REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. REPORT DATE *(DD-MM-YYYY)*	2. REPORT TYPE	3. DATES COVERED *(From - To)*
16/07/2009	Final	July 2009

4. TITLE AND SUBTITLE

Geophysical Investigation Plan for RVAAP-34 Sand Creek Disposal Road Landfill, RVAAP-03 Open Demolition Area 1 and RVAAP-28 Mustard Agent Burial Site

5a. CONTRACT NUMBER W912QR-08-D-0013

5b. GRANT NUMBER N/A

5c. PROGRAM ELEMENT NUMBER N/A

6. AUTHOR(S)

Sandra Takata

5d. PROJECT NUMBER 133616

5e. TASK NUMBER 11001100

5f. WORK UNIT NUMBER N/A

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

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8. PERFORMING ORGANIZATION REPORT NUMBER

N/A

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

U.S. Army Corps of Engineers - Louisville District
600 Martin Luther King, Jr. Place
Louisville, KY 40202

10. SPONSOR/MONITOR'S ACRONYM(S)

CELRL-ED-EE

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

N/A

12. DISTRIBUTION/AVAILABILITY STATEMENT

Reference distribution page.

13. SUPPLEMENTARY NOTES

None

14. ABSTRACT

The purpose of this Geophysical Investigation Plan is to collect and evaluate geophysical data for the characterization of subsurface anomalies and to estimate the munitions and explosives of concern (MEC) density over approximately 2 acres of the RVAAP -34 Sand Creek Disposal Road Landfill Site, 8 .6 acres at the RVAAP-03 Open Demolition Area 1 (ODA1) and 6000 square feet at the RVAAP-28 Mustard Agent Burial Site (MABS). Additionally, transect surveys will be performed to delineate the Sand Creek and ODA1 boundaries. The results of the surveys will be presented is a geophysical summary report that features: geophysical data (raw and processed), a summary of the results of the evaluation of existing geophysical data, maps, reports, field sheets, databases, and all other ancillary data used to develop all geophysical results.

15. SUBJECT TERMS

Geophysical Investigation Report, RVAAP-03, Open Demolition Area 1, RVAAP-28, Mustard Agent Burial Site, RVAAP-34, Sand Creek Disposal Road Landfill

16. SECURITY CLASSIFICATION OF: a. REPORT	b. ABSTRACT	c. THIS PAGE	17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
Unclassified	Unclassified	Unclassified	UL	152	David Crispo
					19b. TELEPHONE NUMBER *(Include area code)* 617.589.8146

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Final Geophysical Investigation Plan for the RVAAP-34 Sand Creek Disposal Road Landfill, RVAAP-03 Open Demolition Area #1, and 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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July 16, 2009

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RVAAP – Ravenna Army Ammunition Plant
USACE – U.S. Army Corps of Engineers – Louisville District
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CONTRACTOR STATEMENT OF INDEPENDENT TECHNICAL REVIEW

Shaw Environmental & Infrastructure, Inc. has completed the *Final Geophysical Investigation Plan for the 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*. Notice is hereby given that an independent technical review has been conducted that is appropriate to the level of risk and complexity inherent in the project. During the independent technical review, compliance with established policy, principles and procedures, utilizing justified and valid assumptions, was verified. This included review of data quality objectives; technical assumptions; methods, procedures and materials to be used; the appropriateness of data used and level of data obtained; and reasonableness of the results, including whether the product meets customer's needs consistent with law and existing Corps policy.

Reviewed / Approved by: ______________________ Date: July 13, 2009

David Cobb
Project/Program Manager

Prepared / Approved by: ______________________ Date: July 13, 2009

Sandra Takata
Geophysicist

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Acronyms and Abbreviations

A/E	Architectural/Engineering
AOC	Area of Concern
ASCII	American Standard Code for Information Interchange
bgs	below ground surface
cm	centimeters
DGM	Digital Geophysical Mapping
DID	Data Item Descriptions
DoD	Department of Defense
DQO	data quality objectives
EM	electromagnetic
EM61-MKII	Geonics EM61-MKII Metal Detector
EQM	Environmental Quality Management, Inc.
G858	Geometrics G858G Cesium Vapor Magnetometer (single sensor)
G858G	Geometrics G858 Cesium Vapor Magnetometer (2 sensors)
GIS	Geographic Information System
GIP	Geophysical Investigation Plan
GPO	Geophysical Prove-Out
GPS	Global Positioning System
Hz	Hertz
IRP	Installation Restoration Program
MABS	Mustard Agent Burial Site
MEC	Munitions and Explosive of Concern
mm	millimeters
mph	miles per hour
MR	Munitions Response
mV	milliVolts
NACA	National Advisory Committee for Aeronatics
NMEA	National Marine Electronics Association
NOI	Notice of Intent
nT	nanoTesla
OB/OD	open burning/open detonation
ODA1	Open Demolition Area 1
OHARNG	Ohio Army National Guard
Ohio EPA	Ohio Environmental Protection Agency
PC	personal computer
PIG	steel shipping cylinder
QA	Quality Assurance
QC	Quality Control
QCS	Quality Control Specialist
RVAAP	Ravenna Army Ammunition Plant
RI	Remedial Investigation
RTK	Real-time Kinematic
RTS	Robotic Total Station

SAIC	Science Applications International Corporation
Sand Creek	Sand Creek Disposal Road Landfill
SDZ	Safety Danger Zone
Shaw	Shaw Environmental and Infrastructure, Inc.
SHERP	Safety, Health and Emergency Response Plan
S/N	signal to noise ratio
SUXOS	Senior Unexploded Ordnance Specialist
USACE	U.S. Army Corps of Engineers
USAESCH	U.S. Army Corps of Engineers, Engineering and Support Center, Huntsville
UTM	universal transverse Mercator
UXO	Unexploded Ordnance
UXOSO	Unexploded Ordnance Safety
XYZ	Cartesian orthogonal coordinates

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1.0 Introduction

1.1 Purpose and Scope

This *Geophysical Investigation Plan* (*GIP*) provides a systematic approach for performing the necessary field activities to geophysically map areas at Areas of Concern (AOCs) identified at the Ravenna Army Ammunition Plant (RVAAP), Ravenna, Ohio, in order to determine the horizontal extent of potential munitions and explosives of concern (MEC) contamination and other suspected buried anomalies without performing intrusive activities. The AOCs to be investigation at the RVAAP under this *GIP* include RVAAP-34 Sand Creek Disposal Road Landfill (Sand Creek), RVAAP-03 Open Demolition Area No. 1 (ODA1), and RVAAP-28 Mustard Agent Burial Site (MABS). This *GIP* is being prepared by Shaw Environmental & Infrastructure, Inc. (Shaw) under Delivery Order 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.

1.2 Geophysical Investigation Program Objectives

The geophysical investigations will include evaluation of geophysical data to characterize in terms of anomaly density in the area of Sand Creek, ODA1 and MABS by documenting the locations of detected anomalies. For unexploded ordnance (UXO) avoidance purposes, a UXO Technician will sweep the area in front of the geophysics crew prior to the survey being performed. The results of the survey will be presented is a summary report that features: geophysical data (raw and processed), a summary of the results of the evaluation of existing geophysical data, maps, reports, field sheets, databases, and all other ancillary data used to develop all geophysical results. This *GIP* was developed in accordance with U.S. Army Engineering Support Center, Huntsville (USAESCH) *Data Item Description (DID) Munitions Response (MR)-005-04.01* (USACE, 2007).

1.3 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**).

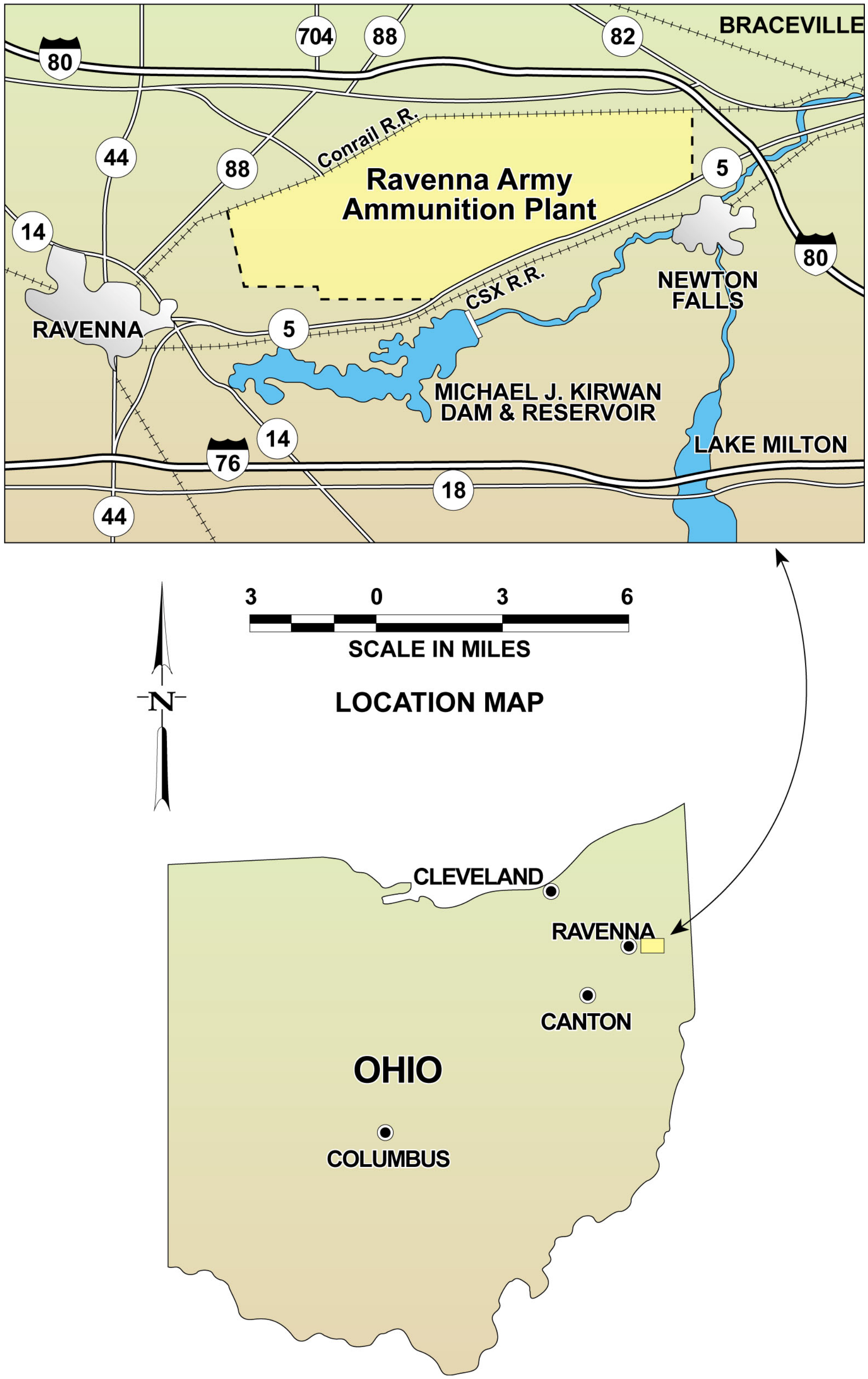
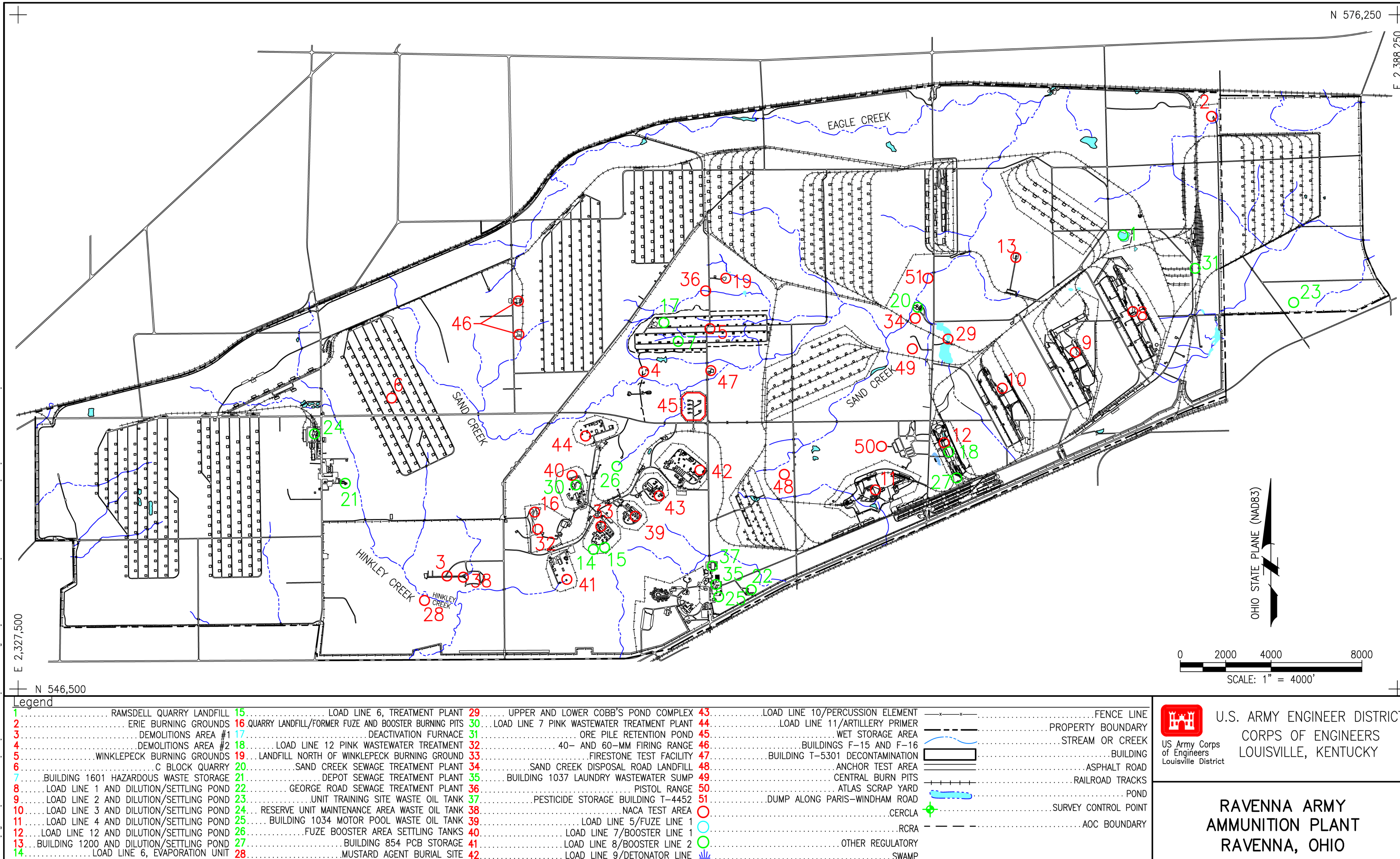


