited in productivity by poor drainage (AMEC, 2008). Installation soils have been heavily influenced in many areas by human-related activities, including agriculture, cut-and-fill operations, fire, and general construction related activities. Eight soil associations exist at the former RVAAP: Chili, Fitchville-Haskins-Sebring, Loudonville-Mitiwanga-Dekalb, Mahoning-Ellsworth, Ravenna-Canfield, Remsen-Geeburg-Trumbull, Sebring-Holly-Canaedea, and Wadsworth-Rittman.

The eastern two-thirds of the property is the Hiram Till, a 5- to 15-foot-thick, clay-rich, relatively impermeable till deposited as a ground moraine. The Hiram Till overlies thin beds of sandy outwash material in the far northeastern corner of the facility. The Hiram Till generally falls in the Mahoning-Ellsworth soil association (AMEC, 2008). The Lavery Till was deposited along the western one-third of the installation (AMEC, 2008). The Lavery Till is composed of silty sand material, few cobbles, and sporadic boulders, and is approximately 20 to 40 feet thick. The Lavery Till generally falls in the Wadsworth-Rittman soil association. In addition to the glacially-formed soils, recent alluvium is present in the Lower Sand Creek area and in the Eagle Creek/Sand Creek confluence area, which is considered the Sebring-Holly-Canaedea association. Additional outwash sand and gravel is present in the elevated area of the northeastern corner of the installation (AMEC, 2008). This installation has very little difficulty with erosion control. Generally, slope on the installation is 5 percent or less. Most areas have a slope of 2 percent or less.

2.3.5.3 Regional 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. Recharge of these units comes from surface water infiltration of precipitation and surface streams (SpecPro, 2006).

The major aquifers underlying the former RVAAP are the sandstone units of the Pottsville formation. These aquifers exist under artesian conditions, and are typically confined by glacial drift or shale. Within this formation, the Sharon Conglomerate is the most productive of these units, and is the major bedrock aquifer in northeastern Ohio. The study performed by Kammer (1982) indicated that of the 71 groundwater wells that penetrated the installation at that time, 57 were penetrating the Sharon Conglomerate. Data from the Kammer study indicated that the thickness of the Sharon Conglomerate ranges from 44 to 177 feet, while the average well depth at the former RVAAP is approximately 155 feet, with a range between 83 and 261 feet (Kammer, 1982).

Groundwater flow at the former RVAAP is generally from west to east. The general shallow groundwater flow directions in the vicinity of SMABS are shown on **Figure 2-2**. Groundwater flow at the SMABS AOC is towards the south-southeast portion of the AOC. (SpecPro, 2006). Throughout the facility, average depth to groundwater is as deep as 50 feet below ground surface (USACE, 2004). However, groundwater has been encountered at much shallower depths in the upper unconsolidated aquifer across the property. Groundwater flows from bedrock highs in the western portion of the property toward stream valleys in the eastern portion; these latter areas act as discharge areas, as indicated by static water levels in monitoring wells across the installation (Kammer, 1982). The groundwater table occurs within the unconsolidated zone in many areas of the installation. Because of the very heterogeneous nature of the unconsolidated glacial materials, groundwater flow patterns are difficult to determine with a high degree of accuracy. Vertical recharge from precipitation likely occurs via infiltration along root zones and partings within the soil column. Laterally, most groundwater flow likely occurs along preferential pathways such as sand seams, channel deposits, or other stratigraphic discontinuities having higher permeabilities than surrounding clay or silt-rich materials (SpecPro, 2006).

Regionally, groundwater recharge occurs via surface streams and surface infiltration through sand and gravel within buried valleys. Two large buried valleys occur southwest and northwest of the facility, and can yield up to 1,600 gallons per minute of groundwater from wells penetrating those particular glacial tills.

The majority of the property itself is comprised of clay-rich glacial till with low permeability and underlying bedrock formations with extremely variable, but relatively low permeability. Typical yields from wells penetrating the Sharon Conglomerate range from 5 to 200 gallons per minute; usually yields from the overlying unconsolidated sediments are considerably lower. In addition, the thickness and permeability of the bedrock formation/unit producing the water at the former RVAAP vary considerably and have a strong effect on well yields, transmissivity, and hydraulic conductivity (Kammer, 1982).

2.3.5.4 Geologic and Hydrogeologic Setting of the SMABS

As shown on **Figure 2-3**, soils at the SMABS AOC investigation areas north of Hinkley Creek consist of the Fitchville silt loam series. This series exhibits 0 to 2 percent slopes, is

somewhat poorly drained, and has low permeability. Soils at the SMABS AOC investigation area south of Hinkley Creek consist of the Bogart silt loam series. This series exhibits 0 to 2 percent slopes. This soil is characterized as a deep, moderately well-drained, nearly level soil formed in sandy and gravelly glacial outwash material, with permeabilities ranging from 4.23x10-4 to 4.23x10-3 centimeters/second. Furthermore, runoff is slow and there is little or no hazard of erosion (U.S. Department of Agriculture, 1978). The surficial geology at the SMABS consists of the Lavery Till. In general, the clayey and silty Lavery Till consists of approximately 28 percent sand and 30 percent clay, but percentages can vary.

As shown on **Figure 2-4**, bedrock beneath the SMABS AOC is mapped as the Sharon Sandstone-Conglomerate Unit of the Cuyahoga Formation.

Mississippian- and Pennsylvanian-age sandstones and conglomerates make up the stratigraphy underlying the Hiram and Lavery Tills at the former RVAAP. The Mississippian Cuyahoga Formation, consisting of blue-gray silty shale with interbedded sandstone, crops out in the far northeastern corner of the facility. The Cuyahoga Formation has a gentle southward regional dip of 5 to 10 feet per mile. The remainder of the facility is underlain by the Pottsville Formation of Pennsylvanian age. The Pottsville rests unconformably on the eroded Cuyahoga Formation, and dips 5 to 10 feet per mile.

The Connoquenessing, Mercer, and the Homewood Members of the Pottsville Formation are present beneath the western half of the former RVAAP. The Connoquenessing Member is coarse, gray sandstone with thin interbeds and partings of sandy shale. The Mercer Member, overlying the Connoquenessing Member, consists of silty to carbonaceous shale with thin, discontinuous sandstone lenses. The Homewood Member lies unconformably on the Mercer Member and consists of coarse-grained cross-bedded sandstones.

The Sharon Sandstone Conglomerate Unit is the primary formation that underlies the eastern half of the former RVAAP; however, the formation is also cross-bedded at the southwest portion of the former RVAAP where the SMABS AOC is located. The Sharon Conglomerate is frequently fractured, highly permeable, highly porous, coarse-grained, gray-white weathered orthoquartzite sandstone, with some white quartz pebbles and locally thin shale lenses. The Sharon shale overlies the conglomerate and consists of sandy, gray-black, fissile shale with plant fragments and thin flagstone beds. The groundwater elevation of water in the Homewood aquifer is more than 77 feet higher than the nearest basal Sharon Conglomerate well. This demonstrates that the Homewood aquifer and Sharon Conglomerate are not representative of the same hydraulic unit. If they were in the same hydraulic unit, the water levels would be expected to be much the same (EQM, 2012). There are five Sharon Conglomerate wells that are located through the basal portion of the Sharon aquifer. The groundwater elevations of the five nearest wells from the upper portion of the Sharon aquifer are 1.19 to 16.77 feet higher than the five basal Sharon Conglomerate groundwater elevations at the same locations. The average elevation difference is more than 8 feet. Again, this groundwater elevation difference indicates that the basal Sharon Conglomerate and the upper portion of the Sharon is not representative of the same hydraulic unit (EQM, 2012).

