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**Final Data Quality Objectives Report for the
RVAAP-28 Mustard Agent Burial Site
Version 1.0**

Ravenna Army Ammunition Plant
8451 St. Route 5
Ravenna, Ohio 44266-9297

Contract No. W912QR-08-D-0013
Delivery Order 0002

Prepared for:



**US Army Corps
of Engineers**®
Louisville District

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May 11, 2009

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CONTRACTOR'S STATEMENT OF INDEPENDENT TECHNICAL REVIEW

Shaw Environmental & Infrastructure, Inc. has completed the Final Data Quality Objectives Report for RVAAP-28 Mustard Agent Burial Site at the Ravenna Army Ammunition Plant, Ravenna, 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, and utilization of 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 Corps policy.

Reviewed/Approved by:  Date: 5/11/2009
David Cobb
Project/Program Manager


Prepared/Approved by:  Date: 5/11/2009
David Crispo, P.E.
Technical/Regulatory Lead

Table of Contents

List of Figures	ii
Acronyms and Abbreviations	iii
1.0 Introduction	1-1
1.1 Purpose and Scope	1-1
1.2 Site Description and Background	1-1
1.2.1 Mustard Agent Burial Site	1-2
1.2.2 Previous Investigation Activities	1-2
2.0 Data Quality Objectives	2-1
2.1 Conceptual Site Model	2-1
2.2 State the Problem	2-2
2.3 Identify Decisions to be Made	2-2
2.4 Define Study Boundaries	2-2
2.5 Identify Decision Rules	2-2
2.6 Identify Inputs to the Decision	2-2
2.7 Specify Limits on Decision Error	2-3
2.8 Optimize the Sample Design	2-3
3.0 Evaluation of Geophysical Data	3-1
4.0 Sample Design	4-1
4.1 Geophysical Investigation	4-1
4.1.1 Rationales	4-1
4.1.2 Geophysical Investigation Location	4-1
4.1.3 Geophysical Investigation	4-1
4.1.3.1 General Geophysical Survey Procedures	4-2
5.0 Summary of Conclusions	5-1
6.0 References	6-1

List of Figures

Figure 1-1	Location Map	1-4
Figure 1-2	RVAAP Facility Map.....	1-5
Figure 1-3	Site Map.....	1-7
Figure 3-1	EM61 Channel Three Map.....	3-3
Figure 3-2	EM61 Channel Difference Map.....	3-5
Figure 4-1	Proposed Geophysical Survey Locations	4-3

List of Appendices

Appendix A	Comment Response Table
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Acronyms and Abbreviations

A/E	Architectural/Engineering
AOC	area of concern
bgs	below ground surface
CAIS	Chemical Agent Identification Sets
DQO	data quality objective
DO	delivery order
EQM	Environmental Quality Management, Inc.
EM	electromagnetic
EMD	electromagnetic metal detection
FSAP	Facility-wide Field Sampling and Analysis Plan
GPO	geophysical prove-out
GPR	ground penetrating radar
IRP	Installation Restoration Program
LUCs	land use controls
MABS	Mustard Agent Burial Site
MMRP	Military Munitions Response Program
NACA	National Advisory Committee for Aeronautics
Ohio EPA	Ohio Environmental Protection Agency
PC	personal computer
QC	quality control
RVAAP	Ravenna Army Ammunition Plant
SAIC	Science Applications International Corporation
Shaw	Shaw Environmental & Infrastructure, Inc.
SOW	scope of work
USACE	U.S. Army Corps of Engineers
USACHPPM	U.S. Army Center for Health Promotion and Preventive Medicine

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1.0 Introduction

1.1 Purpose and Scope

This *Data Quality Objectives (DQO) Report* provides a systematic approach for evaluating data requirements to support the decision making process associated with possible future actions for the RVAAP-28 Mustard Agent Burial Site (MABS) located at the Ravenna Army Ammunition Plant (RVAAP) in Ravenna, Ohio (**Figure 1-1**). This *DQO Report* is being prepared by Shaw Environmental & Infrastructure, Inc. (Shaw) under Delivery Order (DO) 0002 for Architectural/Engineering (A/E) Environmental Services at RVAAP under the Indefinite Delivery/Indefinite Quantity Contract No. W912QR-08-D-0013. The task order was issued by the U.S. Army Corps of Engineers, Louisville District (USACE) on September 22, 2008.

The purpose of this *DQO Report* is to determine if there are any data gaps from past investigation activities at RVAAP-28 where subsurface conditions were not adequately characterized or if there are any other efforts required for environmental closure of the Area of Concern (AOC). Environmental closure for RVAAP-28 is expected to be land use controls (LUCs) that address all investigation results, both environmental and Military Munitions Response Program (MMRP) related. The evaluation processes presented in this document and performed under this DO were conducted in accordance with the Facility-Wide Data Quality Objectives described in the *Facility-Wide Sampling and Analysis Plan (FSAP)*; SAIC 2001) and the revised *Scope of Work (SOW)*, dated August 26, 2008, included as an attachment to the DO contract.

1.2 Site Description and Background

The RVAAP is located in northeastern Ohio within Portage and Trumbull Counties, approximately 1.6 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 facility is a parcel of property approximately 17.7 kilometers (11 miles) long and 5.6 kilometers (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 1-2**).

As of February 2006, a total of 20,403 acres of the former 21,683-acre RVAAP have been transferred to the United States Property and Fiscal Officer for Ohio and subsequently licensed to the Ohio Army National Guard for use as a training site. Currently, RVAAP consists of 1,280 acres in several distinct parcels scattered throughout the confines of the Camp Ravenna Joint Military Training Center (Camp Ravenna). RVAAP's remaining parcels of land are located completely within Camp Ravenna. Camp Ravenna did not exist when RVAAP was operational,

and the entire 21,683-acre parcel 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; therefore, references to the RVAAP in this document are considered to be inclusive of the historical extent of the RVAAP, which is inclusive of the combined acreages of the current Camp Ravenna and RVAAP, unless otherwise specifically stated. The Ohio Environmental Protection Agency (Ohio EPA) is the lead regulatory agency for investigation and remediation conducted by the Army under the U.S. Department of Defense IRP.

1.2.1 Mustard Agent Burial Site

The MABS is a location where Chemical Agent Identification Sets (CAIS), believed to consist of sulfur mustard agent, are suspected to have been buried. The mustard agent CAIS were developed by the Department of the Army from the 1930s through the 1960s. The mustard agent was reportedly buried at RVAAP in the 1950s. The depth at which the CAIS 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.

In 1969, the U.S. Army excavated a possible mustard agent burial site west of the National Advisory Committee for Aeronautics (NACA) Test Area (**Figure 1-3**). One 50-gallon drum and seven small rusted cans were discovered. All recovered items were empty and no contamination was discovered according to reports (USACHPPM 1996). An unidentified and undocumented source reported that the first site excavated was incorrectly identified, and that the mustard agent was buried nearby (USACHPPM 1996). The second proposed site for the mustard agent burial is located in the wooded area approximately 500 feet south of Hinckley Creek along an abandoned power line right-of-way. The suspected site was marked and fenced; however, only remnants of the fence still exist. The area is currently marked with Seibert stakes. A third area was identified by a former employee to be adjacent to the concrete pad at the west end of the NACA crash strip. This location is near the 1969 excavation area and is non-forested and flat, as shown in **Figure 1-3**.

1.2.2 Previous Investigation Activities

The previous study areas at the MABS 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 2006 as discussed below.

Two surface soil samples were collected from along the abandoned power line right-of-way located 500 feet south of Hinkley Creek during the Hazardous and Medical Waste Study conducted in 1996 (USACHPPM 1996). 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.

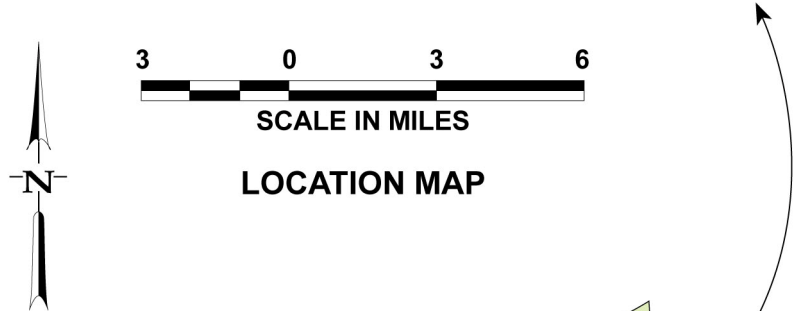
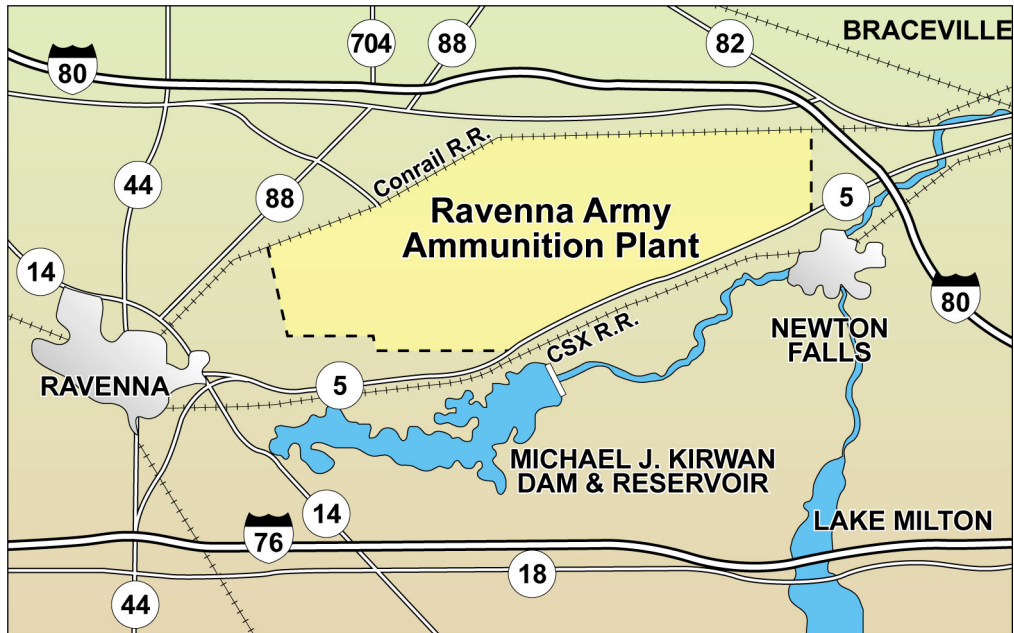
In 1998, Science Applications International Corporation (SAIC) conducted a geophysical survey using EM31 and EM61 electromagnetic metal detection (EMD) units at an approximately 270 square foot area along the abandoned power line right-of-way where the soil samples were collected. Several anomalies were present, which may have been caused by metallic objects being present or may have been related to surface cultural features 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).