Figure 1-1
RVAAP Location Map

Figure 1-2
RVAAP Facility Map



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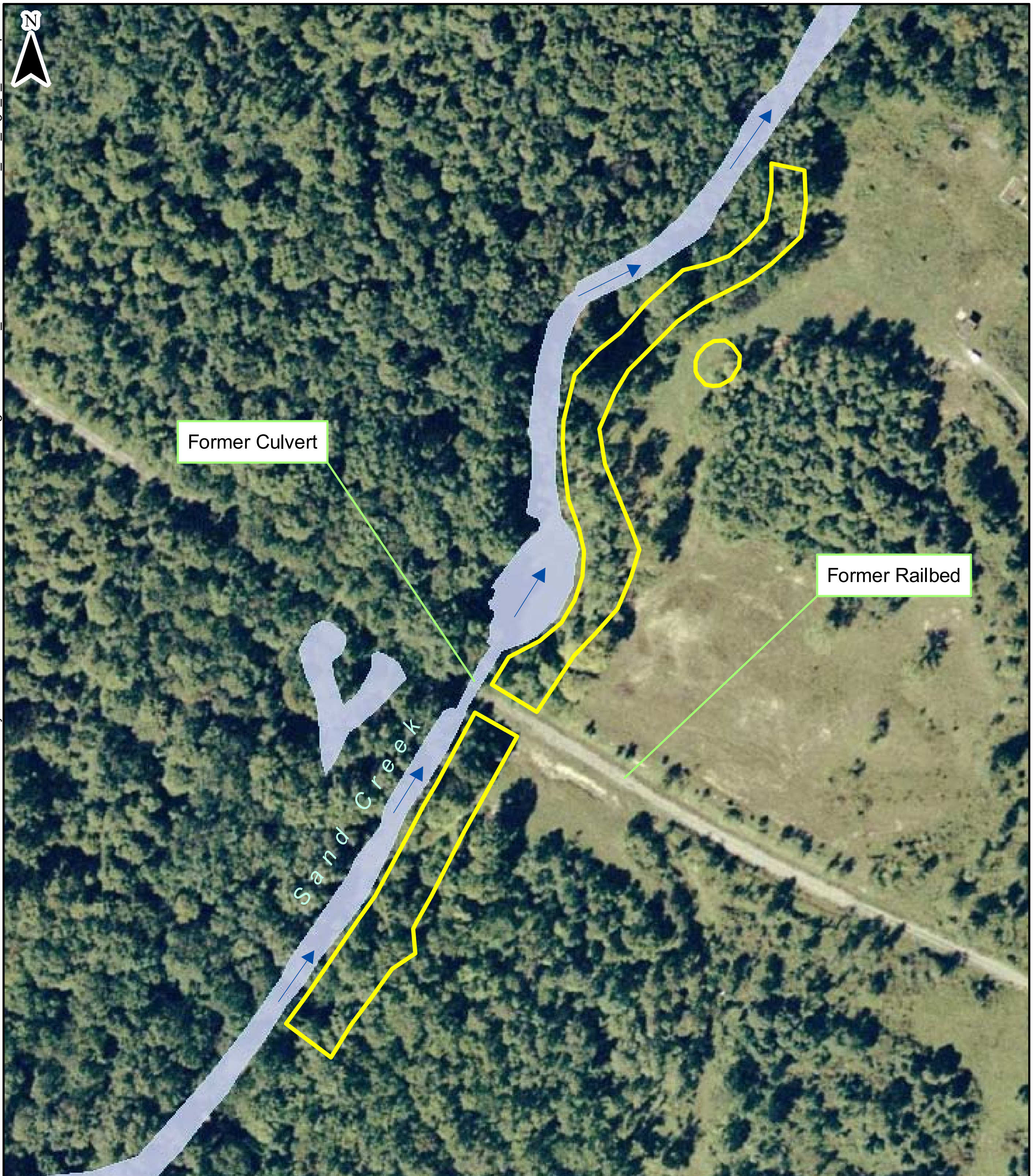
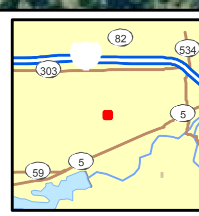


Direction of Flow
RVAAP-34 Investigation Area
Stream



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U.S. ARMY
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LOUISVILLE DISTRICT

FIGURE NUMBER
1-3

RVAAP-34
SAND CREEK DISPOSAL ROAD LANDFILL
SITE MAP

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Project Number: 133616

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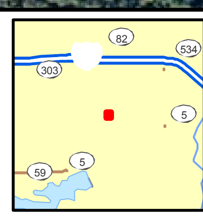
Suspected Mustard Agent Burial Site Investigation Area (5,200 sqft)

Open Demolition Area #1 Investigation Area (8.6 Acres)



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U.S. ARMY CORPS OF ENGINEERS
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FIGURE NUMBER 1-4

RVAAP-28
MABS AND RVAAP-03 ODA1
SITE MAP

Shaw Environmental, Inc.

Project Number: 133616

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 (OHARNG) 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 and; 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 the investigation and remediation conducted by the Army under the U.S. Department of Defense (DoD) IRP.

1.3.1 Sand Creek

The Sand Creek Disposal Road Landfill (**Figure 1-3**) is a former construction debris dump. Materials identified in the debris include transite, concrete and brick rubble, drywall, glass, scrap metal, and wood. Previous work included the removal of the surface debris. An empty 105 millimeter (mm) projectile was previously found downstream from the Sand Creek site. Seventy-five (75) mm casings have also been discovered in the area. The site is currently receives occasional foot traffic from military, security, and maintenance personnel as well as natural resource management activities. This site will be used as part of the Safety Danger Zone (SDZ) for the small arms range complex.

The full coverage Digital Geophysical Mapping (DGM) area for the Sand Creek site is approximately 2.2 acres. It ranges from heavily vegetated and wooded to flat open field. The site terrain includes steep sloped areas along the banks of Sand Creek to flat open areas above the creek embankments. The steeply sloping and flat topographies are each approximately one acre. Because of the wooded nature of the site, a robotic total station (RTS) will be used for navigation. The steep slope also presents a data collection challenge for man-portable deployments. A Geometrics G858G gradiometer, carried such that the two magnetic sensors are vertically spaced, will most likely be used.

1.3.2 Open Demolition Area #1

The ODA1 (**Figure 1-4**) full coverage for the proposed DGM investigation area is approximately 8.6 acres and extends beyond ODA1 into the National Advisory Committee for Aeronautics (NACA) Test Area (RVAAP-38). ODA1 was used during the 1940s for the open burning and open detonation (OB/OD) of munitions, explosives and related debris. The material was brought to the site, burned or detonated for demolition purposes, and the resulting scrap and debris pushed to the sides. Because of these activities and the potential for munitions kickout, there is a potential for the boundaries of the ODA1 to extend beyond the current delineation into the NACA Test Area. The ODA1 site is currently not being used and has been delineated as a no training/limited access area because of the potential risk for MEC. Future proposed military training activities at this site will include dismounted training and field bivouac activities.

ODA1 is relatively flat and covered with grass. Previously, 90mm frag was found at ODA1. An interim removal action to remove surface and subsurface MEC scrap and debris was conducted in 2000 to address issues identified in the *Phase I Remedial Investigation* (*RI*) prepared by Science Applications International Corporation (SAIC) in 1999. The *Phase I RI* was focused on the OB/OD area of ODA 1. An earthen berm within the site that is approximately one foot high currently surrounds the 1.5-acre former OB/OD area. The full coverage DGM area is bounded on three sides by woods and is bisected by an access road. Geophysical transect survey data will be used as an aid in determining the extent of the debris. The transect surveys will extend into the woods. Navigation control will be a combination of real-time kinematic (RTK) global positioning system (GPS) in the open field and RTS in the wooded areas. It is most likely that a man-portable Geonics EM61-MK2 high-sensitivity, metal detector will be used. Final decision on instrumentation will be based on the results of the geophysical prove out (GPO) to be conducted prior to a geophysical investigation at the AOC.

1.3.3 Mustard Agent Burial Site

The MABS area to be investigated under this task order is open and flat (**Figure 1-4**). The full coverage DGM area is approximately 6,000 square feet and is located south of the former operations building. Two strips, one north and one south of the concrete crash strip, comprise the site. It has been reported that steel shipping cylinders (also knows as PIGs), paint cans, and 55 gallon drums may have been buried west of the current study area, although actual physical confirmation has yet to be achieved. One hundred fifty-five (155) mm projectile shrapnel has been found in the area, but to date no material related to mustard agents has been recovered from the site. The proposed investigation area is currently being used for military training. Future proposed military training activities will include dismounted training and filed bivouac activities.

Previous geophysical investigations (electromagnetic), which identified areas potentially containing buried metal and fill, were performed by Environmental Quality Management, Inc. (EQM) on a one-acre area adjacent and west of the DGM site (EQM 2008). Navigation control will be achieved using RTK GPS technology. It is most likely that a man-portable Geonics EM61-MK2 high-sensitivity, electromagnetic (EM) metal detector will be used. Final decision on instrumentation will be based on the results of the GPO to be conducted prior to a geophysical investigation at the AOC.

2.0 Site Conditions

2.1 Anticipated Target Depths

The performance objective is to locate all MEC and MEC-like targets equivalent to their detection depth. In general, the detectable range for items will be approximately the diameter of the target times 11. In this case, the target is a 75mm shell so depth is anticipated at approximately 0.8 meters or 2.7 feet. The diameter of the 75mm shell was used for this calculation because it is believed to be the most probable munitions at Sand Creek. Similarly, a 90mm (found at ODA1) would be detected at 0.99 meters or 3.3 feet, and a steel shipping cylinder called a PIG (suspected at the MABs) at 1.4 meters or 4 feet. The metric estimates specified in the *DID* (USACE, 2003a) were derived from empirical observation over several years, it is anticipated that this depth metric will be met.

At present, Shaw is unaware of the potential presence of 40mm rounds at the sites designated for survey under this *GIP*. Shaw's geophysical survey teams will be accompanied by UXO technicians so if unexpected MEC is encountered it can be assessed and avoided in the field. In the event 40mm rounds are encountered or suspected to be at the site, this *GIP* will be revised to include procedures to assess them.

It should be noted that while the DID states detectable range is approximately 11 times the diameter of an item, this metric is under review by the USACE and may be eliminated in the future. Results from the GPO will be used to determine the detectability at given depths of target items at RVAAP conditions. The depth of detection derived from the GPO is the most accurate one for any given site.

2.2 Digital Topographic Maps

The Sand Creek site has steeply sloping (towards the creek) sides with a flat area to the east. Both ODA1 and the MABS site are relatively flat with minimal changes in grade. Digital maps will be used to aid in interpretation and to provide a base for coverage analysis.

2.3 Vegetation

The vegetation at Sand Creek is thickly wooded with considerable canopy. Both ODA1 and the MABS site full coverage DGM areas are open with vegetation coverage consisting of primarily grass. Transects at ODA1 will likely be in wooded conditions.