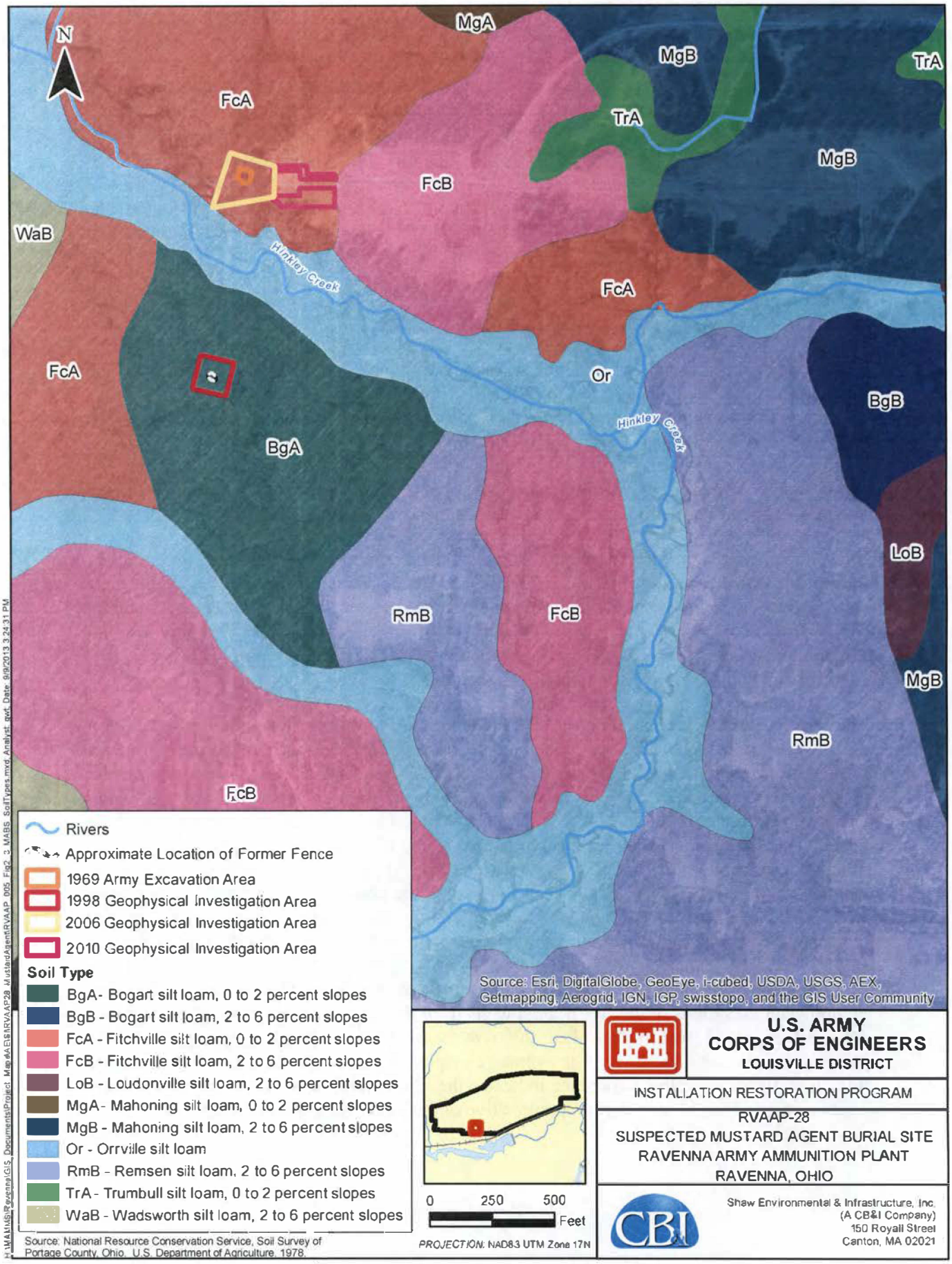

FIGURE 2-3 SOIL TYPES

Characterization of the groundwater regime through monitoring well installation and sampling was not part of the scope of the SI as this is being conducted under a facility-wide program. Subsurface hydrogeologic conditions at the SMABS are largely inferred from surface topography, surface water flow, soil conditions, and information from the surrounding NTA. Hydraulic conductivities measured during the slug tests at the SMABS AOC during the SpecPro monitoring well investigation for the wells screened in unconsolidated sediments were 3.4 x 10-4 centimeters/second, 1.1 x 10-3 centimeters/second, and 3.1 x 10-4 centimeters/second (SpecPro, 2006).

According to a Groundwater Resources of Portage County map prepared by the ODNR (1979), the depth to bedrock in this area of the former RVAAP is approximately 15 feet below surface grade with water yields of 30 gallons per minute from the underlying sandstone aquifer at a depth of 68 feet below surface grade.