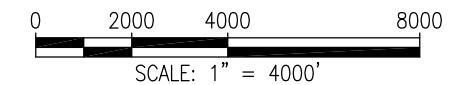
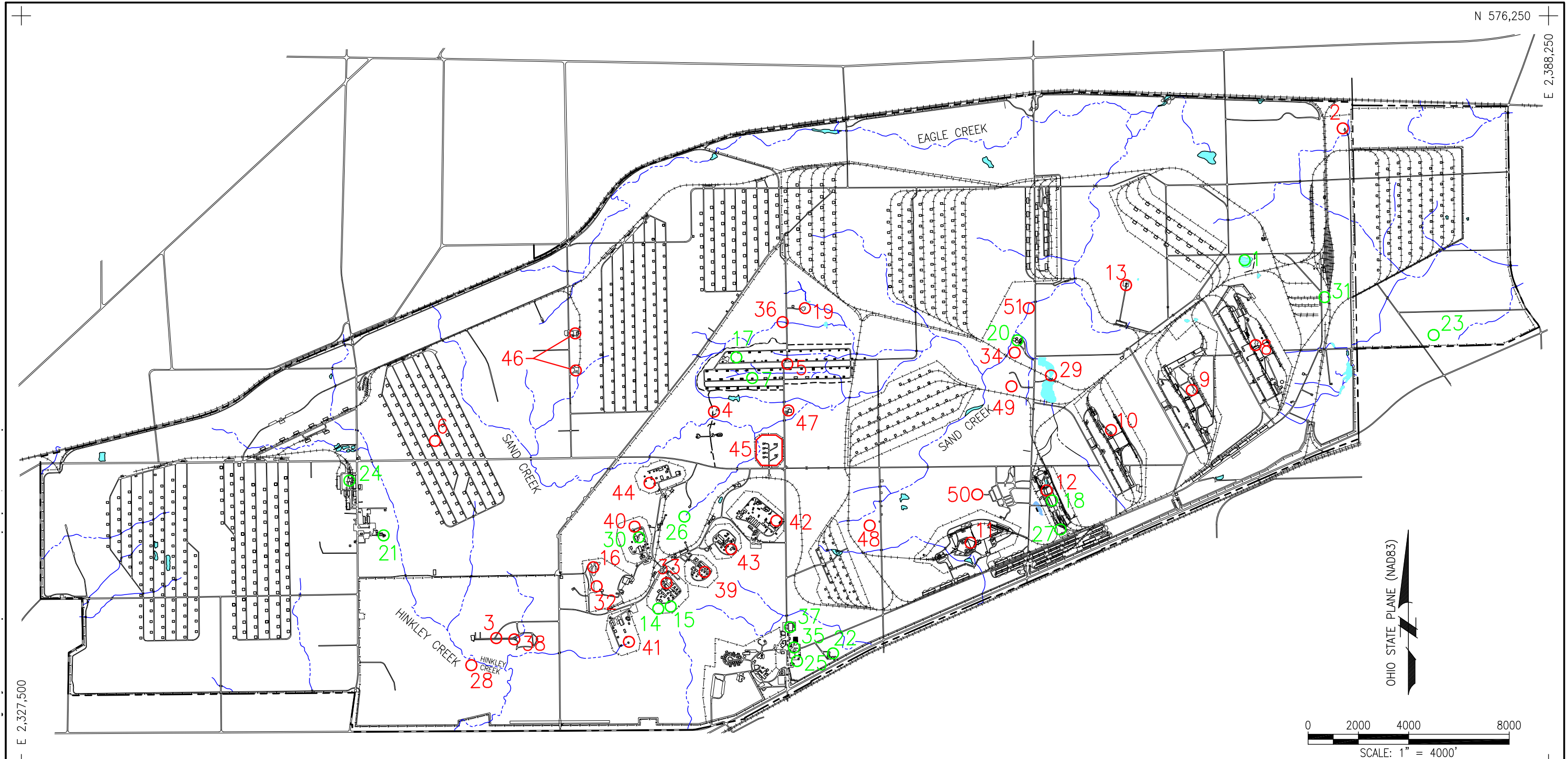
Between 2004 and 2005, SpecPro, Inc. conducted a groundwater investigation at the RVAAP-28 at the suspected area along the abandoned power line right-of-way that included the installation of six monitoring wells. Mustard agent breakdown products were not detected in any of the groundwater samples collected during the sampling events (SpecPro 2006).

Environmental Quality and Management, Inc. (EQM) conducted a series of geophysical surveys at the MABS in 2006 using various methodologies (EQM 2008). The objective of the project was to determine if mustard agent CAIS had been buried in an approximate 1-acre area located on the western portion of the RVAAP. The suspected area, as reported by a former employee, is located adjacent to the NACA crash strip near the area excavated in 1969 (**Figure 1-3**).

The EMD and electromagnetic (EM) conductivity maps included in the *Report on the Geophysical Investigation* (EQM 2008) at MABS identified buried metallic objects within the study area. Based on the results of the geophysical survey, the large metallic anomalies detected in the survey area, especially those that were trench shaped extending off of the edge of the concrete pad, were interpreted to be possible mustard agent test kits. 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.