2.4 Geologic and Soil Conditions

RVAAP is located within the Southern New York Section of the Appalachian Plateau physiographic province. This province is characterized by elevated uplands underlain primarily by Mississippian- and Pennsylvanian-age bedrock units that are horizontal or gently dipping. The province is characterized by its rolling topography with incised streams having dendritic drainage patterns. The Southern New York Section has been modified by glaciation, which rounded ridges, filled major valleys, and blanketed many areas with glacially-derived unconsolidated deposits (i.e., sand, gravel, and finer-grained outwash deposits). Glacial activity in the Southern New York Section disrupted stream drainage patterns in many locales, which resulted in development of extensive wetlands areas (SAIC, 2008).

2.5 Shallow Groundwater Conditions

Groundwater is not expected to be an issue at the RVAAP sites, with the exception of seasonal mounding at ODA1. Historically groundwater at ODA1 has been observed at depths ranging from 14 to 16 below ground surface (bgs). Temporary surficial ponding has also been observed at the site on occasion but it is unsure if this is related to actual groundwater mounding or just a result of slow drainage through isolated hetereogenous soil deposits. The proposed geophysical survey program will be adjusted in the field based on site conditions to account for any ponding present at the time of execution.

2.6 Geophysical Conditions

The magnetic declination at RVAAP is approximately 8.3 degrees west and the inclination is approximately 68.85 degrees from horizontal. The magnetic background is approximately 53,920 nanoTeslas (nT).

2.7 Site Utilities

Utilities are not expected to interfere with the performance of the geophysical survey. ODA 1 and Sand Creek are in undeveloped areas not known to have utilities near by. The MABS site had a former operations building associated with it. Utilities such as metal pipes and electric lines will have very linear signatures and will be clearly evident in the data and; therefore, interpretable. Some undeveloped roads and large culverts are known to be present near the Sand Creek site. The roads accessing the Sand Creek site are primarily gravel, unimproved dirt, slag, and railroad ballast because of the presence of a rail bed associated with a former railroad track. A gravel-covered road and a former concrete crash strip provide access to ODA 1 and the MABS investigation sites. No known surface- or subsurface-utilities that would impact the geophysical survey activities are present in the areas around each site.

2.8 Man-Made Features

Man-made features existing within, or in close proximity to, the site negatively impact geophysical investigations. Features including fences, signs, monitoring wells, berms, and equipment will be noted in the event they negatively impact geophysical activities. A large metal culvert is visible in the creek, and remnants of a former railroad track maybe present at the

Sand Creek site. Concrete pads abut the DGM areas at MABS and a small berm is present at ODA1. A UXO Technician equipped with a Schonstedt magnetometer will precede the geophysics team to detect surface MEC or munitions debris. Man-made structures (wells, poles, culverts, signs, etc.) will be left undisturbed, and their locations and/or boundaries surveyed and incorporated into the project geographic information system (GIS) database.

2.9 Site-Specific Dynamic Events Affecting Geophysical Investigations

Dynamic events (rain, lightning, solar flares, etc.) may temporarily impact geophysical data collection and/or data quality. The following procedures will be followed during these anticipated events:

- **Rain**—Depending on its intensity, rain can be a significant impediment to survey operations. The Geophysicist will assess the intensity of rainfall and its effects on survey instrumentation. The Geophysicist will also assess safety considerations, such as site access (driving and passable roads), hazards (slip, trip, fall), and potential for flash flooding. General guidance for common conditions is as follows:
  - <u>Drizzle or Intermittent Light Rain</u>—Tape plastic around instrument electronics and continue.
  - <u>Thunderstorm</u>—Take cover and cease operation until the storm passes.
  - <u>Continuous Medium or Heavy Rain</u>—Take cover and cease operations until conditions improve.
- **Lightning**—Because most geophysical instruments contain sufficient metal and geometry to pose a preferred pathway for electrical discharge (lightning rod effect), observed lightning in the area will be deemed a safety hazard and will be cause for the cessation of survey activities until the lightning activity has ceased. Site personnel and equipment will shelter in a safe area. The UXO Safety Officer (UXOSO) will document that lightning is present and log the times when site survey activities are shut down and resumed.
- **Solar Flares**—Solar flares are sun-generated atmospheric phenomena, typically occurring in the afternoon, which may temporarily generate high magnitude magnetic noise sufficient to make magnetometers, and often gradiometers, unusable for the duration of the event. It is unlikely that these events will have a significant impact on the magnetometer data. Solar flares are typically readily observable by the instrument operators (throughout the area) as rapidly fluctuating signal readings with no apparent cultural or survey source. The Geophysicist will be alert to solar flares and temporarily cease data collection until static testing shows a cessation of the solar activity.

2.10 Overall Site Accessibility and Impediments

Access to the site will be via existing roads – gravel, unimproved to asphalt. Minor clearing and grubbing to include brush and vegetation removal may be required at the ODA1 site depending on the final area to be surveyed. The Sand Creek site is accessible via roads primarily of gravel, unimproved dirt, slag, and railroad ballast because of the presence of the former railroad track. Depending on the time of year, more extensive vegetation removal, to include small trees, scrub brush and hanging vegetation along the banks of Sand Creek, may be required to allow for the performance of the geophysical survey activities. Clearing activities at the Sand Creek site will be minimized to the extent possible to allow for the execution of work. Brush and vegetation will be left where fallen. Applicable permits, which may include a Notice of Intent (NOI) for Coverage Under an Ohio EPA General Permit, will be obtained prior to performing work and any wetland and/or vegetation disturbance at Camp Ravenna will be coordinated with the OHARNG/Camp Ravenna environmental office prior to disturbance.

In areas inhospitable for the outlined geophysical survey procedures, a UXO technician will perform analog surveys using a Schondstedt or similar instrument.

2.11 Potential Worker Hazards

All site personnel will adhere to the practices, procedures, training, and monitoring requirements mandated by the project's *Safety, Health and Emergency Response Plan* (*SHERP*) (Shaw, 2004) and subsequent addendums (to be provided under a separate submission). Because of the potential MEC hazard, qualified UXO personnel will perform surface sweeps of site roads and adjacent ditches as well as surface clearance of support areas prior to beginning the investigation if deemed required, such that instrument operators may proceed without requiring an active UXO escort in most areas.

In addition to the potential to encounter MEC, normal field-related hazards are also expected. These include slip-trip-fall, poisonous and/or stinging flora and fauna, heat or cold stress, etc. All hazards are addressed in the project's *SHERP* (Shaw, 2004) and will be reviewed with the field team.

3.0 Geophysical Data Quality Objectives

The following data quality objectives (DQOs) will provide sufficient metrics to quantify the quality of the data collected at RVAAP. It is stressed that these DQOs are only intended as objectives that will be used to monitor and evaluate the quality of data collected. Several of the following DQOs will be quantified based on the site-specific factors as seen during the test line/ GPO evaluation and from previously performed DGM. This section identifies the DQOs and investigation program objectives for this project. Data processing requirements identified in *DIDs (MR)-005-05* (USACE, 2003a) and *MR-005-05.01* (USACE, 2007) will be followed.

- **Background Noise based on Leveled Survey Data Set**—A DQO for background noise will be established based on site-specific and deployment-system-specific performance demonstrated on the test line. The data will be clipped such that any measurements that are well above the background noise (i.e., measurements that are potentially items of interest that will not be confused with system noise) will not be included in these statistics. The clipping value(s) will be recorded.
- **Mean Speed**—Maintain speed < 3 miles per hour (mph). The speed will be evaluated based on sensor orientation and bounce in terms of the amount of noise introduced into the data and along line sample spacing. Greater than 95 percent of data will fall within the speed metric.
- **Along Track Sampling**—< 0.6 foot with cumulative gaps less than 5 percent of the line distance.
- **Across Track Sampling**—< 3 feet, excluding data gaps due to trees or other obstacles that preclude the survey platform from providing complete coverage. This metric is intended to control data gaps associated with inconsistent track plots that are not associated with trees or other obstructions. For the purposes of this project, minor occurrences (i.e. measurements where the data quality is good and meets the survey objectives although ideal line spacing was not achieved during the survey) will not be accepted if they exceed 2.5 feet. Greater then 90 percent coverage will be at the 3 foot line spacing or less.
- **Latency Correction**—No visible chevron effects in the data or pseudo-color plots. The use of appropriate color scaling will be maintained throughout the project.
- **Data Leveling**—Consistent parameters and processing methods will be used for all channels within each dataset. Consistent processing routines will be used for all datasets throughout the project.
- **Anomaly Selection**—The anomaly selections will be accepted by the Project Geophysicist or their designated assistants. These individuals will verify that anomaly selections for a given dataset are reasonable and should identify MEC or MEC-like items to the extent possible. Protocols will be tested and evaluated using historical

knowledge and test line/GPO results. The DQOs for anomaly detection and selection are discussed in further detail in Section 3.1.

- **Positioning Errors**—Two positional errors are possible.

 1. Calibration Positional Check—The navigation system will be used to reacquire location data at known fixed locations at the beginning and end of the day. The acceptable difference in location measurement is <0.5 foot.

 2. Dynamic Position Check—Cumulative navigation positioning errors are not to exceed 2.5 feet. A functionality test will be performed each morning and evening to quantify the accuracy of the positioning/navigation system. This includes passing over a target with a known location and comparing the detected location with the known one. These offset distances (which are cumulative errors) between the detected and known locations are indicative of performance with respect to dynamic positioning.

- **Known Location QC Items**—Ground flush rebar hubs will be established at some grid corner locations for use as known location items. All known quality control (QC) locations must be detected to within 2.5 foot of their known locations for grid data and the test item positional offset must be less then 3.3 feet for transect data. Knowing that the QC items are being found within 2.5 feet (gridded data) or 3.3 feet (transect data) of their documented location is a solid indication that any anomaly will be located within the same metric.

- **Reacquisition**—Not Applicable.

- **False Positives**—False positives will be kept to a minimum. This will be achieved by careful data collection activities (i.e., stable, fluid motion) and careful data processing techniques.

3.1 Anomaly Detection

The DQOs for anomaly detection are based on proper execution of the most appropriate methods of data analysis. The performance objective is to detect all anomalies in the geophysical data set that meet or exceed the target pick criteria.

The selection of the most appropriate data analysis method is dependent on the quality of the data being evaluated. Factors that may influence the quality of the data set include site conditions related to vegetation, topography, soil type, proximity to structures, and degree and type of metallic debris; and type, distribution, and numbers of ordnance-related material.

Actual detection depths may vary within the survey area based on specific circumstances, such as the following:

- Item orientation
- Site background/noise levels

- Masking effects from adjacent metallic items
- Item shape
- Material composition of buried targets
- Site geology and soil conditions
- Weathering effects on the magnetic conductivity of item materials

The detection of anomalies will be conducted through the analysis of digital geophysical mapping (DGM) data.

3.2 Geophysical Prove-Out

A GPO will be performed prior to the geophysical investigations to determine which geophysical system will be most effective in the meeting the project detection requirements and to demonstrate that the project DQOs will be met during the subsurface investigations. A work plan for the GPO and reporting requirements are presented in **Appendix A**.

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4.0 Geophysical Project Personnel

All geophysical investigations will be managed by the qualified personnel presented in this section. All technical staff will report to Shaw's Project Manager, Mr. Dave Cobb. Résumés of the qualified project personnel are presented in **Appendix B**.

4.1 Project Geophysicist

Ms. Sandra Takata is the Project Geophysicist and has overall responsibility for design, implementation, and management of all geophysical investigations. She will establish and approve technical procedures, conduct technical QC procedures on the data, communicate with the geophysical crew to guide the progress of the investigation and ensure that the objectives are being met, and approve the geophysical sections of the *RI* reports to be prepared under this task order.

4.2 Quality Control Geophysicist

Mr. Chuck Nycum is the QC Geophysicist responsible for planning and executing QC oversight of geophysical activities and ensuring compliance with geophysical QC requirements. Specifically, he is responsible for the following:

- Reviewing and approving the qualifications of proposed geophysical staff and subcontractors
- Assisting the UXOSO/QC Officer in planning and ensuring the performance of preparatory, initial, follow-up, and completion inspections for the definable geophysical features of work
- Planning and ensuring the acceptable performance and completion of all geophysical QC activities
- Reviewing the geophysical QC, target lists, and dig results as specified in the Work Plan
- Identifying quality problems and verifying that appropriate corrective actions are implemented for geophysical activities
- Completing a weekly report summarizing geophysical activities, quality problems and other issues observed, and how each quality problem or other issues was resolved
- Ensuring that the requisite geophysical QC records, including submittals, are generated and retained as prescribed

Mr. Nycum will have access to all geophysical data. Mr. Nycum will provide a highly detailed degree of review at the onset of the project. Once the project performance levels have been verified to meet project DQOs, the level of effort of the QC may be reduced to periodic checks; however, should deficiencies in the program occur, the QC intensity will be increased until the performance level achieves acceptable levels, and then it will return to weekly checks. Mr. Nycum will report to the Project Geophysicist and be the primary point of contact with the UXOSO and QC Officer. It is anticipated that the majority of QC can be completed remotely by Mr. Nycum.