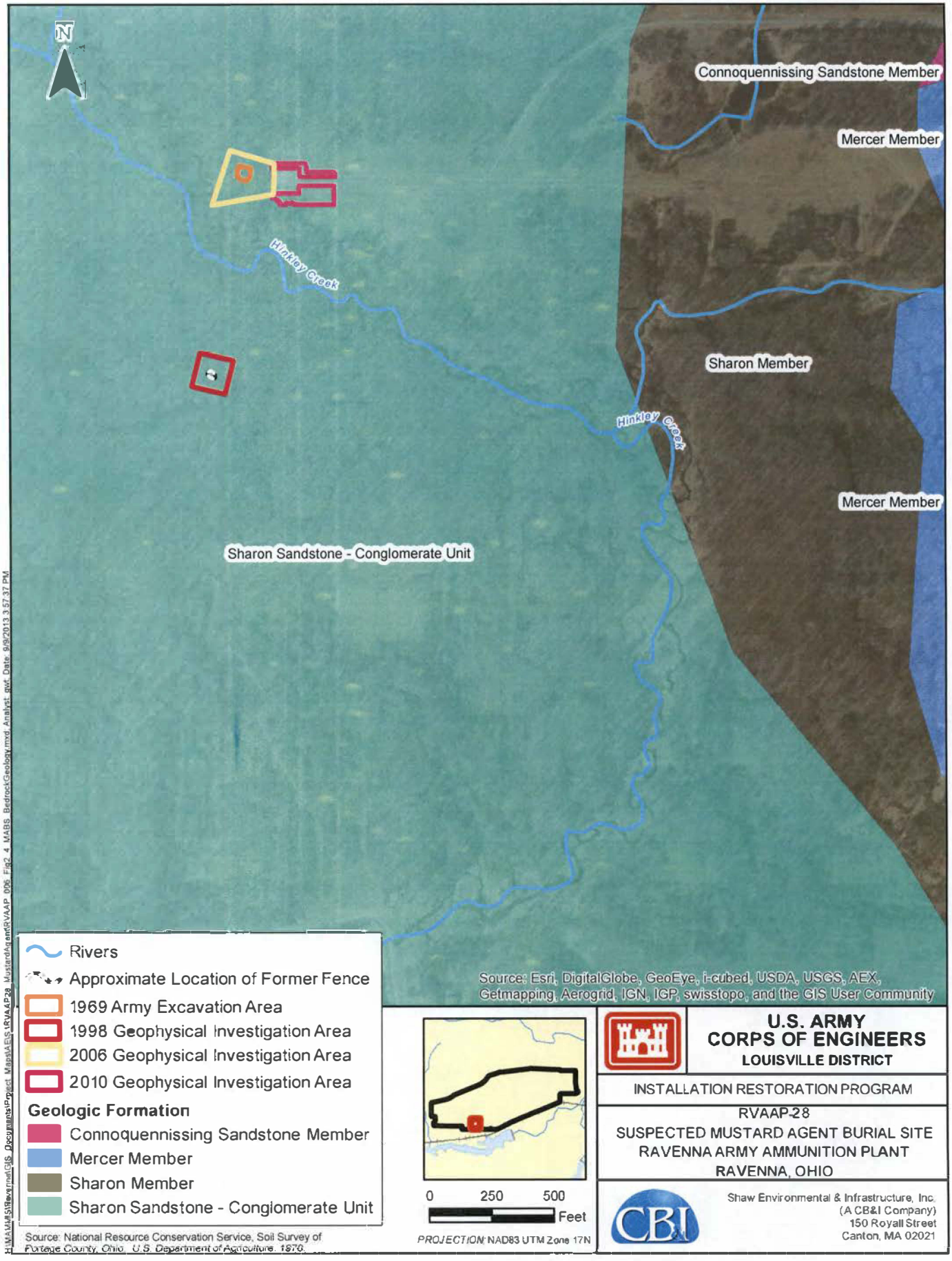

FIGURE 2-4 BEDROCK GEOLOGY

2.3.6 Ecological Environment and Receptors

The former RVAAP has a diverse range of vegetation and habitat resources. The majority of lands within the former RVAAP are post-successional agricultural lands, with the exception of a few areas of large mature forest and areas that were considered too wet to farm. Approximately 90 percent of the former RVAAP, with the exception of wet woods, had historically been cleared and used for agriculture or otherwise disturbed (AMEC, 2008). Habitats currently present within the former RVAAP include large tracts of closed-canopy hardwood forest, scrub/shrub open areas, grasslands, wetlands, open-water ponds and lakes, and semi-improved administration areas.

Vegetated land at the former RVAAP can be divided into three broad vegetation categories: (1) herb-dominated, (2) shrub-dominated, and (3) tree-dominated (AMEC, 2008). Tree-dominated areas are the most widespread form of vegetation across the former RVAAP. The remaining acres at the former RVAAP that are not dominated by vegetation include areas previously developed or disturbed through the emplacement of structures, roads, and other development.

Available estimates indicate that approximately one-third of the former RVAAP facility property meets the regulatory definition of a wetland, with the majority of the wetland areas located in the eastern portion of the facility. Wetland areas at the former RVAAP include seasonal wetlands, wet fields, and forested wetlands. Many of the wetland areas are the result of natural drainage or beaver activity; however, some wetland areas are associated with anthropogenic settling ponds and drainage areas (AMEC, 2008). Federal status as a candidate, threatened, or endangered species is derived from the Endangered Species Act (*16 United States Code § 1538, et seq.*) and is administered by the U.S. Fish and Wildlife Services. State-listed plant and animal species are determined by the ODNR. There are currently no federally listed species or critical habitats on Camp Ravenna property. There are species under federal review for listing, but none are listed. Information regarding endangered, threatened, and candidate species at the facility was obtained from the Camp Ravenna Rare Species List (2014). **Table 2-1** presents State-listed and Federal-listed species that have been confirmed to be on the facility by biological inventories and confirmed sightings. **Table 2-2** presents listed species not known to exist within Camp Ravenna, but were noted within the vicinity.

Table 2-1
Camp Ravenna Rare Species List
Mustard Agent Burial Site
Ravenna Army Ammunition Plant, Ravenna, Ohio

Common Name	Scientific Name
State Endangered	
American bittern	*Botaurus lentiginosus*
Black Bear	*Ursus americanus*
Brush-tipped emerald	*Somatochlora walshii*
Graceful underwing	*Catocala gracilis*
Handsome sedge	*Carex formosa*
Mountain brook lamprey	*Ichthyomyzon greeleyi*
Narrow-necked Pohl's moss	*Pohlia elongata* var. *elongata*
Northern harrier	*Circus cyaneus*
Philadelphia panic-grass	*Panicum philadelphicum*
Sandhill crane	*Grus canadensis*
Tufted Moisture-loving moss	*Philonotis fontana* var. *caespitosa*
Variegated scouring-rush	*Equisetum variegatum*
State Threatened	
Barn owl	*Tyto alba*
Bobcat	*Felis rufus*
Caddisfly	*Psilotreta indecisa*
Hobble-bush	*Viburnum alnifolium*
Least bittern	*Ixobrychus exilis*
Lurking leskea	*Plagiothecium latebricola*
Simple willow-herb	*Epilobium strictum*
Trumpeter swan	*Cygnus buccinator*
Strict blue-eyed grass	*Sisyrinchium montanum*

Table 2-2 (continued)
Camp Ravenna Rare Species List
Mustard Agent Burial Site
Ravenna Army Ammunition Plant, Ravenna, Ohio

Common Name	Scientific Name
State Potentially Threatened Plants	
Arborvitae*	*Thuja occidentalis*
False hop sedge	*Carex lupuliformis*
Greenwhite sedge	*Carex albolutescens*
Long beech fern	*Phegopteris connectilis*
Pale sedge	*Carex pallescens*
Sharp-glumed manna-grass	*Glyceria acutifolia*
Shining ladies-tresses	*Spiranthes lucida*
Straw sedge	*Carex straminea*
Water avens	*Geum rivale*
Woodland horsetail	*Equisetum sylvaticum*
Federal Species of Concern	
Bald eagle	*Haliaetus leucocephalus*
Butternut	*Juglans cinerea*
Handsome sedge	*Carex formosa*

Table 2-1 (continued)
Camp Ravenna Rare Species List
Mustard Agent Burial Site
Ravenna Army Ammunition Plant, Ravenna, Ohio