**Figure 1-1
Location Map**





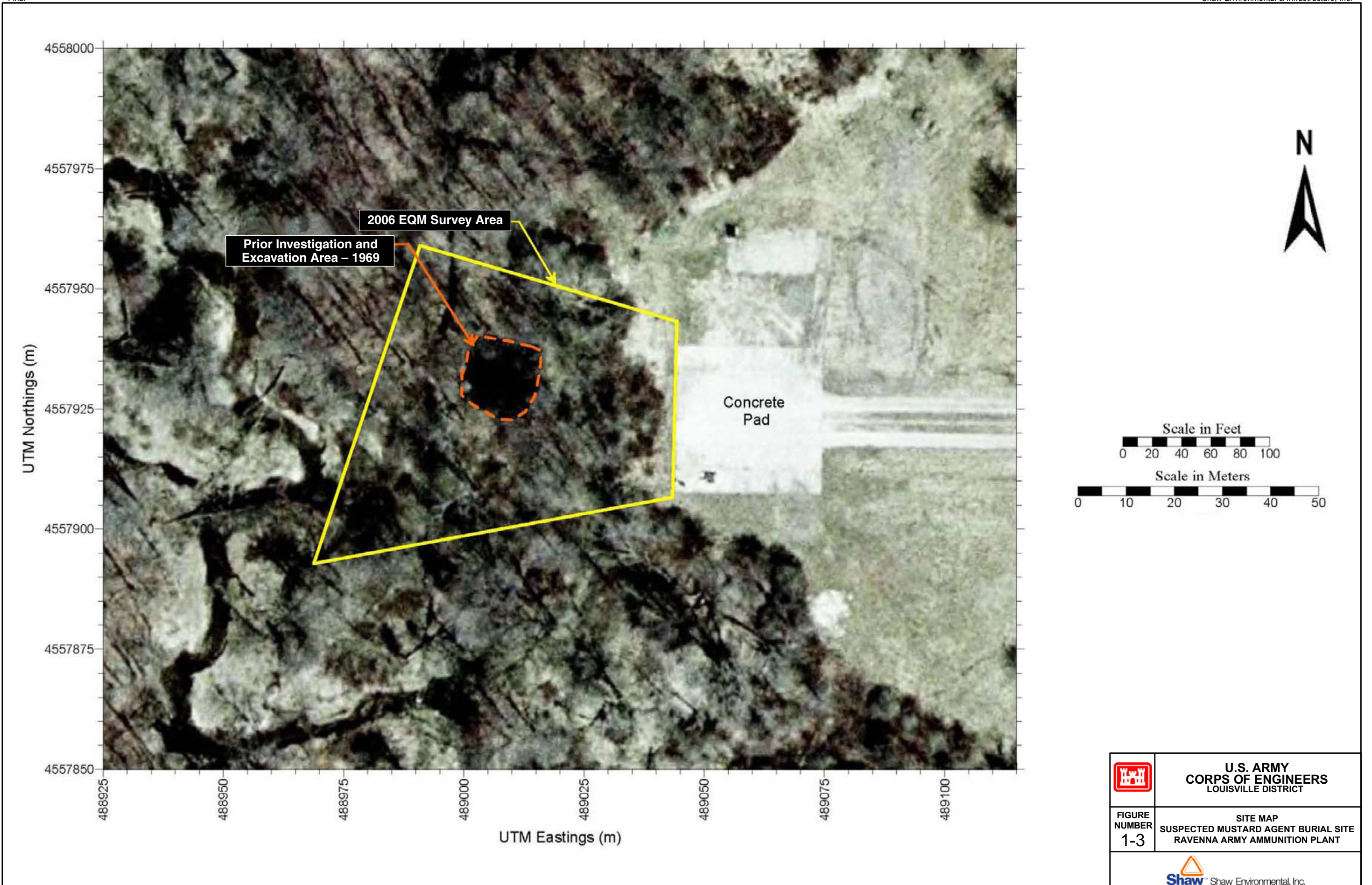
Legend	
1..... RAMSDLELL QUARRY LANDFILL	15..... LOAD LINE 6, TREATMENT PLANT
2..... ERIE BURNING GROUNDS	16..... QUARRY LANDFILL/FORMER FUZE AND BOOSTER BURNING PITS
3..... DEMOLITIONS AREA #1	17..... DEACTIVATION FURNACE
4..... DEMOLITIONS AREA #2	18..... LOAD LINE 12 PINK WASTEWATER TREATMENT
5..... WINKLEPECK BURNING GROUNDS	19..... LANDFILL NORTH OF WINKLEPECK BURNING GROUND
6..... C BLOCK QUARRY	20..... SAND CREEK SEWAGE TREATMENT PLANT
7..... BUILDING 1601 HAZARDOUS WASTE STORAGE	21..... DEPOT SEWAGE TREATMENT PLANT
8..... LOAD LINE 1 AND DILUTION/SETTLING POND	22..... GEORGE ROAD SEWAGE TREATMENT PLANT
9..... LOAD LINE 2 AND DILUTION/SETTLING POND	23..... UNIT TRAINING SITE WASTE OIL TANK
10..... LOAD LINE 3 AND DILUTION/SETTLING POND	24..... RESERVE UNIT MAINTENANCE AREA WASTE OIL TANK
11..... LOAD LINE 4 AND DILUTION/SETTLING POND	25..... BUILDING 1034 MOTOR POOL WASTE OIL TANK
12..... LOAD LINE 12 AND DILUTION/SETTLING POND	26..... FUZE BOOSTER AREA SETTLING TANKS
13..... BUILDING 1200 AND DILUTION/SETTLING POND	27..... BUILDING 854 PCB STORAGE
14..... LOAD LINE 6, EVAPORATION UNIT	28..... MUSTARD AGENT BURIAL SITE
29..... UPPER AND LOWER COBB'S POND COMPLEX	30..... LOAD LINE 7 PINK WASTEWATER TREATMENT PLANT
31..... ORE PILE RETENTION POND	32..... 40- AND 60-MM FIRING RANGE
33..... FIRESTONE TEST FACILITY	34..... SAND CREEK DISPOSAL ROAD LANDFILL
35..... BUILDING 1037 LAUNDRY WASTEWATER SUMP	36..... PISTOL RANGE
37..... PESTICIDE STORAGE BUILDING T-4452	38..... NACA TEST AREA
39..... LOAD LINE 5/FUZE LINE 1	40..... LOAD LINE 7/BOOSTER LINE 1
41..... LOAD LINE 8/BOOSTER LINE 2	42..... LOAD LINE 9/DETONATOR LINE
43..... LOAD LINE 10/PERCUSSION ELEMENT	44..... LOAD LINE 11/ARTILLERY PRIMER
45..... WET STORAGE AREA	46..... BUILDINGS F-15 AND F-16
47..... BUILDING T-5301 DECONTAMINATION	48..... ANCHOR TEST AREA
49..... CENTRAL BURN PITS	50..... ATLAS SCRAP YARD
51..... DUMP ALONG PARIS-WINDHAM ROAD	

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2.0 Data Quality Objectives

As part of the facility-wide approach to environmental investigation activities at RVAAP, facility-wide DQOs have been developed per the requirements outlined in the *FSAP* (SAIC 2001). As stated in the *FSAP*, the DQO process is a tool to guide investigations at Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) sites and will be incorporated to identify data gaps at RVAAP-28. The DQO process culminates in the reduction of uncertainty associated with decisions related to remedial design and response actions. The following are the steps that Shaw will utilize to implement the DQO process:

1. Develop the Conceptual Site Model
2. State the problem
3. Identify decisions to be made
4. Define the study boundaries
5. Develop the decision rule (if/then)
6. Identify inputs to the decision (data uses and data needs)
7. Specify limits on uncertainty
8. Optimize the sample design

2.1 Conceptual Site Model

The conceptual site model presented in the *FSAP* (SAIC 2001) is applicable to the MABS for this *DQO Report* based on current knowledge. An interview with a former employee conducted on July 20, 2006 indicated that the suspected MABS 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 burial site. The geophysical investigation conducted in 2006 indicated anomalies in the area immediately west of the concrete pad. The anomalies abut the concrete pad and, therefore, the limits of the buried material could not be delineated to the east. The survey area did not include the areas north, south, or east of the concrete pad, and the results in the areas immediately west of the pad indicate that the anomalies may extend along the north and south of the pad as well.

The overall facility geology is characterized by sedimentary bedrock overlain by a thin veneer of glacial sediments consisting of tills and outwash deposits. The site soil consists of silt and clay glacial deposits, which have apparently been disturbed by construction and fill activities. The specific study area is relatively flat, sloping gently towards Hinkley Creek to the west and south. The area around the concrete pad is non-forested; however, the EQM survey area to the west of the test pad is heavily vegetated with scrub brush and trees, some of them greater than 10 inches in diameter.

The EQM 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. 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).

2.2 State the Problem

The 2006 geophysical investigation showed anomalies in the area where mustard agent CAIS was reportedly buried but the extent of the area potentially affected has not been delineated.

2.3 Identify Decisions to be Made

The key decisions for all investigations at RVAAP have been identified in Section 3.2.4 and in Table 3-1 of the *FSAP* (SAIC 2001). Additional investigation is needed at RVAAP-28 to ultimately obtain a *Record of Decision* using LUCs that addresses all investigation results, both environmental and MMRP related. Data generated by the additional geophysical investigation will address the key decisions presented in Table 3-1 of the *FSAP* (SAIC 2001) and will be used to determine if the extent of the suspected mustard agent burial extends to the north, south, and east of the concrete pad or if any other metal objects are identified.

2.4 Define Study Boundaries

The boundaries for the proposed additional survey areas at MABS are discussed in **Section 4.0**. The area to be investigated is intended to supplement the previous geophysical investigation survey area as shown in **Figure 1-3** by extending the survey areas along the north, south, and east sides of the concrete pad and along the NACA crash strip as shown in **Figure 4-1**.

2.5 Identify Decision Rules

Decision rules to guide remediation decisions are provided in Section 3.2.6 of the *FSAP* (SAIC 2001); however, this site differs from most other sites at RVAAP since contact with concentrated mustard agent would be immediately dangerous to life and health. Therefore, the decision rule for this investigation is what is most protective of human health and the environment given the presumed presence of intact mustard agent containers at the burial site. No intrusive activities will be included in the identified decision.

2.6 Identify Inputs to the Decision

The inputs to the decision include the results of the geophysical investigation. The preferred instrument for this investigation will be the EM61-MK2 metal detector. The EM61-MK2 has very good stability, is very reliable in the detection of metallic anomalies, and is less affected by

disturbed soils and the highly conductive clayey soils at the site than the EM31 and GEM-2. Ground penetrating radar (GPR) is not proposed for use during this geophysical investigation since the method was determined to be of little value in further characterizing identified anomalies during the EQM investigation due to severe signal attenuation from the conductive clayey soils (EQM 2008).

2.7 Specify Limits on Decision Error

The objectives of the geophysical investigation is to accurately locate and record the location of anomalies and measurement errors in the collected data that can be minimized through proper planning and implementation of quality control (QC) procedures. The limits on the decision errors for the geophysical investigation, including QC and corrective measures to be implemented to correct, mitigate, or eliminate potential cause of DQO failure is presented in the *Shaw Geophysical Investigation Plan for RVAAP-34 Sand Creek Disposal Road Landfill, RVAAP-03 Open Demolition Area 1 and RVAAP-28 Mustard Agent Burial Site* (Shaw 2009).

2.8 Optimize the Sample Design

Further investigation at the MABS will focus on thorough subsurface characterization of the site using geophysical investigation methodology. In order to accomplish the geophysical investigation, biased locations will be used based on historical information, the results of previous geophysical investigations, interviews with previous workers at the RVAAP, and the conceptual site model. Data generated by the additional geophysical investigation will be used to determine if the extent of the MABS extends to the north, south, and east of the concrete pad or if any metal objects are identified. The proposed survey area will be the locations north, south, and east of the concrete pad to an approximate depth of 5 feet below ground surface (bgs). Additionally, the survey area will be 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. Grid design will be such that the coverage area is >90 percent of the total survey area, as specified in *Section G, Contractor Minimum Quality Control Requirements*, of the *SOW*.