4.3 Senior UXO Supervisor/Quality Control Specialist

Mr. Charles Thomas will serve as the Senior UXO Supervisor/Quality Control Specialist (SUXOS/QCS) for this project. Mr. Thomas has over 40 years of experience in the explosive field and over 25 years of experience in the UXO field. He has worked as a UXO Tech III up to the Project Manager on UXO projects. He specializes in the UXO Quality Control on UXO projects and has been UXO Safety and Senior UXO Supervisor on numerous projects. He is proficient in all aspects of explosives and explosive demolition of MECs. As a UXO QCS, he has also been responsible for planning, execution, and compliance of the UXO QC operation, including: developing, assessing the effectiveness of, and maintaining QC requirements and related procedures; reviewing and approving the qualifications of the technical staff and subcontractors; and planning and ensuring the performance of the preparatory, initial, follow-up and complication inspection of each definable feature of work. In addition, he has 15 years of experience using explosives in the underground mining industry.

5.0 Geophysical Survey Equipment

The geophysical technology to be used for the geophysical investigations at the RVAAP AOCs has three main components: sensors, navigation, and deployment system. A Geometrics G858G cesium vapor magnetometer (G858G) or Geonics EM61 MK2 will be deployed based on the results of the GPO. Due to the terrain conditions the G858G will likely be used at the Sand Creek Site. The system will be positioned with a Leica RTS due to the wooded nature of the area. At ODA1 and MABS, an EM61-MK2 will be deployed along with an RTK GPS in open areas. Transect areas of ODA1 will be in wooded areas and a RTS will likely be used. The technical aspects of these components are discussed in Section 5.2.

5.1 Survey Type and Procedures

Full coverage and transect survey modes will be utilized. 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. Transect surveys are utilized to evaluate the extent of contamination in a large area through systematic surveying along linear paths with offset patterns and swath widths. All data traverses will be brought into the Geosoft for verification of full coverage.

Specific Procedures for Full Coverage Survey Mode include the following:

- Define the bounds of the site that requires full coverage. This is accomplished by reviewing and identifying issues that may affect the selection of the most appropriate technology.
- Systematically survey the site in the most effective pattern. The survey pattern will consist of consecutive multi-sensor passes. To ensure that full, overlapping coverage is obtained over the entire survey area, the operator will navigate through several methods, including: 1) observing the tracks of previous lines and offsetting the new line to obtain overlapping coverage; or 2) using spray paint or portable markers to mark the position of lines and then offsetting the new lines.

Specific Procedures for Transect Survey Mode include the following:

- Definition of transect coordinates. The GIS is used to update, as necessary, prescribed transect coordinates. All transects will consist of straight-line paths to the maximum extent possible.
- In-field transects definition. Stakes and highly visible flagging are placed in the field along transect paths such that the distance between flags is visible to the sensor operator. The maximum distance between stakes is highly variable and is dependent on site conditions such as tree density, topography and location of any other line of

sight obstruction. The first point and last point of each traverse will be identified with double flags.

- Transects are surveyed systematically. Typically transects will consist of a single pass of the sensor system. In cases where two passes are required, the sensor system will run on one side of the transect flags on the first pass and to the other side on the return pass.

Common Elements for Both Survey Modes 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 Project Geophysicist at a convenient control point of known location. Confirm location control via check shots to at least one other control point of known location.
- Place temporary location control QC items in the survey area using the GPS or RTS 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. At least one location control item will be present in every five acres surveyed.
- 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 mph or as demonstrated 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.

5.2 Geophysical and Navigation Sensors

5.2.1 Geometrics G858G Magnetometer/Gradiometer

Total field magnetic surveys will be conducted using Geometrics G858G total field magnetometers for survey data acquisition and a G858 magnetometer (a single sensor G858G) for base station measurements. The G858G, which is an optically pumped cesium vapor instrument, measures the intensity of the earth's magnetic field in nT. Magnetometer samples are typically collected at a rate of five (5) samples per second per channel. For the survey, the G858G will be operated in the vertical magnetic gradient mode; however, both the vertical magnetic gradient data and either the total magnetic field or a derivative of the lower sensor will be evaluated real-time.

The earth's magnetic field undergoes low-frequency diurnal variations associated with the earth's rotation, generally referred to as magnetic drift. A base station G858 optically pumped cesium magnetometer may be used to monitor and record this drift as well as monitor for periods of magnetic storms with high-frequency, high amplitude fluctuations of the total magnetic field.

If ferrous-rich geologic formations are present, magnetometers are ineffective. Total field magnetometers are used when the clearance is beyond 4 feet as theoretically the instruments have a deeper depth of investigation.

5.2.2 Geonics EM61-MK2

The EM61-MK2 sensor is battery-powered and operates at a maximum output of 10,000 milliVolts (mV). The EM61-MK2 sensor is a 1 meter (m) x 0.5 m air-core coil that acts as both a transmitter and receiver. The transmitter generates a pulsed magnetic field that induces eddy currents in conductive objects within the subsurface. These currents are proportional to the conductive nature of the material below the instrument. When conductive objects are present below the instrument, the amplitude and decay time of the induced eddy currents vary in response to the size, mass, and orientation of the objects. The receiver measures the amplitude of these eddy currents at 216, 366, 660, and 1,260 micro-second intervals (time gates) during the decay period.

A single EM61-MK2 sensor will be hand-pulled on a wheel- or sled-mounted cart. A GPS antenna or RTS prism will be mounted over the center of the sensor and linked to a portable receiver unit attached to the EM61-MK2 backpack. This receiver captures positional information and outputs a National Marine Electronics Association (NMEA) message directly into the Allegro data logger at one second intervals. Direct interfacing between the GPS and EM61-MK2 utilizes a single clock and streams position information directly into a raw MK2 data file.

5.2.3 Navigation and Mapping System

For navigational purposes either a RTK GPS or RTS technology will be used. Due to the heavy vegetation and tree canopy, it is expected that the RTS will be deployed at the Sand Creek area. At ODA1 and MABS, an EM61-MK2 will be deployed along with an RTK GPS. Transect areas of ODA1 will be in wooded areas and a RTS will likely be used. Both methods are described in detail below.

RTK GPS utilizes a base station that is set up on a known position. Once the base station is set up, the instrument determines its location using satellites and then applies a correction based on the offset from the known coordinates at the location. This correction is used by a rover that is in direct communication with the base station through a radio link. The rover must be within 6 to 10 miles of the base station and must have line of sight if it is farther away. Line of site is not necessary if the base is close to the rover. Therefore, preliminary survey control is required. RTK GPS is capable of taking survey-grade measurements in real time and providing immediate accuracy to within 1 to 4 centimeters (cm).

RTS uses a motorized total station with automatic target recognition to track the location of the prism. The Leica RTS TPS1200 used by Shaw has a highly accurate distance/azimuth measurement system to produce +/-5 millimeter +2 parts-per-million accuracy for both lateral and vertical coordinates. The RTS tracks the roving prism and outputs a pseudo-NMEA coordinate stream at user-selectable rates up to 10 Hertz (Hz) via serial output on both the base station and rover computing units. Prism tracking parameters may be optimized for rapid recovery of lock if line-of-sight is interrupted by trees or other obstacles during a survey. The pseudo-NMEA data string is connected via serial link directly into the geophysical instrument's data logger, just as GPS output would be.

The navigation system will be used for location tasks including feature identification. The GPS or RTS will be used to augment geophysical data and improve geophysical mapping through capture of visual observations made during the site walk-over. During this process, the GPS will be used for position-stamping debris piles, unidentified fences, soil changes, vegetation and burn areas. Navigational data will be presented in WGS84, Universal Transverse Mercator (UTM) coordinates, or as specified by the project team.

5.2.4 Data Processing System

Geosoft Oasis Montaj and UX-Detect software will be utilized for most data reprocessing tasks and evaluation, as well as target picking tasks. Shaw has also developed Matlab-based routines for specialized data processing and analysis techniques, which may be utilized. The majority of these routines have been developed to format the geophysical data before importing it into Geosoft.

5.3 Production Rates

Data production rates are expected to be approximately ½ acre per day at Sand Creek. For the open areas at ODA1 and MABS, a production rate of 1 to 3 acres per day is expected.

5.4 Data Spatial Density

The sampling frequency will be no less than 1 Hz for the navigation data stream and 4 to 10 Hz for the geophysical instrument. As specified in the DQOs, along-track sampling densities will be less than or equal to 0.6 foot, and across-sampling will be approximately 3 feet. Exception will be taken where physical obstructions are encountered in the field.

Transect separations and locations will be determined after review of the DGM area so that they can be selected based on the locations and concentrations of buried metal locations. This will maximize the effectiveness of the interpretation of the transect data.

5.4.1 Anomaly Reacquisition

Anomaly removal or reacquisition activities are not included in the scope of work for the geophysical investigations to be performed under this task order; therefore, no discussions regarding instrument use for reacquisition, anomaly marking and data flagging, feedback process for reacquisition or intrusive anomaly verification with regards to anomaly reacquisition is presented in this *GIP*.

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6.0 Data Processing

Shaw's standard data processing will include statistical data assessment, grid generation, and data filtering to accentuate target signatures. Shaw will use Geosoft's Oasis Montaj and UX-Detect software to complete all tasks. All data filtering will be conducted using Geosoft. However, if necessary, in-house software may be used to facilitate some data filtering functions. Subsequent to the processing and review of the data, all data grids and target detections will be loaded into the GIS.

The Project Geophysicist will review sensor and navigation data for accuracy, completeness, and data fidelity and will verify that the data are complete. The quality of the data will be determined and additional filtering or reprocessing of the data that may be necessary. Additionally, one-dimensional line data will be reviewed in Geosoft's Oasis Montaj UX Detect software that has a profile display mode. All observations related to data review will be fully documented in the Data Processing Log (Form C-1) included in **Appendix C**.

All activities will be documented on the Data Processing Log. The initial steps taken in the data processing flow will include the following:

- **Initial Review of Collected Data**—The data will be reviewed to assess the coverage area, noise levels, and erroneous points.
- **Navigation Data Review**—Positional information collected via GPS and RTS navigation is designed to provide real-time XYZ location solutions concurrent with collection of the sensor data. However, circumstances can arise where the data require post-processing to remove errors in coordinate locations. If positional errors are detected, they will be documented in the Data Processing Log (Form C-1). Subsequently, these position data will be used in the data-merging step to create XYZ files.
- **Coverage Assessment**—To verify that complete coverage has been achieved during survey activities, all navigation traverses will be reviewed and documented during the data processing and analysis steps. The areas surveyed and areas missed will be calculated and documented on the Navigation QC Function Log.
- **Deletion of Extra or Erroneous Data**—Extra or erroneous data such as instrument run-ons at the ends of lines, data collected in turnaround areas, data spike, nulls, etc. will be deleted.
- **Site Feature Check**—Additionally, the geophysicist will examine the data with respect to cultural or natural features (wells, trees, utilities, etc.) observed on site or mapped in the GIS.

- **Analysis of Data Sampling**—Data sampling statistics will be calculated in Geosoft and entered on the Navigation QC Function Log. These statistics include: velocity, along-track and across-track data spacing, area surveyed, and area of data gaps. The survey platform will maintain a mean speed less than 3 mph. Along-track sampling error will be less than 0.5 foot. Across-track sampling error will be less than 2.5 feet excluding data gaps due to trees or other obstacles that preclude the survey platform from providing complete coverage. This metric is intended to control data gaps associated with inconsistent track plots that are not associated with trees or other obstructions. For the purposes of this project, minor occurrences (i.e. measurements where the data quality is good and meets the survey objectives although ideal line spacing was not achieved during the survey) will be accepted if they do not exceed 2.5 feet.
- **Analysis of Replicate Data**—The pre-and post-survey replicate data lines will be reviewed for each data set. Data sampling statistics will be calculated in Geosoft and entered on the Navigation QC Function Log. The amplitudes of the responses over standard test items should be within 20 percent, the location accuracy should be within 2.0 feet, and the latency calculation should check with the Navigation Function Test results.

6.1 Standard Data Analysis

Geophysical data analysis will begin after execution of data preprocessing where field data will be verified, cataloged, and reviewed. All activities will be documented on the Data Processing Log (Form C-1). The digital data will be an American Standard Code for Information Interchange (ASCII) space or comma delimited XYZ file suitable for input into the Geosoft programs.

6.1.1 Sensor Bias, Background Leveling and/or Standardization Adjustment

Based on the initial review of the data, the statistical assessment results, and the calibration data, further data leveling may be applied to the data. Consistent parameters and processing methods will be used for all channels within each data set. Consistent processing routines will be used for all data sets throughout the project.

6.1.2 Latency Correction

Latency corrections based on the navigation QC data will also be performed. These corrections are applied such that chevron effects are not visible in the processed data.

6.1.3 Geophysical Noise Identification and Removal (Spatial, Temporal, Motional, Terrain Induced)

Profile data will be reviewed and any noise will be identified and removed. Any cultural features suspected of introducing noise into the data will be identified on maps and notes.