Common Name	Scientific Name
State Species of Concern	
Big brown bat	*Eptesicus fuscus*
Bobolink	*Dolichonyx oryzivorus*
Cerulean warbler	*Dendroica cerulea*
Common moorhen	*Gallinula chloropus*
Creek heelsplitter	*Lasmigona compressa*
Deer mouse	*Peromyscus maniculatus*
Eastern box turtle	*Terrapene carolina*
Eastern garter snake	*Thamnophis sirtalis*
Eastern red bat	*Lasiurus borealis*
Eastern sand darter	*Ammocrypta pellucida*
Four-toed salamander	*Hemidactylium scutatum*
Great egret	*Ardea alba*
Henslow's sparrow	*Ammodramus henslowii*
Hoary bat	*Lasiurus cinereus*
Little brown bat	*Myotis lucifugus*
Marsh wren	*Cistothorus palustris*
Mayfly	*Stenonema ithica*
Moth	*Apamea mixta*
Moth	*Brachylomia algens*
Northern bobwhite	*Colinus virginianus*
Northern long-eared bat	*Myotis septentrionalis*
Prothonotary warbler	*Protonotaria citrea*
Pygmy shrew	*Sorex hovi*
Scurfy quaker	*Homorthodes furfurata*
Sedge wren	*Cistothorus platensis*
Sharp-shinned hawk	*Accipiter striatus*
Smooth green snake	*Opheodrys vernalis*
Sora rail	*Porzana carolina*
Southern Bog Lemming	*Synaptomys cooperi*
Star-nosed mole	*Condylura cristata*
Tri-colored bat	*Perimyotis subflavus*
Virginia rail	*Rallus limicola*
Woodland jumping mouse	*Napaeozapus insignis*
Yellow-bellied sapsucker	*Sphyrapicus varius*

Table 2-1 (continued)
Camp Ravenna Rare Species List
Mustard Agent Burial Site
Ravenna Army Ammunition Plant, Ravenna, Ohio

Common Name	Scientific Name
State Special Interest	
American Black Duck	*Anas rubripes*
Blackburnian warbler	*Dendroica fusca*
Black-throated blue warbler	*Dendroica caerulescens*
Brown creeper	*Certhia americana*
Canada warbler	*Wilsonia canadensis*
Dark-eyed junco	*Junco hyemalis*
Gadwall	*Anas strepera*
Golden-crowned kinglet	*Regulus satrapa*
Green-winged teal	*Anas crecca*
Hermit thrush	*Catharus guttatus*
Least flycatcher	*Empidonax minimus*
Magnolia warbler	*Dendroica magnolia*
Mourning warbler	*Oporornis philadelphia*
Northern shoveler	*Anas clypeata*
Northern waterthrush	*Seiurus noveboracensis*
Pine siskit	*Carduelis pinus*
Purple finch	*Carpodacus purpureus*
Red-breasted nuthatch	*Sitta canadensis*
Redhead duck	*Aythya americana*
Ruddy duck	*Oxyura jamaicensis*
Subflava sedge borer moth	*Archanara subflava*
Wilson's Snipe	*Gallinago delicata*
Winter wren	*Troglodytes troglodytes*
State Extripated	
Golden-winged warbler	*Vermivora chrysoptera*

Source: Camp Ravenna Joint Military Training Center Federal and State Species List. 28 February 2014.
**Arborvitae was planted on site and does not occur naturally within the facility.*

Table 2-2
Listed Species Noted Within the Vicinity of Camp Ravenna (Not Known to Exist Within Camp Ravenna)
Mustard Agent Burial Site
Ravenna Army Ammunition Plant, Ravenna, Ohio

Common Name	Scientific Name
Federal Endangered	
Indiana Bat	*Myotis sodalis*
Mitchell's satyr	*Neonympha mitchellii*
Clubshell mussel	*Pleurobema clava*
Federal Threatened	
Northern Monkshood	*Aconitum noveboracense*
Federal Candidate Species	
Eastern Massasauga	*Sistrurus catenatus catenatus*
State Endangered	
Northern Monkshood	*Aconitum noveboracense*
Indiana Bat	*Myotis sodalis*
Upland Sandpiper	*Bartramia longicauda*
State Threatened	
Flat-Stem Pondweed	*Potamogeton zosteriformis*
State Potentially Threatened	
Virginia Meadow-beauty	*Rhexia virginica*
White Beak-rush	*Rhynchospora alba*
Rare Plant Communities	
Floodplain Forest	*n/a*

Source: Camp Ravenna Joint Military Training Center Federal and State Species List, 28 February 2014.

2.3.7 Sulfur Mustard in the Environment

Sulfur mustard released into surface soils may be lost by volatilization. Droplets deposited on surfaces evaporate slowly, large quantities may remain intact during cool weather or under winter conditions. Sulfur mustard freezes below 15°C, which allows it to be persistent in soils at low temperatures. Mustard buried deep in the soil, where it cannot vaporize or undergo weathering, can persist for years. Mustard can also degrade in soil through hydrolysis. The rate depends on the moisture in the soil. Thus, the major fate pathways would be hydrolysis in soil due to soil moisture and evaporation at the soil surface.

The vapor pressure of mustard is moderate, but is still sufficient for mustard to be in the air immediately surrounding droplets of the liquid. At moderate temperatures (25°C), mustard deposited on the surface of soil will evaporate within 30-50 hr. Factors that influence vaporization include weather, pH, moisture content, porosity of the surface, and physical constituents of the soils.

Hydrolysis is the primary degradation route for sulfur mustard in water. Due to its very low aqueous solubility and the slow rate at which it dissolves, sulfur mustard is considered fairly persistent in the environment. Hydrolysis occurs slowly at lower temperatures. Mustard is not transported through soil into groundwater due to low solubility in water and the rate at which mustard will undergo hydrolysis once dissolved.

Mustard can be biodegraded in soil through the thioether oxidation pathway, hydrolytic dechlorination, reductive dehalogenation and dehydrohalogenation. Sulfur mustard does not bioconcentrate or biomagnify due to its reactivity and it is unlikely that it is transported through the vascular systems of plants since it would almost surely undergo hydrolysis in the process.

Breakdown products of sulfur mustard include thiodiglycol and hydrogen chloride. Under certain conditions minor quantities of 1,4-dithiane and 1,4-oxathiane are also formed. The hydrolysis products of mustard are more water soluble and can migrate at a higher rate than mustard. They also degrade more slowly than mustard because the compounds are not utilized by microorganisms as efficiently (ATSDR, 2003; Munro et al., 1999).

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3.0 PREVIOUS SI ACTIVITIES AND FINDINGS

Since the initial excavation conducted by the U.S. Army in 1969 as described in Section 2.2, SI activities were completed at the SMABS AOC from 1996 through 2010 and were primarily nonintrusive in nature. Several groundwater monitoring wells were installed at the SMABS AOC in 2004 and 2005 in order to gain information at the AOC without having to implement intrusive subsurface activities; monitoring and results are discussed below.

The following sections describe the SI activities and results. These activities have been previously documented in the following reports, including geophysical survey reports (SAIC, 1998; EQM, 2008), the DQO Report (Shaw, 2009), the GPO Report (Shaw, 2010), and the DGM Report (Shaw, 2011). The information presented in this section was obtained from those previous reports.

3.1 Limited Surficial Soil Sampling, 1996

As stated in Section 2.2, the initial investigation of a suspected mustard agent burial site was conducted by the U.S. Army in 1969. According to reports that are no longer available, recovered items were empty and no contamination was discovered in the excavated area shown on **Figure 1-3**, located west of the NTA (SAIC, 1998).