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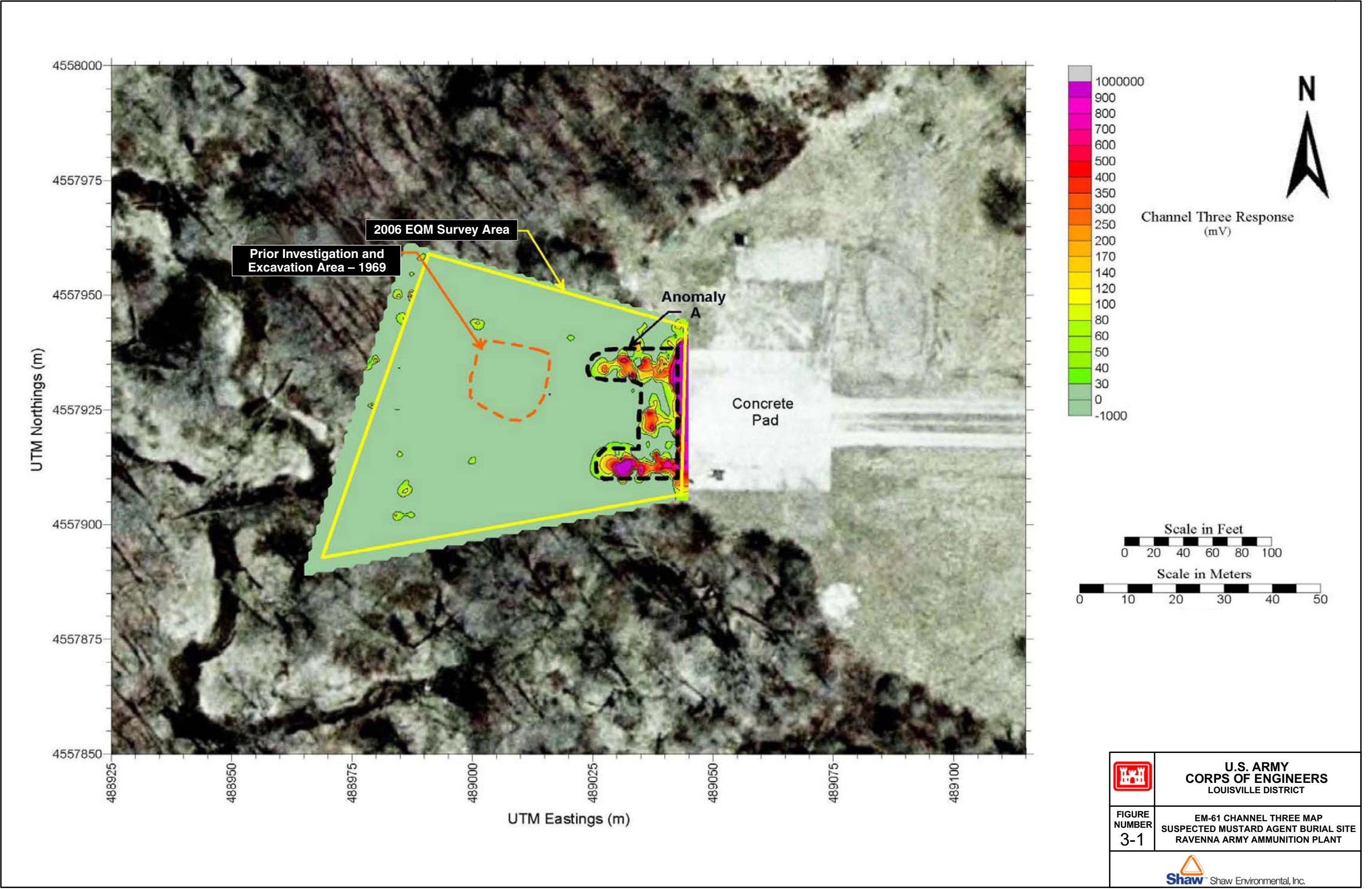
3.0 Evaluation of Geophysical Data

EQM performed a geophysical investigation at the MABS in 2006 using various survey methodologies including EMD, EM conductive mapping, and GPR. The surveys were conducted in an approximate 1-acre area west of the concrete pad adjacent to west end of the NACA crash strip. The mustard agent CAIS were reportedly buried in metal shipping containers; therefore, the purpose of the geophysical survey was to determine if buried metal objects existed in this study area.

The EM61 channel three and channel difference maps are presented as **Figures 3-1** and **3-2**, respectively. The earlier time gates of the EM61 (Channels 1 and 2) reveal the presence of a wide range of objects, and are most useful for locating all metallic objects within the study area. The last time gate (Channel 3) is a more selective view of metallic objects because it tends to indicate the locations of the most extensive and conductive objects. The additional measurement from the top coil (Channel 4) is used to filter out the effect of near-surface metallic materials, allowing for a distinction between deeper and shallower metallic objects. The filtering effect is obtained by subtracting the bottom coil response (Channel 3) from the top coil response (Channel 4) to yield the channel difference.

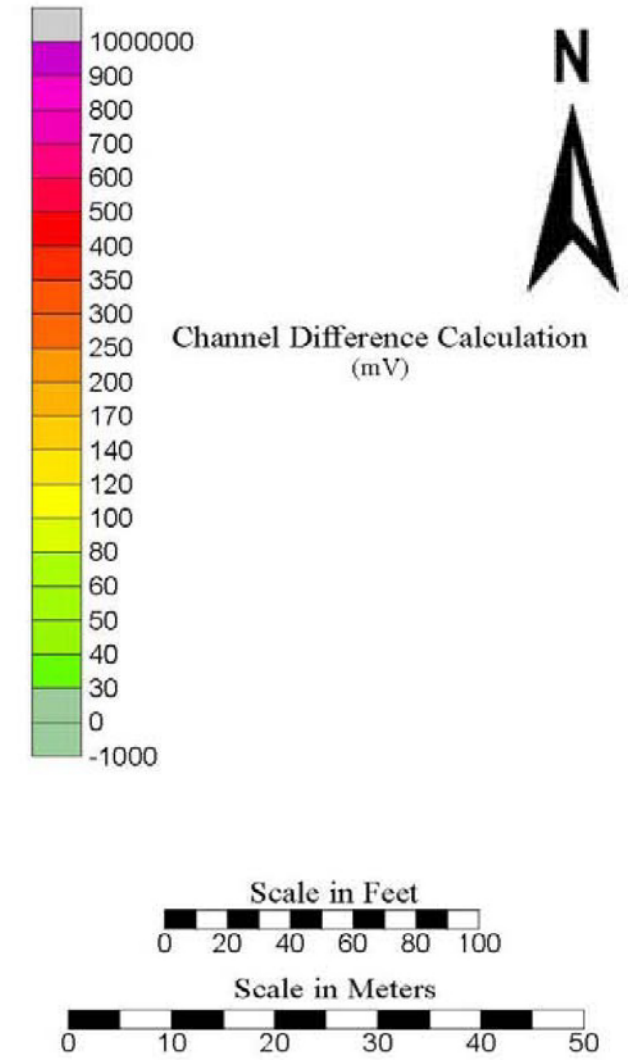
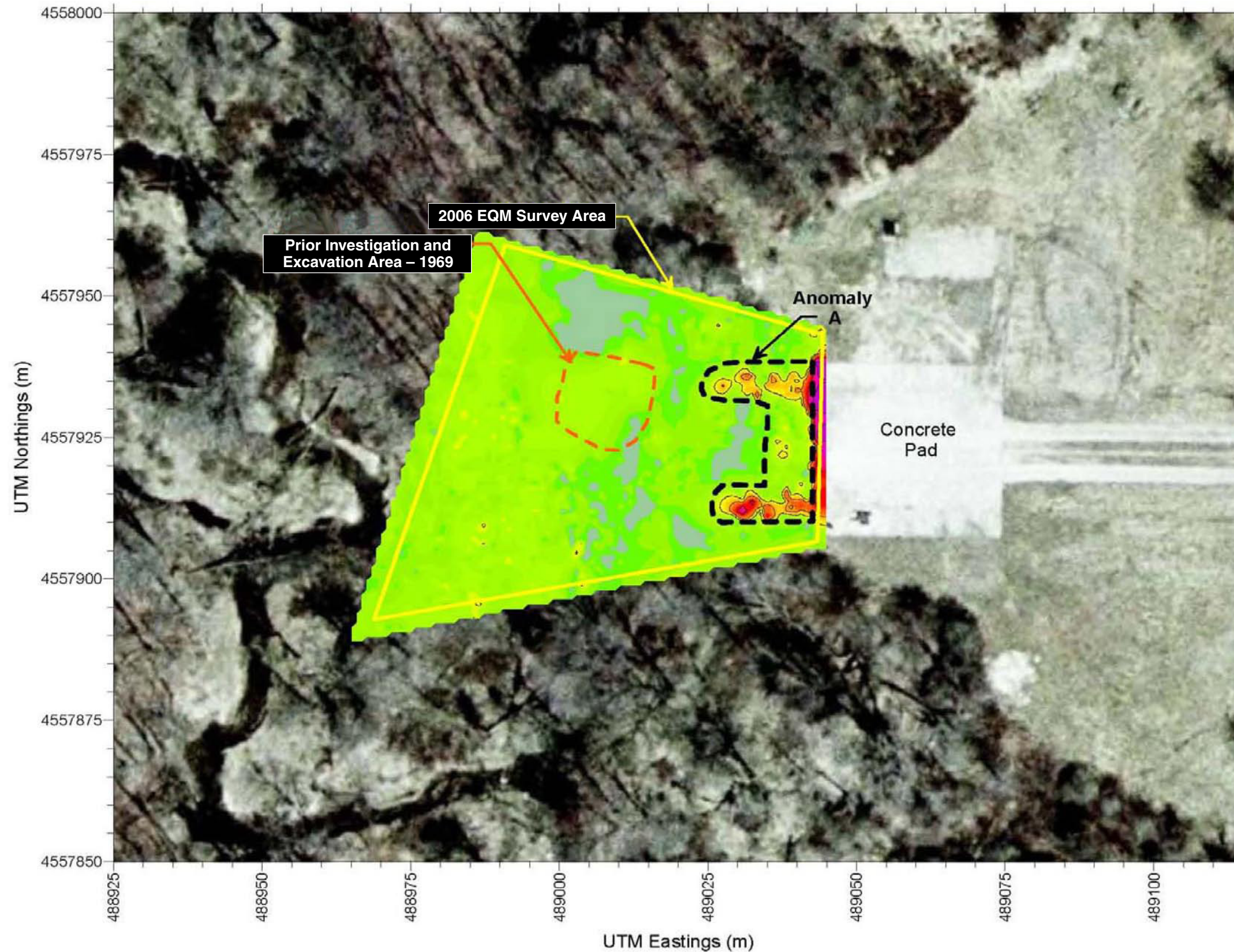
The EM61 maps from the EQM report indicate an irregularly shaped anomaly located at the western edge of the concrete pad and extending to the west; this has been denoted as Anomaly A (**Figures 3-1** and **3-2**). The center of this anomaly is much lower in amplitude on the channel difference map (**Figure 3-2**), indicating that this area contains predominantly shallow metal compared to the northern and southern lobes of the anomaly. From the results it is likely that substantial portions of this metallic debris maybe buried within 5 feet of the ground surface, although accumulations of materials could exceed this depth in some areas (EQM 2008).