6.1.4 Gridding Method and Search Criteria

XYZ files will be interpolated onto right-rectangular, evenly spaced grids. Gridding will initially be performed using Shaw geophysical software with an optimal grid cell size of 0.75 feet by 0.75 feet. Gridding parameters will be adjusted based on the sampling intervals actually observed in the data; however, interpolated grids will be reviewed by the data processor to determine the completeness and accuracy of prior data manipulation steps.

6.1.5 Contour Level Selection with Background Shading and Analysis

Gridded data will be reviewed in plan view to select color contour intervals and background to facilitate target analysis. Background levels will be established such that target locations will be highlighted. Color contour intervals will be logical and will highlight target locations. Standard color scaling will be maintained throughout the project. All plots of the DGM data will apply the same color scale.

Other successive data processing steps will include:

- **Statistical Analysis**—All XYZ files will be processed to calculate statistics describing survey coordinates and sensor values. These statistics will be calculated to assist the Geophysicist in the assessment of data quality.
- **Data Cataloging**—After completion of the data processing and target selections, all XYZ files will be cataloged into a Microsoft® Access database. Information in the database will document the sensor types, deployment configurations, navigation methods, crew members, statistical analysis results, etc.
- **Data Filtering**—Initial assessment of the data will be performed on grids with no filtering applied to the data. However, a suite of simple data filters is available to enhance target signatures by reducing the effects of high frequency and/or low frequency noise sources. If filtering is needed, it will be optimized to maximize the signal-to-noise-ratio on both weak and strong anomalies. Filter selections and all filtering parameters will be recorded.

6.2 Advanced Data Processing, Digital Filtering, and Enhancement

6.2.1 Dipole Match or Analytic Signal Calculation

Dipole match or analytic signal calculation will be performed as needed.

6.2.2 Digital Filtering and Enhancement (Low Pass, High Pass, Band Pass, Convolution, Correlation and Nonlinear)

Digital filtering and enhancement will be applied as determined from the GPO results.

6.3 Anomaly Selection and Decision Criteria

Targets will be detected via a two-step process: (1) initial automated detection and (2) operator-aided detection by a qualified Geophysicist. The first step is automated target detection based on threshold analyses. Geosoft's UX-Detect will be used for simple threshold detection. Parameters controlling the selection of targets will include proximity of adjacent targets, signal power density, co-location of targets on other channels of data, area size, decay constant (Tau) and distribution of anomaly amplitudes.

The second step will consist of manual detection of targets based on a systematic visual search of raw and filtered data, on single or multiple channels. This will be accomplished within the Oasis Montaj/UX-Detect software system. At this stage, automatic target detections will be modified, deleted, and/or added by the operator. The automated and operator target detection steps will result in a target list and a set of target parameters, including XY, area, proximity to other targets, and signal strength statistics.

The steps of the target detection process are documented in the Data Processing Log (Form C-1) to facilitate replication of the target analysis results during QC.

For each data set, the Geophysicist will assess each of the following factors prior to generating an anomaly list:

- The local background conditions of the instrument's field response
- Data completeness and accuracy
- Data quality
- Field notes on site and survey conditions and observations
- The boundary conditions, utilities and/or other cultural features present and unsurveyable areas (beneath roads, trees, buildings, etc.)
- The shape and amplitude of the response of relevant anomalies encountered in previous MEC removals
- Local geology and soil conditions
- The extent and boundaries of metal-rich fill areas, if any

Target selection procedures and parameters are based on the data analysis results. Geosoft UX-Detect will be used to automate the initial anomaly selection process.

A manual review of the anomalies and target lists will be performed to verify the anomalies and to optimally locate the target location on the anomaly as needed. Targets will be removed if caused by cultural anomalies (roads, fences, wells, etc.) or are due to obvious artifacts (e.g., drop-outs) in the data.

6.3.1 Dig Sheet Development

The target analysis process culminates in the creation of standardized Dig Sheets (Form C-2), which contain target location and peak amplitude values (**Appendix C**). Following the identification of potential target anomalies from the geophysical data evaluation, the anomalies will be assigned to the appropriate grid for development of the dig sheets. Target anomalies chosen for intrusive verification will be chosen to further define the nature and extent of MEC. Dig sheets will be provided for use by the Army for future work.

The dig sheet will contain the following information:

- Facility
- Responsible geophysicist
- Geophysical data sets used
- Transect/Grid identification
- Background response levels
- Unique anomaly identification numbers
- Predicted anomaly easting and northing in WGS84, UTM or any other coordinate system specified by the project team
- QC target anomalies
- Sensor peak values for each target anomaly

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7.0 Quality Control

7.1 Instrument Standardization

Instrument standardization procedures are implemented to ensure accuracy and repeatability of all collected field data. Instrument standardization procedures, minimum test frequency, and acceptance criteria requirements outlined in Attachment B of *DID MR-005-05* (USACE, 2003a) will be followed.

7.2 Equipment Function Verification

Equipment function verification will be performed at the site to ensure that the geophysical survey equipment is working according to manufacturer's specifications and is appropriate for the intended reacquisition and excavation QC activities. The Project Geophysicist or the QC Geophysicist will review and approve each Sensor QC Verification Log (Form C-3) and Navigation QC Function Log (Form C-4) daily to document the proper equipment function. These forms are modeled after Attachment B, Quality Control Frequency and Acceptance Criteria Chart in *DID MR-005-05* (USACE, 2003a) are included in **Appendix C** of this *GIP*. Additionally, the UXOSO/QC will review the Equipment Verification Log forms as part of the QC program.

7.3 Calibration Site Establishment

One or more calibration test areas will be established at convenient locations. Each calibration site will consist of marked, reference areas where calibration and QC tests may be performed.

A number of QC tests will be performed as indicated in **Table 7-1**. Forms are provided in **Appendix C**. Descriptions and frequency of QC tests to be performed are as follows:

- **Equipment Warm-Up**—Most instruments require a few minutes to warm up before data collection begins to minimize sensor drift due to thermal stabilization effects. All instruments will be allowed to warm up for at least 5 minutes before data collection. This procedure will be followed each time the instrument is powered up (e.g., at the start of the day, after breaks, etc.).

- **Record Sensor Position**—At the beginning of the survey, and thereafter at any change in form factor, or when a sensor is reattached to a pole or cart, the relative positions of the sensors and the sensor heights off the ground will be measured and recorded.

Table 7-1
QC Frequency and Acceptance Criteria, Geophysical Investigation at Sand Creek, ODA 1, and MABS

Test	Acceptance Criteria	Frequency of Testing			
		Start of Day	Start & End of Day	First Day of Project Only	Equipment Change
Equipment Warm-up	Equipment Specific - typically 5 minutes	X			
Record Sensor Position	+/- 1 inch			X	X
Personnel Test	EM: 2 mV pole to pole (p-p) Mag: 1 nT p-p	X			X
Vibration Test (Cable Shake)	Data spiking not evident in profile		X		X
Static Background Test	EM: 2.5 mV p-p Mag: 1 nT p-p		X		X
Static Spike Test	+/- 10% of standard response after background correction on all channels		X		X
Azimuthal Test (magnetics only)	Sensor orientation minimizes drop outs			X	
Height Optimization (magnetics only)	Maximum S/N ratio that reliably detects smallest target objective			X	
6 Line Test	Repeatability of response amplitude +/- 20%, Positional accuracy +/- .5 foot			X	X
Octant Test (magnetics only)	Document heading error for post-processing correction			X	X
2 Line Repeat Data	Repeatability of response amplitude +/- 20%, Positional accuracy +/- 2 feet		X		

Notes:

Test frequency and acceptance criteria are based on the contract SOW and the Geophysical Investigation Plan, Data Item Description, MR-005-05 (USACE, 2003a)
EM = electromagnetic
Mag = magnetometer
mV = milliVolt
nT = nanoTesla
S/N = signal to noise ratio

- **Static Background Test**—The Static Background Test and Spike Test monitors the instrument background readings, monitors for electronic drift, and identifies potential interference. With the instrument held in static position, measurements will be recorded for a period of at least 3 minutes. The test will be performed twice daily, prior to collecting data and after completion of data collection. Static background readings for the EM61-MK2 should remain within 2.5 mV of background. The results of the Static Background Test will be documented on the Sensor QC Verification Form (Form C-3).

- **Static Spike Test**—The Static Spike Test monitors the impulse response and repeatability of measurements over a standard test item. The standard test item is usually a 2-inch-diameter steel trailer hitch ball; at least 1 minute of data will be recorded. Readings for the response of the standard test item should be within 10 percent after subtraction of the sensor baseline response. The test will be performed twice daily, prior to collecting data and after completion of data collection. The results of the Static Spike Tests will be documented on the Sensor QC Verification Form (Form C-3).

- **Two-Line Repeat Data**—The repeatability of geophysical mapping data will be monitored by the collection of replicate data. Replicate data will be collected for each data set. Generally, a 50- or 100-foot long replicate data line will be established about 10 feet outside of the area to be surveyed and oriented in the general direction of planned traverses. Start and endpoints of the line will be marked with pin-flags and measuring tape line. A standard test item (2-inch-diameter steel trailer hitch ball) will be placed at the center of the line located such that the sensor will pass over it. The line will be recorded, up and back, at the start and again at the completion of each data set. The amplitudes of the standard test items should be within 20 percent. The on-line offset locations will be used to calculate instrument latency.

- **6 Line Test**—A 50-foot test line is set up and well marked such that the same path can be repeatedly surveyed. Background conditions are evaluated on Lines 1 and 2. Heading effects, repeatability of response amplitude, positional accuracy and latency are evaluated in Lines 3 through 6. The test line is then surveyed as follows:

  – Lines 1 and 2: Survey up and back on the test line at a normal speed.

  – A standard 2 inch trailer hitch ball is placed at the center of the line for Lines 3-6. For multi-sensor form factors, a hitch ball is used for each sensor tack.

  – Lines 3 and 4: The line is surveyed up and back at a normal speed.

  – Line 5: The line is surveyed at a fast speed.

  – Line 6: Coming back, the line is surveyed at a slow speed.

- **Azimuthal Test (magnetics only)**—For the Azimuthal Test, an area free of geophysical noise is selected. A measurement point and the four cardinal directions are marked on the ground. A sensor head is fixed on the form factor to be deployed. Data are then recorded in a variety of sensor head orientations such that the orientation which minimizes drop outs can be selected. This test is performed once for each system deployment and each operator.

- **Octant Test (magnetics only)**—For the Octant Test, a total of eight lines of magnetic data are collected, passing over the same central point. The arrangement of lines is North-South, Northeast-Southwest, East-West, and Northwest-Southeast arranged radically over a marked central point. The difference in the response over the central point documents heading effects. This is the recommended test for establishing heading correction parameters. Typically, this test is performed once over the project duration for each system deployment and each operator. However, small changes in heading errors from the same deployed system have been observed to change over short periods of time. Therefore, in most instances, the actual heading corrections applied to any given set of data will need to be optimized during data processing. Should large heading changes be seen during data QC, the test will be re-run for further evaluation of both the equipment and data processing parameters.
- **Height Optimization (magnetics only)**—A test line is established with at least one test object along its length. Data are collected with the instrument using a minimum of three different sensor heights. The goal is to optimize the target signal to noise ratio, and maintain adequate sensitivity. This test is performed once for each system deployment and each operator.

Instrument standardization procedures will be implemented to ensure accuracy and repeatability of all field data. Applicable requirements for instrument standardization, minimum test frequency, and acceptance criteria are outlined in Attachment B of *DID MR-005-05* (USACE, 2003a) and detailed as follows:

- **Personnel Test**—The Personnel Test is performed to check the influence of personnel-carried metallic items (e.g., keys, boots, belt buckles, etc.) on the sensors. With the instrument held in static position, the operator(s) will walk around the sensors while measurements are being recorded for a period of at least one (1) minute. The test will be performed daily, prior to collecting data. The Personnel Test is included in the Static Background Test.
- **Cable Shake Test**—The cable shake test will be performed for each sensor at the beginning and end of each day to document any cable or connection problems. With the instrument motionless and recording, each data cable will be shaken to test for shorts or bad connections. Data collected during the Cable Shake Test should be free from spikes or variations. Cable problems generally require replacement. Connection problems will generally be fixed either by cleaning or reconnection. The results of the Cable Shake Tests will be documented on the Sensor QC Verification Form (Form C-3).

7.4 Standardization Logs

Standardization for geophysical mapping will be ensured through adherence to standard procedures and full documentation. The following logs will be used to maximize standardization, repeatability, and control of mapping activities:

- **Sensor QC Verification Log**—This log (Form C-3) will be used to document the daily calibration of each field sensor. This form will also document the results and analysis of the pre- and post-survey Static Test, Static Spike Tests, and Cable Shake Test.
- **Navigation QC Function Log**—This log (Form C-4) will be used to document daily calibration of the navigation system. Pre-and post-survey results of the detection of location test points will also be documented.
- **Survey Rework Form**—This log (Form C-5) will be used to document any necessary data that was re-collected and the reasons why.
- **Dig Sheet**—Form C-2: Sample Dig Sheet.
- **Data Processing Log**—All DGM survey data will be processed as outlined in the GPO report. This procedure will be the same for all data and will be tracked with the Data Processing Log (Form C-1). This data processing log will be used to document all coordinate transformations, visual data quality checks, statistical data quality checks, statistics, interpolation parameters, etc.
- **Field Data Sheet**—The Field Data Sheet (Form C-6) will be used to identify the location of each geophysical survey member on a daily basis. The log will track crew members, equipment, and expected areas to be surveyed. Maps of the areas to be surveyed containing the coordinates of benchmarks in the areas as well as the coordinates of each quadrant corner will be attached to this daily log. Additionally, this will document observations about crew performance, sensor performance, site conditions, and weather changes including notes regarding features and site conditions that could impact the survey either in regard to data coverage and/or data quality.