A second suspected mustard agent burial site was identified by an unidentified and undocumented source as being located in the wooded area approximately 500 feet south of Hinkley Creek along an abandoned power line right-of-way (SAIC, 1996). This second suspected site, measuring 270 square feet, was marked and enclosed by a cyclone fence (as shown on **Figure 1-3**). However, only remnants of the fence existed in 2006 and the area has since been marked with Seibert stakes. Two surface soil samples were collected from this area during the Relative Risk Site Evaluation conducted in 1996 by the U.S. Army Center for Health Promotion and Preventive Medicine (1996). The surface soil samples were tested for thiodiglycol, a mustard agent decomposition product, and no concentrations were detected at or above the method detection limit (22.5 parts per million) (SpecPro, Inc. [SpecPro], 2004). It should be noted, however, that since the soil samples taken were surface only, the results may not necessarily show any potential subsurface contamination, since it is unlikely that mustard buried at depth would have a surface expression of breakdown products.

3.2 Geophysical Survey, 1998

In 1998, SAIC conducted a digital geophysical mapping (DGM) survey at an approximately 18,900-square-foot area along the abandoned power line right-of-way centered on a 270-square-foot formerly fenced area where the surface soil samples were collected in 1996 (**Figure 3-1**).

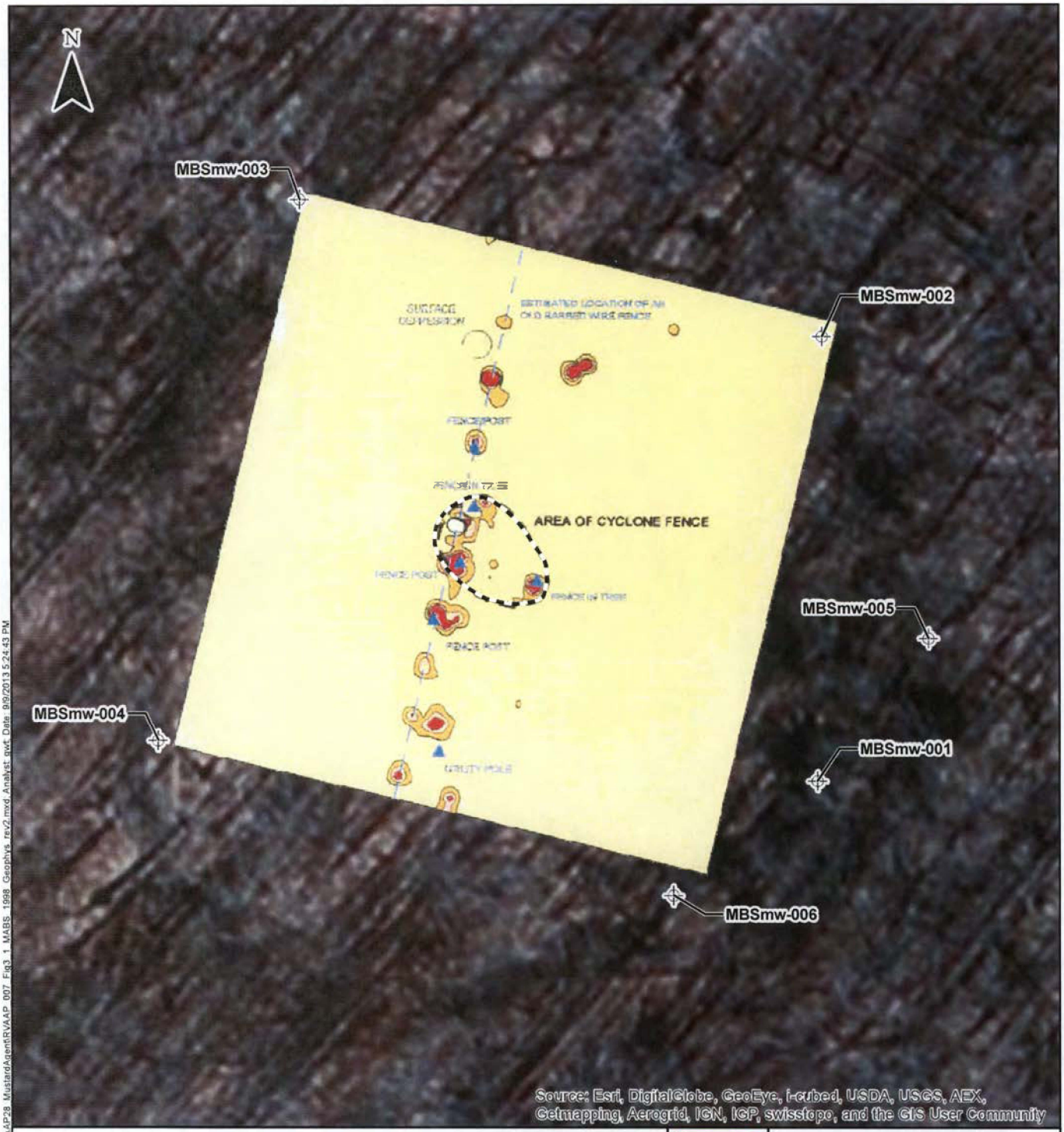

FIGURE 3-1 1998 GEOPHYSICAL INVESTIGATION AREA AND RESULTS

Several anomalies were identified, which may have been the result of metallic objects or cultural features located at or near ground surface. During the survey, metal fencing embedded in trees and buried fallen fence posts were discovered. Some of the anomalies were attributed to a former barbed wire fence that trended through the area. However, the results determined that it was difficult to discriminate these interferences from any potential buried waste containers. In conclusion, there was no signature of disturbed soils or numerous buried metallic objects that would clearly delineate a former burial site (SAIC, 1998).

3.3 Groundwater Investigation, 2004–2011

Between 2004 and 2005, SpecPro conducted a groundwater investigation under a separate facility-wide groundwater program that included installation of six monitoring wells around the perimeter, including locations hydraulically downgradient of the portion of the SMABS AOC located along the abandoned power line right-of-way as shown on **Figure 1-3**. Mustard agent breakdown products were not detected in any of the groundwater samples collected during the sampling events (SpecPro, 2006). In October 2011, an additional monitoring event was conducted with no detections of mustard agent breakdown products reported in Monitoring Wells MBSmw001 through MBSmw-006 (EQM, 2012). The groundwater samples were analyzed for 1,4-dithiane; 1,4-oxathine; and thiodiglycol. EPA method 8270C CWM was used to analyze 1,4-oxathiane and 1,4-dithiane. EPA method 8321A was used to analyze thiodiglycol. The detection limit was 0.88 ug/L for 1,4-dithiane, 1 ug/L for 1,4-oxathiane, and 10 ug/L for thiodiglycol.

3.4 Employee Interviews and Geophysical Surveys, 2006

In July 2006, stakeholders, which included members from the OHARNG, the Ohio Environmental Protection Agency, BRACD, and the USACE, conducted an interview with three local members of the public who formerly worked at the former RVAAP and claimed to have knowledge of suspected mustard agent burial areas at the facility. One of the former workers interviewed identified a new area adjacent to the concrete pad at the west end of the NACA crash strip. This location encompasses the 1969 excavation area and is nonforested and flat (EQM, 2008).