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	U.S. ARMY CORPS OF ENGINEERS LOUISVILLE DISTRICT
FIGURE NUMBER 3-1	EM-61 CHANNEL THREE MAP SUSPECTED MUSTARD AGENT BURIAL SITE RAVENNA ARMY AMMUNITION PLANT
Shaw Environmental, Inc.	

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	U.S. ARMY CORPS OF ENGINEERS LOUISVILLE DISTRICT
FIGURE NUMBER 3-2	EM-61 CHANNEL DIFFERENCE MAP SUSPECTED MUSTARD AGENT BURIAL SITE RAVENNA ARMY AMMUNITION PLANT
Shaw Environmental, Inc.	

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4.0 Sample Design

This section summarizes evaluation of the EQM geophysical investigation as discussed in Section 3.0 and presents the rationale for additional investigation. The selection for the areas for biased sampling is based on the project DQOs, the conceptual site model described in Section 2.0, discussions with Ohio EPA, and the direction as provided in the *SOW*.

4.1 Geophysical Investigation

4.1.1 Rationales

The EQM geophysical survey identified buried metallic objects adjacent to the west side of the concrete pad that were interpreted to be possible mustard agent CAIS. Furthermore, interviews with former RVAAP workers indicated that the concrete pad may have been constructed over an area of buried mustard agent CAIS. An additional geophysical investigation will be required around the perimeter of the concrete pad to assess the potential for buried metal anomalies.

4.1.2 Geophysical Investigation Location

An additional geophysical investigation will be performed in the areas north, south, and east of the concrete pad, as shown in **Figure 4-1**, to further delineate the extent of the anomalies detected to the west of the concrete pad as identified in the *SOW*. In addition to the survey areas adjacent to the north and south of the concrete pad (115'x13'), the survey area extends an additional 115 feet to the east along the NACA crash strip. The width of the survey areas on both sides of the crash strip and to the north and south of the concrete pad is approximately 4 meters (13 feet). This equates to approximately four passes with the geophysical instrumentation at approximately 1 meter width per pass. The total survey area is approximately 6,000 square feet to an approximate survey depth of 5 feet bgs, the likely substantial portion of metallic debris buried at MABS, as identified in the EQM report (EQM 2008).

4.1.3 Geophysical Investigation

For the MABS, a Geonics EM61-MK2 metal detector will most likely be deployed based on the results of the Geophysical Prove-Out (GPO) that will be used to assess and document the performance of the geophysical instrumentation, navigation system, and field deployment form-factor. The GPO will also be used to assess the most optimal data processing techniques and anomaly selection criteria given the local soil, site conditions, and targets of interest at RVAAP. The EM61-MK2 will be deployed along with a Real-Time Kinematic global positioning system in open areas, which is ideal for the MABS. The EM61-MK2 may detect buried metal beyond 4 feet depending on the size of the target and the contrast between the native soils/geology and the target. Additionally, the EM61-MK2 response is focused directly

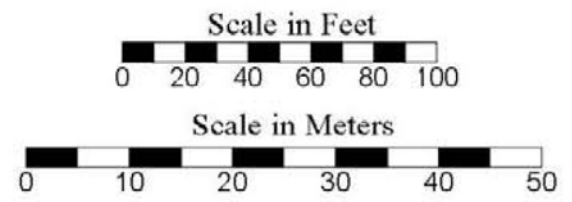
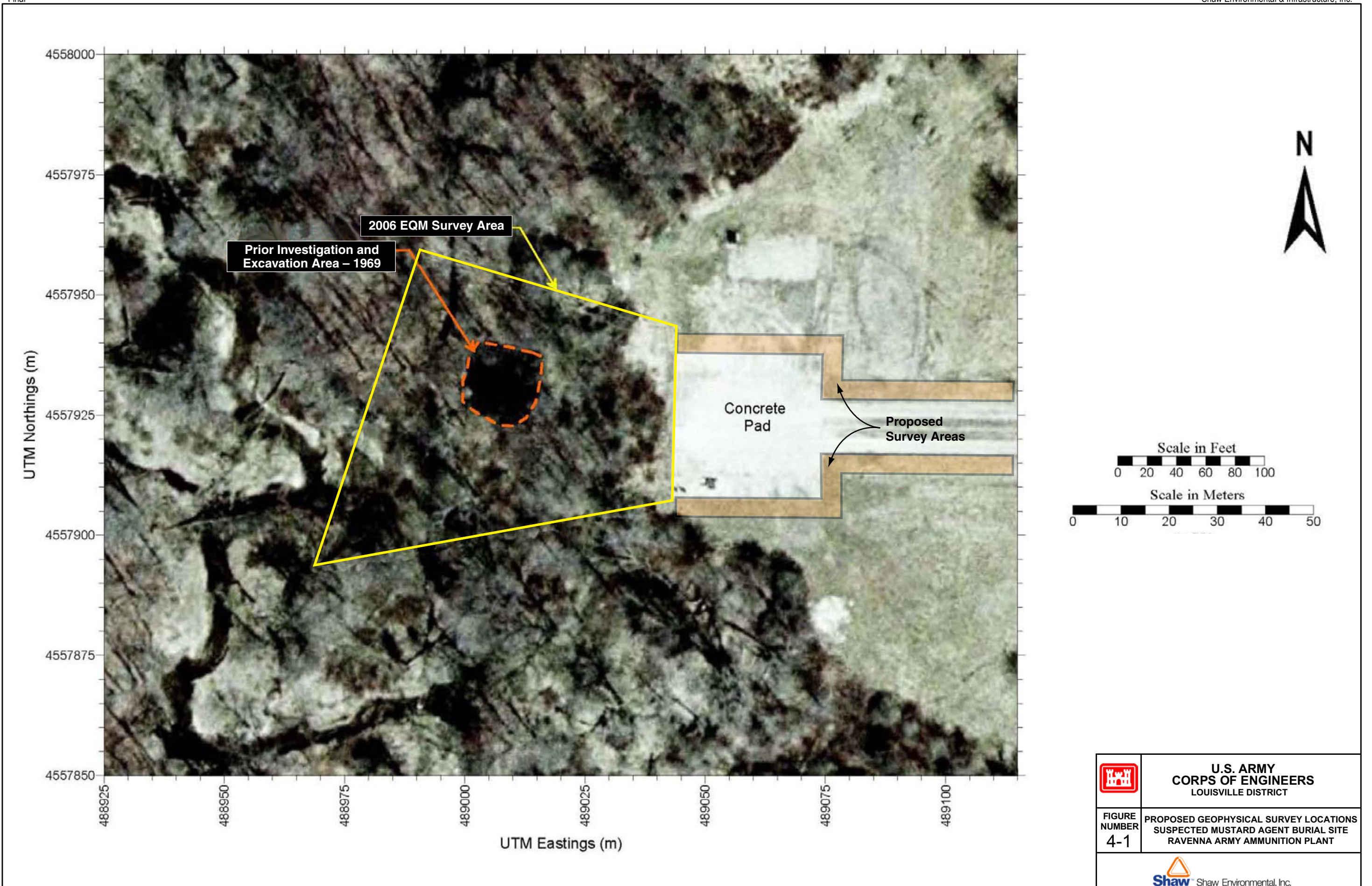
beneath the coils so the response from nearby structures is minimal compared to other sensors such as the magnetometer.