7.5 Additional Checks

Additional function tests may be performed as the operator deems necessary. The data from each sensor will be compared with the data collected on previous days. If there is a significant change in results, the instrument will be rechecked. If the difference in data cannot be accounted for, the instrument will be taken out of service until repaired.

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8.0 Corrective Measures

The objectives of the geophysical investigations are to accurately locate and record the location of anomalies. In the event of a DQO failure, Shaw's Project Geophysicist and QC Geophysicist will perform a root-cause analysis to identify the reason for the failure and how much data have been affected, and whether corrective actions can be taken to correct, mitigate, or eliminate the cause of the failure. This will include examining the ability to meet the metric for any DQO given the site conditions where the data were collected. The root-cause analysis will be submitted.

In the event that a particular geophysical method, instrument, or procedure is not generating meaningful results or advancing the project goals, Shaw will convene a review team consisting of Shaw's Project Manager, the USACE Project Manager, the Project Geophysicist and QC Geophysicist, the USACE technical and quality assurance (QA) staff (if requested), and Ohio EPA to investigate the cause and recommend corrective action.

Specific corrective measures are dependent on the type of geophysical equipment used during an operation and will be developed on a site-specific basis. However, the following are the basic corrective measures Shaw will employ:

- Replace sensors if they fail to meet calibration requirements.
- Replace navigation equipment if daily check of location accuracy is not met.
- Re-collect impacted data.

Basic corrective measures will be implemented as part of day-to-day activities (i.e., replacing faulty equipment). The USACE and Ohio EPA will receive written notification of all actions taken. If an instrument or process cannot be corrected to meet a DQO, Shaw will cease using that instrument or process and make recommendations to USACE and Ohio EPA. These recommendations may include modifications to this *GIP*; Shaw will implement the amended plan upon approval from the USACE and Ohio EPA.

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9.0 Records Management

The geophysical records management plan includes four components: field survey records management, data management, GIS records management, and data processing/analysis records management.

9.1 Field Survey Records Management

All data files and field logs generated during the field operation will be managed by the Project Geophysicist and provided to the USACE and Ohio EPA. Photocopies of all paper documents will be made and filed at an off-site location. Paper documents with significant information not captured digitally will be scanned and archived. Electronic files and forms will be organized on Shaw's computer network. File directory structures for field data will be organized by day of year, with subdirectories for specific field activities (sensor verification data etc.).

Posted deliverables of field survey records are as follows:

- Weekly QC geophysical summaries of field activities including DGM activities, production rates, issues encountered, and actions taken
- Weekly updates of processing and standardization tracking spread sheets

9.2 Data Management

The geophysical data files will be organized on Shaw's computer network; electronic files will include, but will not be limited to navigation files, sensor calibration files, and QC test data files. Standardized file naming conventions and directory names will be used. File directory structures for field data will be organized by day of year, with subdirectories for specific field activities (navigation data, instrument verification data, etc.).

9.3 GIS Records Management

GIS files will be managed by the GIS Manager and stored on Shaw's computer network. The data will be stored within the standard GIS subdirectory structure with README files in each directory containing a description of the contained files. All GIS data will be archived on a daily basis.

9.4 Data Processing and Analysis Record Management

All data files and Data Processing Logs (Form C-1) generated during the processing and analysis of geophysical field data will be managed by the Project Geophysicist. Photocopies of all paper documents will be made and filed at an off-site location. Electronic files will be organized on

Shaw's computer network by day-of-year, with subdirectories for specific field activities (navigation data, instrument verification data, excavation QC data, etc.).

10.0 Reporting

Shaw will prepare a draft *Geophysical Investigation Summary Report* with GIS data for Army review within 60 days of the completion of field work. The final version of this report will require review and approval from both the Army and the Ohio EPA. Access to interim geophysical survey and navigation data as the report is being developed will be provided via a project SharePoint site. Data will include the following:

- All processed XYZ and grids files (if appropriate), with associated README files
- Data and QC reports for all targets in Microsoft® Word format
- Draft and final anomaly lists in Microsoft® Access format
- Dig lists and relocation coordinates in Microsoft® Access format

Interim GIS data will include electronic base and topographic maps for all surveyed areas, in Geosoft or ArcView format.

10.1 Map Format

Finalized data will be transmitted after completion of data processing activities, along with a letter of transmittal conveying explanations and pertinent information, and will include maps, QC reports, summaries, and supporting data.

10.2 Sensor Data

All sensor data will be preprocessed for sensor offsets, latency effects, etc. and correlated with navigation data. The geophysical mapping technology will digitally capture the instrument readings into a file coincident with WGS84, UTM or other specified coordinate system. These field data will be checked, corrected and processed into ASCII files in the XYZ file format. Corrections (e.g., for navigation and instrument bias) will be applied and all corrections will be documented.

10.3 Data Format

The data will be presented in delineated fields as “X, Y, Z1, Z2, Z3 …,” where X and Y will be State Plane Coordinates in East and North and “Z1, Z2, Z3 …” will be the instrument readings. The data will be either comma or space delimited. Geophysical field data will consist of files in column format and native geophysical processing software format (e.g., Geosoft gdb). Header information such as contractor, project name, grid name, date, sensor used, all data channel names showing processing steps as well as the data will be included in each file. Each grid of data will be logically and sequentially named so that the file name can be easily correlated with the grid or transect name used by other project personnel.

10.4 Data Maps

A digital planimetric map of each geophysical survey grid or transect will be prepared as part of the final deliverable. The map format will be consistent with *DID MR-05-005.01* (USACE, 2007). These maps will reflect the current site conditions after site preparation work (removal of vegetation, fencing, dumpsters, debris, etc.) has been completed. ArcView format GIS or Geosoft or common image (e.g., JPEG, TIFF) maps will be provided including the locations of all targets and excavation results. Geophysical image maps and target density maps will be provided for each grid with the geophysical data displayed in color with overlaid target data. Site features such as monitoring wells, utilities etc. that are documented by the survey team using the navigation system will also be included. These maps will be in the project team's specified coordinate system, and will be coincident with the location of the geophysical survey data.

11.0 References

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APPENDIX A
GEOPHYSICAL PROVEOUT WORKPLAN

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Final Geophysical Prove-Out Plan for the Ravenna Army Ammunition Plant
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
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July 16, 2009

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Acronyms and Abbreviations

A/E	Architectural/Engineering
AOC	Area of Concern
ASCII	American Standard Code for Information Interchange
cm	centimeters
DGM	Digital Geophysical Mapping
DID	Data Item Descriptions
DQO	data quality objectives
EM	Electromagnetic
EM61-MKII	Geonics EM61-MKII Metal Detector
G858	Geometrics G858 Cesium Vapor Magnetometer (single sensor)
G858G	Geometrics G858G Cesium Vapor Magnetometer (2 sensors)
GIP	Geophysical Investigation Plan
GPO	Geophysical Prove-Out
GPS	Global Positioning System
Hz	Hertz
in	inches
MABS	Mustard Agent Burial Site
MEC	munitions and explosive of concern
NMEA	National Marine Electronics Association
M	meter
mm	millimeters
mph	miles per hour
MR	Munitions Response
mV	milliVolts
nT	nanoTesla
ODA1	Open Detonation Area #1
Ohio EPA	Ohio Environmental Protection Agency
PC	personal computer
QA	Quality Assurance
QC	Quality Control
QCS	Quality Control Specialist
RTK	Real-time Kinematic
RTS	Robotic Total Station
RVAAP	Ravenna Army Ammunition Plant
SAIC	Science Applications International Corporation
Sand Creek	Sand Creek Disposal Road Landfill
Shaw	Shaw Environmental & Infrastructure, Inc.
S/N	signal to noise ratio
TDEM	Time-Domain Electromagnetic
TPS	Total Positioning Station
USACE	U.S. Army Corps of Engineers
USAESCH	USACE Engineering and Support Center, Huntsville
UXO	Unexploded Ordnance

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1.0 Introduction

This *Geophysical Prove-Out (GPO) Plan* is provided to establish the planning, performance, and reporting requirements for the construction of a GPO test plot and completion of a GPO at the Ravenna Army Ammunition Plant (RVAAP), Ravenna, Ohio. This *GPO Plan* will be used to support the execution of work by Shaw at the following sites: RVAAP-23 Sand Creek Disposal Road Landfill (Sand Creek), RVAAP-03 Open Demolition Area No. 1 (ODA1), and the RVAAP-28 Mustard Agent Burial Site (MABS). The GPO activities will be used to assess and document the performance of the geophysical instrumentation, navigation system, and field deployment form-factor. It 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 *GPO* will be conducted in accordance with *Date Items Description (DID) Munitions Response (MR)-005-*05 (USACE, 2003a), *DID MR-005-05a* (USACE, 2003b), *Engineering Manual (EM) 1110-1-4009* (USACE, 2007a) and *DID MR-005-05.01* (USACE, 2007b) for general guidance.

This *GPO Plan* is being prepared by Shaw Environmental & Infrastructure, Inc. (Shaw) under Delivery Order 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.

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2.0 Geophysical Prove-Out Objectives

The purpose of the GPO is to determine which geophysical system will be most effective in meeting the project detection requirements and to demonstrate that the project data quality objectives (DQOs) will be met during the subsurface investigation. The GPO will be designed to demonstrate that the selected geophysical system is meeting typical detection performance capabilities for anticipated munitions and explosives of concern (MEC). Secondarily, the GPO will be used to refine site-specific data quality measures and that the DQOs will be met with the system configuration. In addition, the GPO data will be used to develop and demonstrate the most effective and efficient anomaly selection criteria which will be outlined in the GPO Letter Report.

The objective of the Digital Geophysical Mapping (DGM) at RVAAP is to detect and define boundaries of MEC impacted areas at the Sand Creek, ODA1 and MABS Areas of Concern (AOCs). Standard USACE performance depths for detection of MEC items are essentially eleven (11) times the diameter of the item (**Table 2-1**). However, these metrics are only approximations and the standards are considered somewhat outmoded in the present industry. Site-specific performance depths will be established/optimized through the execution of this GPO Plan.

Table 2-1
Potential Seed Items and Standard USACE Performance Detection Depths

Ordnance	Diameter		Performance Detection Depth (11 x diameter metric)	
	mm	inches	m	inches
75mm	75	3.0	0.8	32.5
90mm	90	3.5	1.0	38.5
105mm	105	4.1	1.2	45.1
155mm	155	61.0	1.7	67.0
PIG	168	6.6	1.9	72.9

Note: Larger items are typically detected to performance depths which are generally deeper then clearance depths.
mm = millimeter(s)
m = meter(s)

2.1 GPO Tasks

The following principal tasks will be performed during the GPO.

- A prove-out test plot will be constructed in a centrally located area designated near the DGM areas at RVAAP so that the site conditions are representative of those to be encountered during the DGM effort. A pre-construction survey will be conducted using the same Geonics EM61-MK2 high-sensitivity electromagnetic (EM) metal detector that will be deployed in the seeded GPO plot. The area will be designated by RVAAP with concurrence from Shaw as to its applicability to the proposed work.
- A GPO will be performed over the test plot using the EM61-MK2, high-sensitivity metal detector deployed in a standard single sensor, wheeled configuration. A second prove-out using a Geometrics G858G cesium vapor magnetic gradiometer (G858G) will be conducted. This will verify that the geophysical sensors, navigational equipment, and deployment form-factors are acceptable.
- The sufficiency of the equipment, survey techniques, and data management, processing, and interpretation to meet the detection requirements will be demonstrated.
- Anomaly relocation techniques will be demonstrated.
- Sufficiency of quality control (QC) methods and techniques will be demonstrated.
- A GPO report will be prepared and submitted to USACE and Ohio Environmental Protection Agency (Ohio EPA) for approval.

2.1.1 Ordnance and Explosives Detection

The selection of the most appropriate technology is dependent on site conditions related to vegetation, topography, soil type, proximity to structures, degree and type of metallic debris, as well as type, distribution, and number of MEC. The EM61-MK2 and Geometrics G858G magnetic gradiometer sensors were chosen due to their high sensitivity, ease of deployment, and metal detection capability. Both the EM61-MK2 and G858G has a proven track record for detecting MEC at numerous sites world-wide. The main focus of this GPO is to observe and document the performance of the system on the specific site conditions at RVAAP targeting a sample of items known to be at the installation.