As reported by EQM (2008), additional historical records were also researched to determine the location and extent of the SMABS AOC. These records included historical USGS topographic maps (1908, 1960, 1970, 1977, and 1994) and USGS aerial photographs (1952, 1960, 1970, 1982, and 1994). Based on features identified on these maps and aerial photographs, along with the documented interviews with the former RVAAP employees, a possible burial area was identified and was the subject of the 2006 geophysical survey (as shown on **Figure 1-3**). As shown, this area encompassed the original 1969 excavation area.

EQM conducted a series of geophysical surveys at this SMABS AOC investigation area in 2006 using EM61, EM31, and ground penetrating radar (EQM, 2008). The objective of the investigation was to determine if mustard agent CAIS packaged in metal had been buried in an approximate 1-acre area located adjacent to the west end of the NACA crash strip and encompassing the area excavated in 1969 (**Figure 3-2**). The electromagnetic metal detection and electromagnetic conductivity maps included in the EQM report identified buried metallic

objects in the area where CAIS mustard agent was reportedly buried, but the extent of the area potentially affected had not been delineated. The results indicated that most of the metallic debris in that area may be buried within 5 feet of the ground surface. The trench-shaped anomaly is located at the western edge of the concrete pad and extending to the west, and is denoted on **Figure 3-2** as Anomaly A. It was noted in the EQM report that steel mill slag was commonly used as fill at the installation and could possibly be the source of the metallic anomalies (EQM, 2008). However, this cannot be determined without intrusively investigating the anomalies.

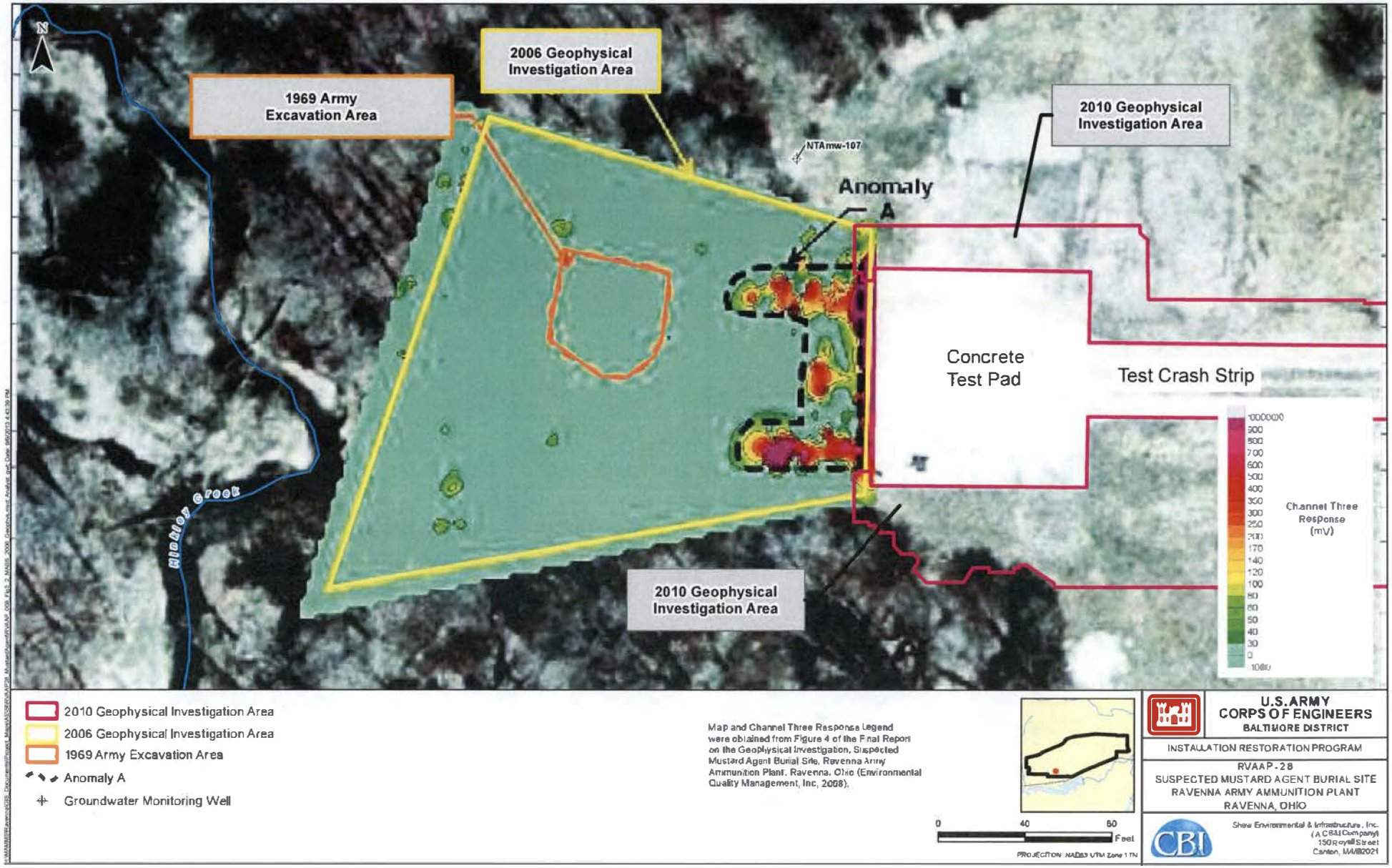

FIGURE 3-2 2006 GEOPHYSICAL INVESTIGATION AREA AND RESULTS

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3.5 Geophysical Surveys, 2010

The 2006 interview with a former employee described in Section 3.4 also indicated that the NACA crash strip concrete pad may cover part of the burial site. Therefore, in 2010, Shaw conducted a DGM survey to further evaluate the suspected burial area around the test pad at the NACA crash strip. The 2010 survey areas included locations north, south, and east of the concrete pad to an approximate depth of 5 feet below ground surface. Additionally, the survey area extended approximately 115 feet east of the concrete pad along the north and south sides of the NACA crash strip to rule out potential anomalies beyond the pad in this direction.

As reported in the DGM Report (Shaw, 2011), Shaw conducted the 2010 geophysical survey using various methodologies. The geophysical survey data indicate that there are anomalies related to anthropogenic features, and south and southeast of the suspected burial site, there are two regions characterized by relatively denser aggregates of individual anomalies (**Figure 3-3**). Several of these anomalies have characteristics similar to the larger MEC items presented in the GPO (90-millimeter and 155-millimeter projectiles and PIGs).

Beyond the north edge of the concrete pad, there are several subsurface anomalies that appear to be linear in nature and could possibly be related to subsurface utilities (i.e., former electrical conduit/drainage pipe/culvert, etc.). These features may be related to the concrete pad and are not indicative of mustard agent burial containers that were described to have been buried, based on the size, length, and perpendicular positions in relationship to the concrete pad. However, there are no available utility maps for the NTA that can be viewed to confirm that these anomalies are intended infrastructure associated with previous activities at the concrete pad.