4.1.3.1 General Geophysical Survey Procedures

Full coverage mode will be utilized at MABS and is discussed further in the *Geophysical Investigation Plan for RVAAP-34 Sand Creek Disposal Road Landfill, RVAAP-03 Open Demolition Area 1 and RVAAP-28 Mustard Agent Burial Site* (Shaw 2009). Full coverage will be achieved through deployment of the sensor system through the collection of sub-parallel survey lines or swaths with sensor separations of 3 feet. The general survey procedures include the following:

- Review the site. The area requiring full coverage will be reviewed through a site walk-over during which the geophysical survey conditions will be reviewed by the site geophysicist.
- Set up the navigational system chosen by the geophysicist at a convenient control point of known location. Confirm location control via checkshots to at least one other control point of known location.
- Place temporary location control QC items in the survey area using the Robotic Total Station as needed to document navigation precision. At least one location QC item (either temporary items or semi-permanent grid hubs) will be present in each data set.
- Set up a replicate data line location and collect the pre- and post-survey data line. These data will be compared to insure repeatability of the data collection method.
- The sensors are towed, pulled or pushed at a mean speed less than 3 miles per hour in the GPO (to be verified by analysis of the navigation data for each data set) to minimize sensor bounce and sway.
- Collect and maintain field logs to document the conditions of the data collections. The field logs will include information and observations of the data collection area, field conditions, data acquisition parameters, and QC performed.
- Field geophysical data and navigation data will be downloaded to a field personal computer (PC). The electronic files will be organized on an office PC dedicated to geophysical investigation management. Data will be backed-up daily.
- Review all traverse data and overlay on the survey grid layout or planned traverse lines as QC and to identify any missed areas.

Following the completion of the geophysical investigation and data processing activities at the prescribed locations at MABS, the data will be incorporated into a geophysical investigation report that will convey explanations and pertinent information, and will include maps, QC reports, summaries, and supporting data.



	U.S. ARMY CORPS OF ENGINEERS LOUISVILLE DISTRICT
FIGURE NUMBER 4-1	PROPOSED GEOPHYSICAL SURVEY LOCATIONS SUSPECTED MUSTARD AGENT BURIAL SITE RAVENNA ARMY AMMUNITION PLANT
Shaw Environmental, Inc.	

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5.0 Summary of Conclusions

This *DQO Report* has utilized the DQO process provided in the *FSAP* (SAIC 2001) to identify additional areas that will require geophysical investigation at the MABS. A previous geophysical investigation showed anomalies immediately west of the concrete pad adjacent to the west end of the NACA crash strip that may represent where mustard agent CAIS were buried. Furthermore, interviews with former RVAAP workers indicated that concrete pad may have been constructed over an area of buried mustard agent CAIS. Therefore, an additional geophysical investigation should be conducted north, south, and east of the concrete pad to delineate the potential burial area within 5 feet of ground surface, the likely substantial portion of metallic debris buried at MABS, as identified in the EQM report (EQM 2008).

The Geonics EM61-MK2 metal detector is the preferred geophysical instrument for the proposed geophysical investigation because it can detect buried metal objects reliably to the required depth and is ideal for the open area conditions at MABS. The EM61-MK2 is capable of detecting buried metal beyond 4 feet bgs depending on the size of the target and contrast between the native soils/geology and the target; therefore, it is expected that the accumulation of bulk metallic objects beyond this depth can be achieved using this instrument. This metal detector will most likely be deployed by Shaw based on the results of the GPO. Further details of the additional geophysical investigation is presented in the *Geophysical Investigation Plan for RVAAP-34 Sand Creek Disposal Road Landfill, RVAAP-03 Open Demolition Area 1 and RVAAP-28 Mustard Agent Burial Site* (Shaw 2009).

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6.0 References

Environmental Quality Management, Inc. (EQM) 2008. Report on the Geophysical Investigation, Suspected Mustard Agent Burial Site, Ravenna Army Ammunition Plant, Ravenna, Ohio. Final. May 21, 2008.

Science Applications International Corporation (SAIC) 1998. Geophysical Survey Results, Possible Mustard Agent Burial Site (RVAAP-28). April 17, 1998

SAIC 2001. Facility-Wide Sampling and Analysis Plan for Environmental Investigations at the Ravenna Army Ammunition Plant, Ravenna, Ohio. Final. March 2001.

Shaw Environmental & Infrastructure, Inc. (Shaw) 2009. Geophysical Investigation Plan for RVAAP-34 Sand Creek Disposal Road Landfill, RVAAP-03 Open Demolition Area 1 and RVAAP-28 Mustard Agent Burial Site at the Ravenna Army Ammunition Plant, Ravenna, Ohio. Draft. January 2009.

SpecPro, Inc. (SpecPro) 2006. Suspected Mustard Agent Burial Area of Concern (RVAAP-28), Report on the Additional Groundwater Monitoring Well Installation and Groundwater Sampling at the Suspected Mustard Agent Burial Area of Concern, Ravenna Army Ammunition Plant, Ravenna, Ohio. Final. May

U.S. Army Center for Health Promotion and Preventive Medicine (USACHPPM) 1996, Hazardous and Medical Waste Study No. 37-EF-5360-97, Relative Risk Site Evaluation, Ravenna Army Ammunition Plant Ravenna, Ohio, 28 October – 1 November 1996, Volume I

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APPENDIX A
COMMENT RESPONSE TABLE

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DRAFT DATA QUALITY OBJECTIVES FOR THE RVAAP-28 MUSTARD AGENT BURIAL SITE, VERSION 1.0
RAVENNA ARMY AMMUNITION PLANT, RAVENNA, OHIO
COMMENT RESPONSE TABLE
April 29, 2009

Comment Number	Page or Sheet	New Page or Sheet	Comment	Recommendation	Response
<i>RTLS Environmental – Katie Elgin (April 3, 2009)</i>					
R-1	General		The ‘concrete test pad’ and the NACA runway are incorrect references.	<ol style="list-style-type: none"> 1. Change ‘concrete test pad’ to ‘concrete pad’ throughout the document. 2. Change ‘NACA runway’ to ‘NACA crash strip’ throughout the document 	<ol style="list-style-type: none"> 1. ‘concrete test pad’ will be changed to ‘concrete pad’ throughout the document. 2. ‘NACA runway’ will be changed to ‘NACA crash strip’ throughout the document.
R-2	Pg 1-2, Line 19-20		“In 1969, an investigation pit was performed at the west end of the NACA runway by the Arsenal to check the integrity of the mustard agent containers.” The word “Arsenal’ needs changed because it is not referenced anywhere else in this document. The facility is usually described as RVAAP.	Change text to: “In 1969, an investigation pit was excavated at the west end of the NACA crash strip by facility personnel to check the integrity of the mustard agent containers.”	Text will be revised to state: “In 1969, an investigation pit was excavated at the west end of the NACA crash strip by facility personnel to check the integrity of the mustard agent containers.”
R-3	Pg 1-2, Line 22		“To date, no materials related to mustard agent have been recovered from the site.” How can you say this when a 55-gallon drum and 7 rusty cans were recovered from this area as stated in the previous line. Those items may have been related to the mustard site. Recommend deleting this line.	Delete “To date, no materials related to mustard agent have been recovered from the site.”	Will delete the line “To date, no materials related to mustard agent have been recovered from the site.”
R-4	Pg 1-2, Section 1.2.1		Since this is a general description of the mustard site and the former investigations at this site, do you think we should also describe the		Section 1.2.2 Previous Investigation Activities will be revised as follows: The previous study areas at the MABS were

DRAFT DATA QUALITY OBJECTIVES FOR THE RVAAP-28 MUSTARD AGENT BURIAL SITE, VERSION 1.0
RAVENNA ARMY AMMUNITION PLANT, RAVENNA, OHIO
COMMENT RESPONSE TABLE
April 29, 2009

Comment Number	Page or Sheet	New Page or Sheet	Comment	Recommendation	Response
			<p>other fenced mustard agent site located 100 feet from Hinckley Creek in the woods? Ultimately this is where the groundwater investigations occurred. Additionally, this area will also be addressed in any future decision documents.</p>		<p>performed in the more heavily wooded area adjacent to the west of the NACA test area. These studies were conducted between 1996 and 2006 as discussed below.</p> <p>Two surface soil samples were collected from along the abandoned power line right-of-way located 500 feet south of Hinkley Creek during the Hazardous and Medical Waste Study conducted in 1996 (USACHPPM 1996). 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.</p> <p>In 1998, SAIC conducted a geophysical survey using EM31 and EM61 units in an approximately 270 square foot area along the abandoned power line right-of-way where the previous soil samples were collected. Several anomalies were detected which may have been caused by metallic objects or related to surface cultural features 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).</p> <p>Between 2004 and 2005, SpecPro, Inc. conducted a groundwater investigation at the RVAAP-28 surrounding an area located</p>

DRAFT DATA QUALITY OBJECTIVES FOR THE RVAAP-28 MUSTARD AGENT BURIAL SITE, VERSION 1.0
RAVENNA ARMY AMMUNITION PLANT, RAVENNA, OHIO
COMMENT RESPONSE TABLE
 April 29, 2009