The performance capability of selected field equipment may vary within the site based on specific circumstances, such as the following:

- Item orientation
- Site background/noise levels
- Masking effects from adjacent metallic items
- Item shape
- Material composition of buried targets
- Weathering effects on the magnetic conductivity of item materials
- Soil properties

- Depth of burial

2.1.2 General Data Quality Objectives

The following DQOs are believed to provide sufficient metrics to quantify the quality of the data collected at the RVAAP. Therefore, they will be demonstrated in the GPO. It is stressed that these DQOs are intended as objectives only which will be used to monitor and evaluate the quality of data collected. Several of the following DQOs will be quantified based on the site-specific factors as seen during the GPO survey.

- **Background Noise based on Leveled Survey Data Set**—A DQO for background noise will be established based on site-specific and deployment-system-specific performance demonstrated in the GPO. Additionally, data from the GPO will be used as guidance on setting a metric for signal to noise ratios. The data will be clipped such that any measurements that are well above the background noise (i.e. measurements that are potentially items of interest that will not be confused with system noise) will not be included in these statistics. The clipping value(s) will be recorded.

- **Mean Speed**—Maintain speed < 3 miles per hour (mph). The speed will be evaluated based on sensor orientation and bounce in terms of the amount of noise introduced into the data and along line sample spacing.

- **Along Track Sampling**—< 0.6 feet (feet) with cumulative gaps less than 5 percent of the line distance.

- **Across Track Sampling**—< 3.0 feet, excluding data gaps due to trees or other obstacles that preclude the survey platform from providing complete coverage. This metric is intended to control data gaps associated with inconsistent track plots that are not associated with trees or other obstructions. For the purposes of this project, minor occurrences (i.e. measurements where the data quality is good and meets the survey objectives although ideal line spacing was not achieved during the survey) will not be accepted if they exceed 2.5 feet.

- **Latency Correction**—No visible chevron effects in the data or pseudo-color plots. The use of appropriate color scaling will be maintained throughout the project.

- **Data Leveling**—Consistent parameters and processing methods will be used for all channels within each dataset. Consistent processing routines will be used for all datasets throughout the project.

- **Anomaly Selection**—The anomaly selections will be accepted by the Project Geophysicist or his/her designated assistants. These individuals will verify that all anomaly selections for a given dataset are reasonable and should identify all MEC or MEC-like items. Protocols will be tested and evaluated using GPO data. The routines used for the production surveys will be finalized based on these results.

- **Positioning Errors**—Two positional errors are possible.

1. Calibration Positional Check—The navigation positioning system will be used to reacquire location data at known fixed locations at the beginning and end of the day. The acceptable difference in location measurement is <15 centimeters (cm) (0.5 feet).

2. Dynamic Position Check—Cumulative navigation positioning errors are not to exceed 2.5 feet. A functionality test will be performed each morning and evening to quantify the accuracy of the positioning/navigation system. This includes passing over a target with a known location and comparing the detected location with the known one. These offset distances (which are cumulative errors) between the detected and known locations are indicative of performance with respect to dynamic positioning.

- **Known Location QC Items**—Ground flush rebar hubs will be established at some grid corner locations for use as known location items. All known QC locations must be detected to within 2.5 feet for grids and for transects, the test item's positional offset within 3.3 feet (1 meter) of their known locations.

- **Reacquisition**—Not applicable.

- **False Positives**—False positives will be kept to a minimum. This will be achieved by careful data collection activities (i.e., stable, fluid motion) and careful data processing techniques.

The GPO may be used to demonstrate and quantify metric specific issues which can be adjusted if required or requested by the Quality Assurance (QA) Geophysicist or Project Geophysicist. It is intended that once the QA (USACE), Ohio EPA and Project Geophysicists agree on the DQOs, these revised specifications will be the basis for pass/fail decisions relating to the production data collection. Those issues will be documented in the GPO report.

In addition, the applicable *MR DIDs* (USACE, 2003a; 2003b and 2007b) will also be adhered to.

3.0 Site Conditions

Site conditions are discussed in detail in the project *Geophysical Investigation Plan* (*GIP*). A condensed description of the site conditions relevant to the GPO is presented below.

3.1 Topography and Vegetation

The plot location has not yet been selected but is expected be located in a flat, open area.

3.2 Geologic and Soil Conditions

The RVAAP is located within the Southern New York Section of the Appalachian Plateau physiographic province. This province is characterized by elevated uplands underlain primarily by Mississippian- and Pennsylvanian-age bedrock units that are horizontal or gently dipping. The province is characterized by its rolling topography with incised streams having dendritic drainage patterns. The Southern New York Section has been modified by glaciation, which rounded ridges, filled major valleys, and blanketed many areas with glacially-derived unconsolidated deposits (i.e., sand, gravel, and finer-grained outwash deposits). Glacial activity in the Southern New York Section disrupted stream drainage patterns in many locales, which resulted in development of extensive wetlands areas (SAIC, 2008).

3.3 Site Utilities and Man-Made Features

These conditions will not be evaluated in the GPO. Characterization and mitigation of features such as roads, above-ground and below-ground utilities, fences, and housing known to be present at RVAAP is identified and discussed in the *Geophysical Investigation Plan*.

3.4 Site-Specific Dynamic Events Affecting Geophysical Investigations

Dynamic events (rain, lightning, solar flares, etc.) may temporarily impact geophysical data collection and/or data quality. For the purposes of this GPO, if any of these events do occur, operations will cease until conditions improve.

3.5 Potential Worker Hazards

Other than the potential to encounter unexploded ordnance (UXO), only the normal field-related hazards are expected. These include slip-trip-fall, poisonous and/or stinging flora and fauna, heat or cold stress, etc. All hazards are addressed in the site-specific health and safety plan and will be reviewed with the field team prior to the GPO operations.

3.6 Site Access

GPO site conditions show no significant challenges in terms of site accessibility and system deployment impediments. If encountered, the following general site conditions and remedies are expected:

- Remote access—Access to the GPO plot will be via established roads. Site access is not expected to be a significant impediment.
- Poisonous plants—To the maximum extent possible, these plants will be removed prior to surveying by brush cutting. It is expected that the GPO plot will be selected so as to not include any poisonous plants.
- Sensitive habitats—In cases where surveying is coincident with the location of sensitive plant or animal habitats the Site Biologist, in conjunction with the Site Geophysicist, will be responsible for issuance of a memo of sensor deployment options. For the GPO plot, and the sites being surveyed, no sensitive habitats are expected to be encountered.
- Steep slopes—Unsurveyable, steep slopes will not be selected for the GPO site.
- Thick vegetation—The GPO site will be set up in an open area so thick vegetation is not expected for the GPO survey. Areas of open to thick vegetation are expected during the DGM, however, any vegetation will be cleared prior to surveys to the extent necessary with previous approval from RVAAP, the Army and the Ohio Army National Guard/Camp Ravenna environmental office. Both real-time kinematic (RTK) global positions system (GPS) and robotic total station (RTS) technologies will be used due to these conditions.

4.0 Geophysical Prove-out Test Plot

A GPO prove-out test plot will be constructed to test and demonstrate the performance of the DGM system used at RVAAP and the procedures to meet the project objectives.

4.1 Site Selection

A GPO test plot location will be selected adjacent and close to the field investigation area. The field investigation area is discussed and defined in the *Geophysical Investigation Plan*. The test plot location will be selected based on site access, representativeness to the DGM survey area, site conditions, access to survey control, and avoidance of obvious MEC issues or construction difficulties. Additionally, other considerations for site selection include avoiding areas of known contamination and avoiding conflicts with other activities. The area will be designated by RVAAP with concurrence from Shaw as to its applicability for the work to be performed.

4.2 Seed Items

A listing of potential seed items are presented in the **Table 2-1** along with their calculated USACE standard performance depth criteria of essentially 11 times the diameter of the item. It should be noted that the standards are only approximations. The seed items in Table 2-1 are based on the site histories and documentation of items found during previous investigations that include steel shipping containers (also known as PIGs), 90 millimeter (mm), 155mm projectiles and 75mm shells or simulants. From previous reports, PIGS, 155mm projectiles and drums either were found at or suspected at the MABS; 90mm are suspected at the ODA1 and 75mm shell casings have been recovered at Sand Creek.

Figure 4-1 illustrates the test plot design. It includes the general location of the buried item which will be accurately measured with GPS or the RTS during the construction of the test plot. It also shows the azimuth, inclination (dip), depth and type of buried target. Note that the depths are approximate and depend on the depth of bedrock. Ordnance will be buried at the depth specified or at bedrock, whichever is encountered first.

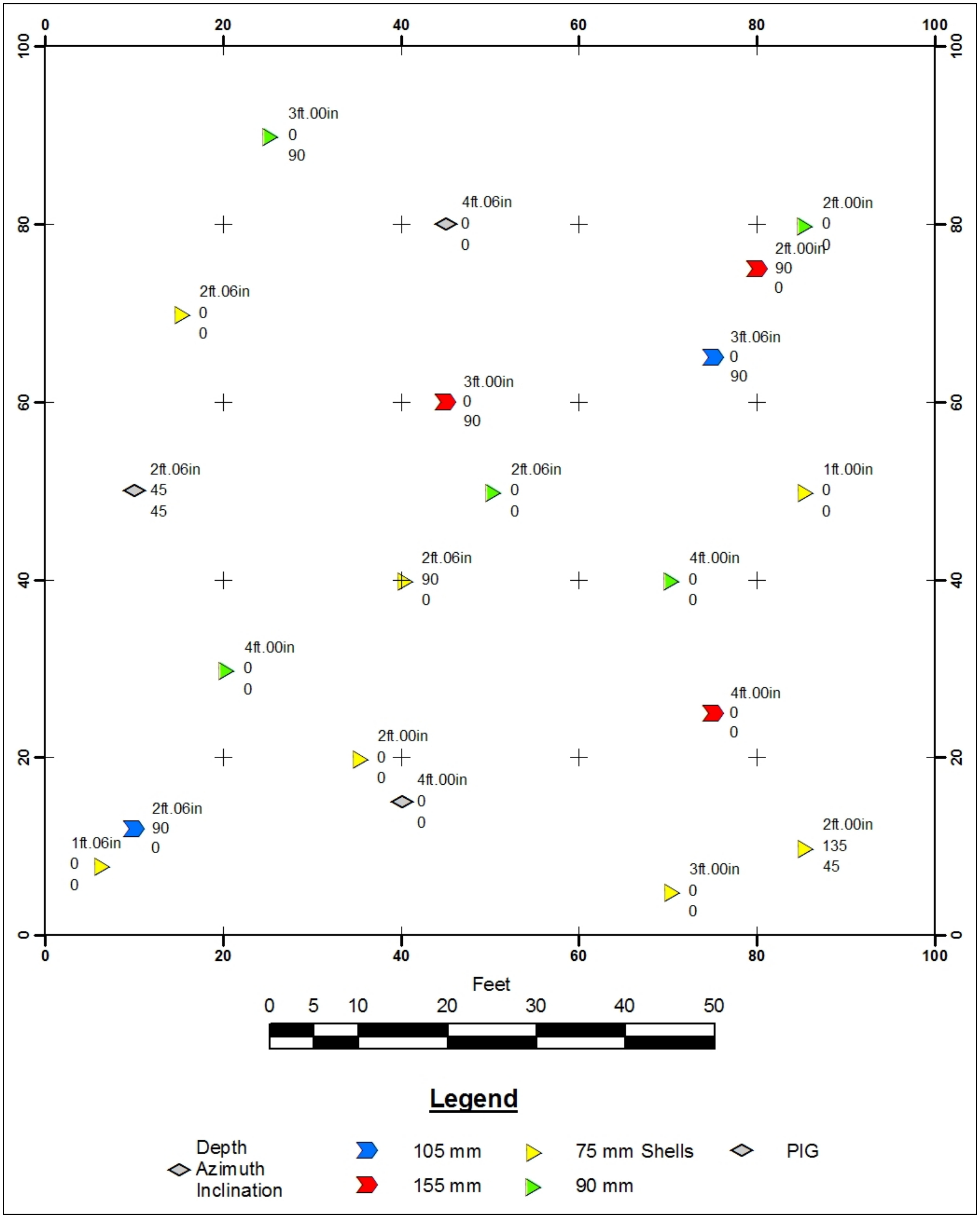

Figure 4-1
Test Plot Design

Based on the calculated performance depths (11 times the diameter of the object), the following approach is proposed for each item:

- Horizontal and/or vertical orientations slightly less than the performance depth;
- East-West and/or North-South azimuths, oriented perpendicular to the magnetic field; and
- Horizontal orientation placed at or slightly below the performance depth or at bedrock, whichever is encountered first.

A minimum of 20 seed items are planned but may be adjusted based on the availability of inert ordnance. Simulants will be used if inert ordnance is not available; however, every effort to obtain inert ordnance will be made.

4.3 Prove-Out Grid Construction

The prove-out grid layout and design, presented as Figure 4-1, will be approved prior to construction. Shaw UXO personnel will construct the prove-out grid. General clearance and grubbing and digging procedures will be performed. The proposed GPO plot is 100-feet by 100-feet with 25, 20-feet by 20-feet cells.