3.6 Probability Assessment, 2013

The USAESC, in coordination with ARNG/OHARNG, prepared a Probability Assessment for the SMABS to document the probability of encountering chemical warfare materiel (CWM) prior to conducting ground disturbing (i.e., construction) or other intrusive activities (i.e., range clearance activities and environmental sampling), other than a CWM response, at CWM sites or sites where previous encounters with CWM have occurred or where there is evidence (i.e., historical or physical) that CWM may be present (USAESC, 2013). In addition to the geophysical testing results, the Probability Assessment presented results of archived records searches. A 2004 archive search report prepared for the former RVAAP indicated that "no records were found during the records search of any CWM at this installation." Furthermore, in a follow-up records review in 2012 of all documents available at the former RVAAP, there was no indication that any shipment of CWM had passed through the former RVAAP. However, historical documentation is most likely incomplete due to potential disposal of some archived documents over the years. Therefore, results should not rely solely on archived documentation but should consider sampling and geophysical results. Based on the Probability Assessment (USAESC, 2013), the probability of encountering CWM or CAIS at the SMABS is judged to be "Seldom". A "Seldom" probability is defined as "remotely possible (and) could occur at some time." In accordance with the Probability Assessment's recommendation, work in this area can be conducted as

non-CWM without MEC support. However, the site-specific safety and health plan to identify and address any encounters with CWM or CAIS in future activities shall include a site-specific contingency plan for the SMABS for emergency response actions should CWM be encountered or suspected. If CAIS or an intact item with an unknown liquid fill are identified in the field, work will stop and the contingency plan will be initiated. The contingency plan would be incorporated in the installation standard operation plans.

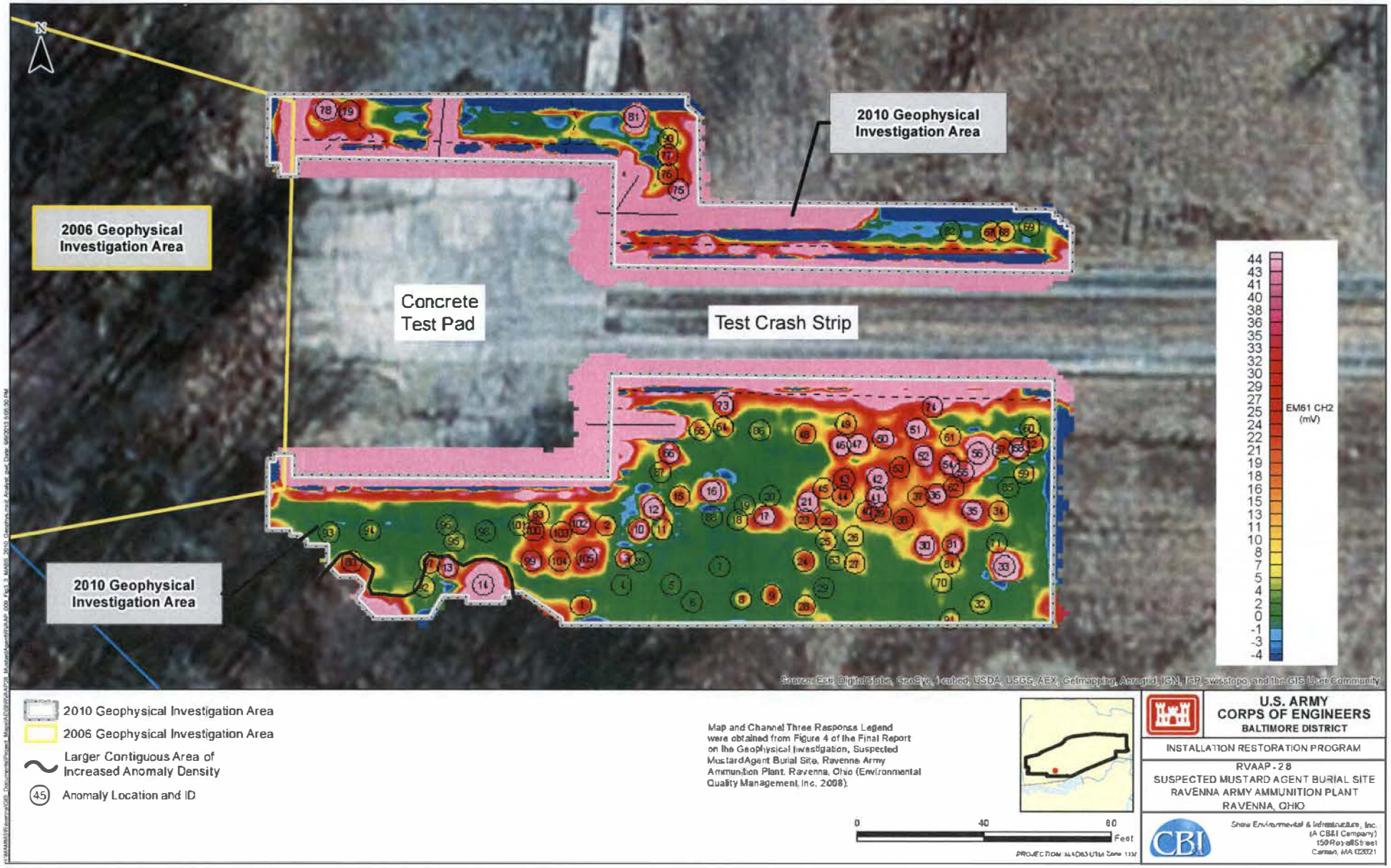

FIGURE 3-3 2010 GEOPHYSICAL INVESTIGATION AREA AND RESULTS

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4.0 SMABS EXPOSURE PATHWAY EVALUATION AND CONCEPTUAL SITE MODEL

This section evaluates the potential principal pathways for human or ecological exposure to CAIS and mustard agent at the SMABS AOC, and presents the conceptual site model based on the SI investigations.

4.1 Terrestrial Pathway

Soils at the SMABS contain anomalies identified during multiple geophysical investigations. The anomalies have not been investigated. Full-time personnel work at the facility.

The SMABS AOC is not currently used for military training activities, but may receive periodic foot traffic during restoration activities. Current restrictions for SMABS prohibit access (i.e., Siebert stakes, signage, and fencing) and intrusive activities. The OHARNG projected future land use for the SMABS AOC is as a restricted access site. The potential for current human exposure to contaminants migrating from the site is remote, but may occur at some time. Human exposure to potential contaminants is also mitigated by the current inactivity at the site (although limited military training occurs adjacent to the NTA), the absence of permanent residents, and the low population density on adjacent private properties. Based on findings of the SI the terrestrial pathway is considered potentially complete for human or ecological exposure.

4.2 Surface Water/Sediment Pathway

The investigation areas at the SMABS AOC do not include any major surface water features. Hinkley Creek is the nearest surface water, but is located outside the AOC. No surface water or sediment samples have been collected as part of SMABS SI activities. Because there are no surface water features within the AOC the surface water/sediment pathway is considered incomplete for human or ecological exposure.

4.3 Groundwater Pathway

Based on findings of the SI, there is no documented source in the SMABS and the possibility of encountering mustard agent at the SMABS is remote; therefore the groundwater pathway is considered incomplete for human or ecological exposure. A limited number of groundwater samples have been collected from monitoring wells installed outside the perimeter and hydraulically downgradient of the investigation area located along the abandoned power line right-of-way (the AOC investigation area south of Hinkley Creek). Groundwater samples have been collected over recent years from these monitoring wells and analyzed for mustard agent breakdown products with no detections in any of the groundwater samples. Further evaluation of the groundwater pathway via these monitoring locations will be conducted under the facility-wide groundwater AOC.