Comment Number	Page or Sheet	New Page or Sheet	Comment	Recommendation	Response
					<p>approximately 300 feet south of Hinkley Creek that included the installation of six monitoring wells. Mustard agent breakdown products were not detected in any of the groundwater samples collected during the sampling events (SpecPro 2006).</p> <p>Environmental Quality and Management, Inc. (EQM) conducted a series of geophysical surveys at the MABS in 2006 using various methodologies (EQM 2008). The objective of the project was to determine if CAIS mustard agent had been buried in an approximate one acre area located on the western portion of the RVAAP. The suspected area, as reported by a former employee, is located adjacent to the NACA crash strip.</p> <p>The electromagnetic metal detection (EMD) and electromagnetic (EM) conductivity maps included in the <i>EQM Report on the Geophysical Investigation</i> (EQM 2008) at MABS identified buried metallic objects within the study area. Based on the results of the geophysical survey, the large metallic anomalies detected in the survey area, especially those that were trench shaped extending off of the edge of the concrete pad, were interpreted to be possible mustard agent test kits. 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.</p>

DRAFT DATA QUALITY OBJECTIVES FOR THE RVAAP-28 MUSTARD AGENT BURIAL SITE, VERSION 1.0
RAVENNA ARMY AMMUNITION PLANT, RAVENNA, OHIO
COMMENT RESPONSE TABLE
April 29, 2009

Comment Number	Page or Sheet	New Page or Sheet	Comment	Recommendation	Response
R-5	Figure 1-2 Facility Map		Highlighted areas on map are incorrect.	Please unhighlight LL1-4 areas and delete the symbol from the key on this map as they are not the subject area. Also, please delete the symbol for the AOC boundary as the AOC boundaries are not defined on this map. It is just an AOC general location map.	This figure will be revised to remove highlighted references to LLs 1-4. References to AOC boundaries will also be removed.
R-6	Figure 1-3		Add 1969 date to figure.	Change 'Prior Investigation and Excavation Area' to 'Prior Investigation and Excavation Area – 1969'	The label in Figure 1-3 that states 'Prior Investigation and Excavation Area' will be revised to 'Prior Investigation and Excavation Area – 1969'
R-7	Pg 2-1, Line 18		"Interviews of former employees conducted on July 20, 2006 indicated that the suspected MABS is located west of the NACA concrete runway and test pad." The interview regarding the mustard site that pointed to the NACA area was with one person. The other person at the interview (Ray McDaniel) indicated that this area was further back in the woods south of the NACA area.	Change text to "An interview with a former employee conducted on July 20, 2006 indicated that the suspect mustard site may be located west of the NACA concrete pad."	Text will be revised to state "An interview with a former employee conducted on July 20, 2006 indicated that the suspect mustard site may be located west of the NACA concrete pad."
R-8	Pg 2-1, Line 30		"The area around the concrete test pad is open; however..." I think what you mean here is that the area is not forested.	Change text to "The area around the concrete pad is nonforested (i.e. grassy); however..."	'open' will be revised to 'nonforested'.
R-9	Pg 2-2, Line 11		"Additional investigation is needed at RVAAP-28 to ultimately obtain a	Change text to "Additional geophysical investigation is needed at the site to survey	Shaw does not concur with the comment. Shaw's SOW for MABS is to ultimately

DRAFT DATA QUALITY OBJECTIVES FOR THE RVAAP-28 MUSTARD AGENT BURIAL SITE, VERSION 1.0
RAVENNA ARMY AMMUNITION PLANT, RAVENNA, OHIO
COMMENT RESPONSE TABLE
April 29, 2009

Comment Number	Page or Sheet	New Page or Sheet	Comment	Recommendation	Response
			<p>Record of Decision (ROD) using Land Use Controls (LUCs) that address all investigation results, both environmental and Military Munitions Response Program (MMRP) related. Data generated by the additional geophysical investigation will address the key decisions presented in Table 3-1 of the FSAP (SAIC 2001) and will be used to determine if the extent of the suspected mustard agent burial extends to the north, south and east of the concrete test pad or if any other metal objects are identified.” This section is located within section 2.3 - Identify Decisions to be Made. This section is stating what decision will be made based on the stated problem. The problem, listed in the prior section, was that the 2006 investigation identified anomalies in the suspected area but the area was not fully delineated. Therefore, this section, should state that the decision to be made is the extent of the mustard agent site.</p>	<p>and delineate the extent of the suspect mustard agent burial site. Data generated during this geophysical investigation will address the key decisions presented in Table 3-1 of the FSAP (SAIC 2001) and will be used to determine if the suspect mustard agent burial site extends to the north, south and east of the concrete test pad.”</p>	<p>achieve ROD with LUCs. The area to be surveyed to achieve the ROD is based on the SOW and discussions with Ohio EPA conducted prior to the preparation of this DQO report. Therefore, it is recommended that the text remain as is currently stated.</p>

DRAFT DATA QUALITY OBJECTIVES FOR THE RVAAP-28 MUSTARD AGENT BURIAL SITE, VERSION 1.0
RAVENNA ARMY AMMUNITION PLANT, RAVENNA, OHIO
COMMENT RESPONSE TABLE
April 29, 2009

Comment Number	Page or Sheet	New Page or Sheet	Comment	Recommendation	Response
R-10	General – Extent of the Geophysical Survey		Figure 4-1 illustrates that the area north and south of the concrete pad and crash strip is being investigated because interview information pointed to this additional area. However, I thought that the area of interest still to be investigated was just the area north and south of the concrete pad not north and south of the crash strip. Please explain why the area north and south of the ‘crash strip’ is included.		The approximate location maps for the geophysical investigation at MABS was included in the SOW that included the areas north and south of both the concrete pad and the NACA crash strip and are the locations identified in Figure 4-1.
R-11	General		Report references a Draft Geophysical Investigation Work Plan for the mustard site issued in January 2009. Has this report been issued? I do not have a copy of that report.		The Geophysical Investigation Work Plan was being prepared concurrently with this DQO report and was Preliminary Draft and Draft at different stages. The Draft version of the Geophysical Investigation Plan was issued for Army and regulatory review on April 9, 2009. Please let us know if you did not receive your copy.
<i>Ohio EPA – Eileen Mohr (April 16, 2009)</i>					
O-1	Document distribution page		Change OEPA to Ohio EPA. (several places.)		A word search will be performed for the entire document and OEPA will be changed to Ohio EPA.

DRAFT DATA QUALITY OBJECTIVES FOR THE RVAAP-28 MUSTARD AGENT BURIAL SITE, VERSION 1.0
RAVENNA ARMY AMMUNITION PLANT, RAVENNA, OHIO
COMMENT RESPONSE TABLE
April 29, 2009

Comment Number	Page or Sheet	New Page or Sheet	Comment	Recommendation	Response
O-2	Pg 1-1, line 13		How is “closure” being defined? At this AOC, we are always going to have LUCs in place, because we will never be able to confirm/refute that there is anything buried here as we will never be able to conduct the needed intrusive activities, unless a lot of money shakes free (and I don’t believe that it would be a good use of limited funds that are available). The best we will ever be able to say is that we investigated the areas pointed out to us by former employees using geophysical methods near the test strip and surface soil and groundwater sampling in the wooded area. This AOC will always have questions related to it.		The SOW states “environmental closure” for RVAAP-28 to be included in the ROD is expected to be LUCs that addresses all investigation results, both environmental and MMRP. The following sentence will be included in line 14 following the first sentence; “Environmental closure for RVAAP-28 is expected to be land use controls (LUCs) that addresses all investigation results, both environmental and Military Munitions Response Program (MMRP) related.
O-3	Pg 1-2, line 9		Two previous investigations were in the location in the woods – the RRSE soil samples collected by USACHPPM (1996 or 1998) and the groundwater wells installed and sampled by SpecPro. The previous study conducted by EQM was partially located in a relatively clear area. There is a reference to a current study area (which should be Shaw’s) that would be in a clear area. Please clarify the various studies.		Sections 1.2.1 and 1.2.2 have been revised as follows: Section 1.2.1 Mustard Agent Burial Site The MABS is a location where Chemical Agent Identification Sets (CAIS), believed to consist of sulfur mustard agent (HD), are suspected to have been buried. The CAIS mustard agent was developed by the Department of the Army from the 1930s through the 1960s. The mustard agent was reportedly buried at RVAAP in the 1950’s. The depth at which the CAIS may have

DRAFT DATA QUALITY OBJECTIVES FOR THE RVAAP-28 MUSTARD AGENT BURIAL SITE, VERSION 1.0
RAVENNA ARMY AMMUNITION PLANT, RAVENNA, OHIO
COMMENT RESPONSE TABLE
 April 29, 2009

Comment Number	Page or Sheet	New Page or Sheet	Comment	Recommendation	Response
					<p>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.</p> <p>In 1969, the 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 reports (USACHPPM 1996). An unidentified and undocumented source reported that the first site excavated was incorrectly identified, and that the mustard agent was buried nearby (USACHPPM, 1996). The second proposed site for the mustard agent burial is located in the wooded area approximately 500 feet south of Hinckley Creek along an abandoned power line right-of-way. The suspected site was marked and fenced; however, only remnants of the fence still exist. Section The area is currently marked with Seibert stakes. The current MABS study area is non-forested and flat and is located adjacent to the concrete pad at the west end of the NACA crash strip (Figure 1-3).</p> <p>Section 1.2.2 – Previous Investigation Activities</p>

DRAFT DATA QUALITY OBJECTIVES FOR THE RVAAP-28 MUSTARD AGENT BURIAL SITE, VERSION 1.0
RAVENNA ARMY AMMUNITION PLANT, RAVENNA, OHIO
COMMENT RESPONSE TABLE
 April 29, 2009

Comment Number	Page or Sheet	New Page or Sheet	Comment	Recommendation	Response
					<p>The previous study areas at the MABS were performed in the more heavily wooded area adjacent to the west of the NACA test area. These studies were conducted between 1996 and 2006 as discussed below.</p> <p>Two surface soil samples were collected from along the abandoned power line right-of-way located 500 feet south of Hinkley Creek during the Hazardous and Medical Waste Study conducted in 1996 (USACHPPM 1996). 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.</p> <p>In 1998, SAIC conducted a geophysical survey using EM31 and EM61 units in an approximately 270 square foot area along the abandoned power line right-of-way where the previous soil samples were collected. Several anomalies were detected which may have been caused by metallic objects or related to surface cultural features 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).</p> <p>Between 2004 and 2005, SpecPro, Inc.</p>

DRAFT DATA QUALITY OBJECTIVES FOR THE RVAAP-28 MUSTARD AGENT BURIAL SITE, VERSION 1.0
RAVENNA ARMY AMMUNITION PLANT, RAVENNA, OHIO
COMMENT RESPONSE TABLE
 April 29, 2009

Comment Number	Page or Sheet	New Page or Sheet	Comment	Recommendation	Response
					<p>conducted a groundwater investigation at the RVAAP-28 surrounding an area located approximately 300 feet south of Hinkley Creek that included the installation of six monitoring wells. Mustard agent breakdown products were not detected in any of the groundwater samples collected during the sampling events (SpecPro 2006).</p> <p>Environmental Quality and Management, Inc. (EQM) conducted a series of geophysical surveys at the MABS in 2006 using various methodologies (EQM 2008). The objective of the project was to determine if CAIS mustard agent had been buried in an approximate one acre area located on the western portion of the RVAAP. The suspected area, as reported by a former employee, is located adjacent to the NACA crash strip.</p> <p>The electromagnetic metal detection (EMD) and electromagnetic (EM) conductivity maps included in the <i>EQM Report on the Geophysical Investigation</i> (EQM 2008) at MABS identified buried metallic objects within the study area. Based on the results of the geophysical survey, the large metallic anomalies detected in the survey area, especially those that were trench shaped extending off of the edge of the concrete pad, were interpreted to be possible mustard agent test kits. 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</p>

DRAFT DATA QUALITY OBJECTIVES FOR THE RVAAP-28 MUSTARD AGENT BURIAL SITE, VERSION 1.0
RAVENNA ARMY AMMUNITION PLANT, RAVENNA, OHIO
COMMENT RESPONSE TABLE
April 29, 2009

Comment Number	Page or Sheet	New Page or Sheet	Comment	Recommendation	Response
					of the metallic anomalies.
O-4	Pg 1-2, lines 22-23		Either confirm with historical records that the drum and 7 rusty cans were not related to the Mustard AOC, or remove this sentence in the revised report.		“To date, no material related to mustard agents have been recovered from the site” will be removed from the text. See previous comment (RTLS Comment R-3)
O-5	Figure 1-2		Highlight Mustard Agent AOC. Remove LL highlighting.		Figure 1-2 will be revised to remove load line highlighting. The boundaries of the proposed RVAAP-28 study area to be conducted by Shaw are defined; however, it appears that the boundary for the entire RVAAP-28 is less defined. The circle area shown on Figure 1-2 shows RVAAP-28 to be located approximately 1,000 feet south of the NACA concrete pad. Any clarification on where to highlight on this figure would be appreciated.
O-6	Pg 2-2, line 22		This would be an ideal place (right at the end of line 22) to cross-reference the proposed study area (figure 4-1) so the reviewer can easily compare figure 1-3 with 4-1.		This sentence will be revised as follows: “The area to be investigated is intended to supplement the previous geophysical investigation survey area as shown in Figure 1-3 by extending the survey areas along the north, south and east sides of the NACA test pad as shown in Figure 4-1.”
O-7	Pg 2-2, line 33 to pg 2-3, line 2		The text indicates that the preferred instrumentation will be the EM61-MKII metal detector. Please provide additional justification for		The EM31 was not suggested for use at the site due to its ineffectiveness during the EQM investigation to detect smaller objects that were more easily observed by the EM61 unit. As

DRAFT DATA QUALITY OBJECTIVES FOR THE RVAAP-28 MUSTARD AGENT BURIAL SITE, VERSION 1.0
RAVENNA ARMY AMMUNITION PLANT, RAVENNA, OHIO
COMMENT RESPONSE TABLE
April 29, 2009

Comment Number	Page or Sheet	New Page or Sheet	Comment	Recommendation	Response
			<p>not doing a concurrent EM-31 survey. The EQM report indicated that they had some difficulties with the EM-31 due to soil conductivities, but in my experience at RVAAP it has also supplied some useful information. Would it be helpful to also use an EM-31? Also add in additional text that describes why GPR and the GEM II are not proposed (can justify lack of use from EQM report results).</p>		<p>indicated in the EQM report, the EM61 is a very sensitive instrument that is capable of detecting anomalies as small as nails and screws; whereas, the EM31, although capable of detecting metallic objects, is designed to detect minute conductivity variations in the soil, and usually only detects metallic objects large enough to affect the conductivity value of a unit volume of soil such as drums and tanks. It is expected that any objects still in the ground at this location have most likely deteriorated and will require the most sensitive instrumentation such as the EM61.</p> <p>Lines 33-34 will be revised and will include reference as to why GPR and the GEM II are not proposed as follows; “The EM61-MK2 has very good stability, is very reliable in the detection of metallic anomalies and is less affected by disturbed soils and the highly conductive clayey soils at the site than the EM31 and GEM-2. Ground penetrating radar (GPR) is not proposed for use during this geophysical investigation since this method was determined to be of little value in further characterizing identified anomalies during the EQM investigation due to severe signal attenuation from conductive, clayey soils”.</p>

DRAFT DATA QUALITY OBJECTIVES FOR THE RVAAP-28 MUSTARD AGENT BURIAL SITE, VERSION 1.0
RAVENNA ARMY AMMUNITION PLANT, RAVENNA, OHIO
COMMENT RESPONSE TABLE
April 29, 2009

Comment Number	Page or Sheet	New Page or Sheet	Comment	Recommendation	Response
O-8	Pg 2-3, lines 9-10		This section of the text references the geophysical investigation work plan and that it will contain limits on decision errors. Since this DQO report does not contain the needed details, all comments on this issue will be deferred to the geophysical investigation work plan.		Shaw understands comments referencing the decision errors for RVAAP-28 and the associated geophysical investigation work will be addressed in the comments to the geophysical investigation work plan.
O-9	Pg 3-1, line 6		Change gas to agent.		“gas” will be changed to “agent”. The sentence will be revised to state “The CAIS mustard <i>agent</i> was reportedly.....”
O-10	Figure 3-1		Shouldn't there be a cross-reference to EQM on this figure?		The note “2006 Survey Area” shown on Figure 3-1 will be revised to “2006 EQM Survey Area”.
O-11	Figure 3-2		Shouldn't there be a cross-reference to EQM on this figure?		The note “2006 Survey Area” shown on Figure 3-2 will be revised to “2006 EQM Survey Area”.
O-12	Pg 4-1, line 25		MK2 or a MKII detector as described on page 2-2, line 33 (and pg 5-1, line 10)? Also, this section may change based upon the response to comment #7 above.		For consistency purposes, “MKII” will be changed to “MK2” throughout the report wherever referenced. This section will remain the same based on the response to comment O-7 and the revisions proposed to Section 2.6.
O-13	Pg 5-1, lines 8-9		The text specifies a maximum depth of 5 feet. How was this determined? Is it based upon instrumentation		The five foot depth specified is based on the 2008 EQM report which concluded that it is likely that substantial portions of metallic debris

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RAVENNA ARMY AMMUNITION PLANT, RAVENNA, OHIO
COMMENT RESPONSE TABLE
 April 29, 2009

Comment Number	Page or Sheet	New Page or Sheet	Comment	Recommendation	Response
			<p>limitation? Provide rationale for a 5 foot depth. (I couldn't find a maximum depth in the EQM report except for GPR, which we are not using).</p>		<p>identified during the geophysical investigation may be buried within 5-feet of the ground surface, although accumulations of materials could exceed this depth in some areas.</p> <p>The sentence on page 5-1, lines 7-9 and the following paragraph, will be revised to state: "Therefore, an additional geophysical investigation should be conducted north, south and east of the concrete pad to delineate the potential burial area within five feet of ground surface, the likely substantial portion of metallic debris buried at MABS, as identified in the EQM report (EQM 2008).</p> <p>The Geonics EM61-MK2 metal detector is the preferred geophysical instrument for the proposed geophysical investigation because it can detect buried metal objects reliably to the required depth and is ideal for the open area conditions at MABS. The EM61-MK2 is capable of detecting buried metal beyond 4 feet depending on the size of the target and contrast between the native soils/geology and the target; therefore, it is expected that the accumulation of bulk metallic objects beyond this depth can be achieved using this instrument."</p>