4.4 Air Pathway

Air was not considered to be a potential pathway, primarily because of the extensive ground cover and moisture present from the major surface water features (i.e., the creek and the swamp-like surrounding areas). Mustard agent would most likely be in the air immediately surrounding droplets on the surface, and would evaporate fairly quickly. There is no evidence of mustard on the surface. Furthermore, based on findings of the SI, the possibility of encountering CWM or CAIS at the SMABS is remote; therefore, the air pathway is considered incomplete for human or ecological exposure.

4.5 Conceptual Site Model

The conceptual site model for the former RVAAP presented in the Facility-Wide Sampling and Analysis Plan (SAIC, 2001) is applicable to the SMABS for the SI based on current knowledge. An interview with a former employee conducted on July 20, 2006, indicated that a suspected mustard agent burial site may be located west of the concrete pad at the west end of the NACA crash strip. The interview further indicated that the concrete pad may cover part of the suspected burial site. The 2006 geophysical investigation identified the presence of buried metallic objects near the western edge of the concrete pad, and shallow conductivity maps show an area of elevated conductivity in the same general area. The anomalies abut the concrete pad and, therefore, the limits of the buried material could not be delineated to the east. From the results, it is likely that substantial portions of this metallic debris may be buried within 5 feet of the ground surface, although accumulations of materials could exceed this depth in some areas. The report noted that steel mill slag was commonly used as fill at the installation and could possibly be the source of the metallic anomalies (EQM, 2008). This would require additional subsurface investigation to determine for sure. Additional geophysical testing conducted in 2010 along the north, south, and east of the pad indicated anomalies north and south of the pad as well (Shaw, 2011).

Based on limited surficial soil and perimeter groundwater sampling at one of the SMABS AOC investigation areas, no compounds related to mustard agent have been detected in soil or groundwater. Furthermore, during the 1969 excavation activities, no CAIS or contamination from CAIS were observed in the suspected burial site, according to report results. The actual reports for the 1969 excavation, however, are no longer available. Based on SI activities, there is no known historical or physical evidence that CAIS or mustard agent is present at the former RVAAP.

Human exposure to potential contaminants is mitigated by current inactivity at the site (although limited military training occurs at the adjacent NTA); the absence of permanent residents; and the low population density on adjacent private properties. Additionally, there is no known documented source in the SMABS and the possibility of encountering CAIS or mustard agent at the SMABS is remote. This report recommends that the AOC undergo an EE/CA to determine the cost of further investigation compared to the cost of evaluating and selecting remedial alternatives for the site.

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5.0 SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

This section presents a summary of the investigation activities conducted to date and conclusions and recommendations for the SMABS AOC.

5.1 Summary

The SMABS AOC consists of three investigation areas located in the south-southwestern portion of the former RVAAP (**Figures 1-2** and **1-3**). The SMABS AOC is a location where sulfur mustard agent (dichlorodiethyl sulfide), potentially in the form of CAIS, is suspected to potentially have been buried at the former RVAAP after World War II and before 1950, based on unconfirmed verbal evidence from former RVAAP employees. The mustard agent CAIS were developed by the U.S. Army from the 1930s through the 1960s. However, an archive search report prepared for the former RVAAP indicated that "no records were found during the records search of any CWM at this installation." Furthermore, in a follow-up records review in 2012 of all documents available at the former RVAAP, there was no indication that any shipment of CWM had passed through the former RVAAP. However, historical documentation is most likely incomplete due to potential disposal of some archived documents over the years. Therefore, results should not rely solely on archived documentation but should consider sampling and geophysical results.

The former RVAAP is a federal facility that is currently operated by the OHARNG. Full-time personnel work at the facility. Military training and operations are conducted at the facility. Currently, the land use of the SMABS is restricted access, due to the suspected presence of mustard agent.

In 1969, the U.S. Army excavated the original area identified by a former RVAAP employee as a suspected mustard agent burial site located west of the NACA concrete pad. One 50-gallon drum and seven small rusted cans were discovered. All recovered items were empty and no contamination was discovered, according to documentation which cites the results of the excavation reports. The original reports for this excavation are no longer available. Subsequent hearsay evidence indicated that the burial site was located to the south of Hinkley Creek.

To date, investigations at the SMABS AOC investigation areas, including the original excavation area, the area south of Hinkley Creek, and the extended areas around the NACA concrete pad, have been limited to one discrete soil excavation (1969), the collection of two surface soil samples, and geophysical mapping. Groundwater sampling has been conducted in the SMABS AOC in 2004 and 2005 during the SpecPro groundwater sampling events (SpecPro, 2006). Compounds related to mustard agent were not detected in the surface soil or in groundwater samples, and no other lines of evidence indicating the presence of CAIS or compounds related to mustard agent have been encountered.

The results of the geophysical investigations indicate that subsurface anomalies are present in the SMABS AOC investigation areas. Many of the anomalies were identified as possible cultural and anthropogenic features based on location, size, length, position, and/or historical

practices at the facility. Those anomalies include former fencing/fence posts, subsurface utilities, and steel mill slag. An EE/CA is recommended for this site to determine the cost of further investigation compared to the cost of evaluating and selecting remedial alternatives for the site.

Based on the findings of the Probability Assessment (USAESC, 2013), the possibility of encountering CWM or CAIS at the SMABS is remote. The recommendation from the Probability Assessment is that work in this area can be conducted as non-CWM without MEC support. However, a site-specific contingency has been developed to address any encounters with CWM or CAIS during future activities and emergency response procedures for SMABS should CWM be encountered. The contingency plan will be incorporated into the installation standard operating procedures.

Based on the exposure pathways evaluation, the SMABS AOC represents a remote exposure potential for human or environmental receptors, although exposure could occur at some time. The SMABS AOC was scored as a low relative risk designation under the DOD's relative risk site evaluation methodology (SAIC, 1996).

5.2 Conclusions and Recommendations

Based on the Probability Assessment, the possibility of encountering CWM or CAIS is remote, but could occur at some time. According to the geophysical data available, there are anomalies present which could be caused by metallic items the size of items of potential concern. This potentiality cannot be ruled out without an intrusive investigation of the anomalies. Therefore, this SI Report recommends an Engineering Evaluation/ Cost Analysis (EE/CA) and Action Memorandum to determine the cost of investigation verses the cost of evaluating and selecting remedial alternatives (i.e. Land Use Controls), such as fencing the site off.

In accordance with the Probability Assessment (USAESC, 2013) and as a common-sense safety measure , a site-specific contingency plan for encountering items with unknown liquid fill (such as mustard agent) has been developed and finalized for SMABS for potential emergency response actions in the remote event that CWM is encountered. Users and planners of activities in these areas should remain aware of the possibility of contamination and be alert to what actions to take in the event of encountering potential indications of such. The site-specific contingency plans will be integrated into installation standard operating procedures.

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