4.3.1 Site Preparation

Site preparation will mimic, as much as possible, clearance area site preparation as described in the overall Ravenna work plan. UXO technicians will remove surface metal which might interfere with geophysical responses. If location control is not present, a licensed surveyor will establish survey control to the grid with UXO avoidance support as needed. Rebar hubs of known location will be installed at the prove-out plot corners for reference. Locational accuracy of the corner hubs will be at least +/- 3 cm horizontally and +/- 5 cm vertically.

4.3.2 Pre-Seed Survey

A background survey will be conducted in the area identified for the construction of the GPO test plot. The test plot location will be sited in an area where the local conditions are the same or similar to those for the production surveys. The objective of the background survey will be to identify existing anomalies and provide a baseline in which to compare the GPO results. The background surveys will be performed using the EM61-MK2. The background survey will be reviewed and determined if this location is feasible for the GPO test plot prior to seeding inert items. If some anomalies are encountered in the area they may be left in place. That decision will be made conjunctively by the Project Geophysicist and USACE QA Geophysicist.

4.3.3 Burial Items

Project UXO personnel will bury the seed items as directed by the Project Geophysicist. Seed items will be distributed across the grid in accordance to the USACE approved prove-out grid layout and design. Depths to the top of the buried items will be measured to the nearest tenth of a foot below ground surface. Horizontal locations to the center of the items (and nose and tail end points of items as necessary) will be surveyed to a horizontal accuracy of at least +/- 3 cm and vertical accuracy of at least 5 cm. Azimuth and dip of the long axis of the seed items will also be measured and recorded.

5.0 Geophysical Survey Equipment

The geophysical technology to be tested and evaluated during GPO at RVAAP has three main components: sensors, navigation, and deployment system.

5.1 Geophysical Sensors

Based on experience at numerous MEC sites, and the type of targets at the RVAAP site, the GPO will be conducted using the Geonics EM61-MK2 time-domain electromagnetic (TDEM) sensor and the Geometrics G858G Cesium Vapor Magnetometer (G858G).

5.1.1 Geonics EM61-MK2

The Geonics EM61-MK2 is a 4-channel high-sensitivity TDEM sensor designed to detect shallow ferrous and non-ferrous metallic objects with good spatial resolution and minimal interference from adjacent metallic features. The EM61-MK2 consists of two, 1-m by 0.5-m rectangular coils stacked 40 cm apart with the source/receiver coil located below a second receiver coil. An EM pulse induces subsurface eddy currents with an associated secondary magnetic field. The decay of the secondary magnetic fields induced in subsurface materials are subsequently measured by the receiver coil and stored as milliVolts (mV). The EM61-MK2 records four measurements at each data location. Three standard time gates from the bottom coil are recorded. In addition, user selectable fourth bottom coil time gate is recorded or a differential (calculated as the voltage difference between the top and bottom coils) is recorded. For this project, data will be recorded at four (4) time gates from the bottom coil. The responses at these four specified time gates will be recorded and displayed by an integrated system data logger. Sensor sampling rates are user selectable up to about 13 Hertz (Hz), depending on the instrument configuration. The use of EM technology as a primary detection, location and characterization device is dictated by several factors including terrain, vegetation, metallic composition of targets, surface clutter, soil conditions, and proximity to metal structures.

If the presence of non-ferrous metal targets is suspected to be present or magnetic concretions in significant quantities are present, the use of the EM61-MK2 is applicable since it is capable of detecting non-ferrous metals and not affected by magnetic geology. The EM61-MK2 may detect buried metal beyond four (4) feet depending on the size of the target and the contrast between the native soils/geology and the target. Additionally, the EM61-MK2 responses are focused directly beneath the coils so the response from nearby structures is minimal compared to other sensors such as the magnetometer.

5.1.2 Geometrics G858G Magnetometer/Gradiometer

Total field magnetic (mag) surveys will utilize G858G total field magnetometers (2 sensors) for survey data acquisition. An additional G858 (single sensor magnetometer) will also be used for base station measurements. The G858 and G858G, which are an optically pumped cesium vapor instruments, measures the intensity of the earth's magnetic field in nanoTeslas (nT). Magnetometer samples are typically collected at a rate of five (5) samples per second per channel. The base station will monitor and record the earth's magnetic field as it undergoes low-frequency diurnal variations associated with the earth's rotation. This drift can then be removed from the field data during processing.

5.2 Geophysical Navigation

For navigational purposes RTS and RTK GPS technologies will be tested at the GPO.

5.2.1 Robotic Total Station

RTS uses a motorized total station with automatic target recognition to track the location of the prism. Leica RTS Total Positioning Station (TPS) 1200 used by Shaw has a highly accurate distance/azimuth measurement system to produce +/-5 mm +2 parts-per-million accuracy for both lateral and vertical coordinates. The RTS tracks the roving prism and outputs a pseudo-National Marine Electronics Association (NMEA) coordinate stream at user-selectable rates up to 10 Hz via serial output on both the base station and rover computing units. Prism tracking parameters are optimizable for rapid recovery of lock if line-of-sight is interrupted by trees or other obstacles during a survey. The pseudo-NMEA data string is connected via serial link directly into the geophysical instrument's data logger, just as GPS output would be.

5.2.2 Global Positioning Systems

Differential GPS technologies provide the sensor locations at half-foot, real-time accuracy. A dual frequency RTK differential GPS will be utilized for field-mapping applications when satellite visibility conditions are adequate. Global positioning system technologies offer full integration with geophysical sensors, real-time differential solutions based on either satellite-provided or base-station-provided differential corrections.

In addition to mapping geophysical data, the selected navigation instrument will be used for other location tasks including the following:

- **Feature Identification**—The navigation system will be used to augment geophysical data and improve geophysical mapping through capture of visual observations made during site walk-over. During this process, navigation system will be used for position-stamping debris piles, unidentified fences, soil changes, vegetation, burn areas, etc.

- **Target Relocation**—The navigation system are used for target relocation; however, no target relocation will be performed.

5.3 Deployment Form Factors

It is intended that a man portable, single sensor system will be the deployment form factor used at RVAAP.

5.4 Data Processing System

The raw field data will be downloaded to field personal computers (PCs) using Geonics DAT61 or Geometrics MagLog/MagMap software. Geosoft Oasis Montaj and UX-Detect software will be utilized for most data processing tasks and to perform review and QC checks on the DGM and QC data. Shaw has also developed Matlab based routines for specialized data processing and analysis techniques which may be utilized.

5.5 Sampling Frequency

Optimal sampling frequency and data density metrics for the full-scale DGM surveys will be established in the GPO. However, the sampling frequency will be no less than 1 Hz for the navigation data stream and 4-10 Hz for the geophysical sensor data. Along-track sampling densities will be less than or equal to 0.6 feet and across-track sampling densities will be less than or equal to 3.0 feet.

5.6 Geophysical Survey Modes

Full coverage and transect survey modes will be utilized for the GPO. Full coverage will be achieved through deployment of the sensor system through the collection of sub-parallel survey lines or swaths with sensor separations no greater than 3.0 feet. Transect surveys are utilized to evaluate the extent of contamination in a large area through systematic surveying along linear paths with offset patterns and swath widths being tested on the GPO. All data traverses will be brought into the Geosoft for verification of full coverage.

Specific Procedures for Full Coverage Survey Mode include the following:

- Define the bounds of the site that requires full coverage. This is accomplished by reviewing and identifying issues that may affect the selection of the most appropriate technology. For the GPO, the whole GPO plot will be surveyed.
- Systematically survey the site in the most effective pattern. The survey pattern will consist of consecutive multi-sensor passes. To ensure that full, overlapping coverage is obtained over the entire survey area, the operator will navigate through several methods, including: 1) observing the tracks of previous lines and offsetting the new line to obtain overlapping coverage; or 2) the use of spray paint or portable markers to mark the position of lines and then offsetting the new lines.

Specific Procedures for Transect Survey Mode include the following:

- Definition of transect coordinates. The GIS is used to update, as necessary, prescribed transect coordinates. All transects will consist of straight-line paths to the maximum extent possible.
- In-field transects definition. Stakes and highly visible flagging are placed in the field along transect paths such that the distance between flags is visible to the sensor operator. The first point and last point of each traverse will be identified with double flags.
- The transects are surveyed systematically. Typically transects will consist of a single pass of the sensor system. In cases where two passes are required, the sensor system will run on one side of the transect flags on the first pass and to the other side on the return pass. The most effective width of the swath will be determined during this GPO. The full survey data will be displayed as single line profiles (rather then gridded which is typical of a full survey, where target detection is based on multiple detections on adjacent lines) and the comparison of a single line and adjacent lines will be made to insure a single line is sufficient to detect targets.

Common Elements for Both Survey Modes include the following:

- Review the site. The GPO 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 Site Geophysicist at a convenient control point of known location. Confirm location control via check shots to at least one other control point of known location.
- Place temporary location control QC items in the survey area using the RTS 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. At least one location control item will be present in every five acres surveyed.
- 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 mph 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 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.

5.7 Location Control

Survey control for the GPO will be established. Semi-permanent rebar pins will be installed on the corners of the prove-out plot. These semi-permanent control points will be used for location control and navigational base stations set-up points.

RTK GPS or RTS navigation technology will be used for geophysical mapping, anomaly relocation, feature mapping and location, and establishment of interim location control points, utilizing these semi-permanent location control points.

5.8 Anomaly Location Reacquisition

Anomaly removal or reacquisition activities are not included in the scope of work for the geophysical investigations to be performed under this task order.

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6.0 Geophysical Data Processing

Shaw's standard data processing includes data leveling, statistical data assessment, grid generation, and non-customized data filtering to accentuate target signatures. Shaw will use software from the equipment manufacturers, in-house software, and Geosoft's Oasis Montaj and UX-Detect Software to complete all tasks. Subsequent to the processing and review of the data, all data grids and target detections will be loaded into the GIS.

Collected field data will be downloaded in the field directly from the data-logger to a laptop computer for processing. Appropriate vendor software (e.g., Geonics DAT61, Geometrics MagMap) will be used to download the data. The vendor software will also be used for initial review and editing of the data as necessary, for generation of profile lines, and for conversion of the survey line data to (x,y) coordinates for contouring and analysis. The initial steps taken in the data processing flow are outlined below.

Forms associated with the DGM data standardization (referenced throughout text below) are provided in Appendix C of the *GIP*.

6.1 Data Pre-Processing and Review of Data Sets

The data interpretation process begins by verifying the validity of the collected data sets. This will be accomplished by reviewing the associated QC data, insuring that the sensor and navigation equipment are functioning properly, that the data are accurately positioned along the predetermined survey lines, that they match the site dimensions, and properly fit within the predefined survey site. All validation results will be noted in the Data Processing Log (Form C-1).

6.1.1 Review of QC Data

Vendor-supplied software will be used to make initial review of the data. This step validates that the data collected fall within prescribed recording ranges, and that no data outliers or null-values are present. Data statistics will be developed to measure compliance with the DQOs. These QC and calibration data notes will be tracked with respect to collection and processing steps.

- **Review of Sensor QC Data**—Sensor QC test results (equipment warm-up, sensor position, static background and spike tests, cable shake test, personnel test) will be reviewed to ensure proper sensor function. Geonics/Geometrics and Geosoft software will be used to make initial review of the data. This step validates that the data collected fall within prescribed recording ranges, background noise and signal-to-noise-ratios fall within acceptable ranges, and that standard responses to known items are consistent with known values. Minimum, maximum, mean, and standard deviations of the pre- and post-survey Sensor QC tests will be calculated and reported into the Sensor QC Verification Log (Form C-3). Standard values and ranges will be determined, in consultation with USACE, based on GPO results.

- **Review of Navigation QC Data**—Vendor-supplied software will be used to make initial review of the navigation QC and to ensure that the navigation system is functioning properly. Geonics/Geometrics, Leica/Trimble and Geosoft supplied software will be used to make initial review of the data. Navigation offset distances and latency factors will be calculated based on the test results. Cumulative positioning errors (seen as offsets between known and detected anomaly locations) are not to exceed 2.5 feet. Navigation QC data parameters will be entered into the Navigation QC Function Log (Form C-4).

6.1.2 Initial Data Review and Preprocessing

The Site Geophysicist will review sensor and navigation data for accuracy, completeness, and data fidelity. The Geophysicist will also verify that the data are complete and fall within the prescribed survey area.

The operator will examine the quality of the data and define additional filtering or reprocessing of the data that may be necessary. Additionally, one-dimensional line data will be reviewed in Geosoft's Oasis Montaj UX Detect software that has a profile display mode. All observations related to data review will be fully documented in the Data Processing Log (Form C-1).

The vendor software will also be used for initial review and editing of the data as necessary, for generation of profile lines, base-station corrections (for magnetic data) and for conversion of the survey line data to (x,y) coordinates for contouring and analysis. Each sensor record has an associated time stamp. Preprocessing involves synchronization of the GPS navigation data stream coordinates with the sensor output data streams. All data will be converted into XYZ files with positioning data in the appropriate project coordinate system. All activities will be documented on the Data Processing Log (Form C-1). The initial steps taken in the data processing flow will include the following:

- **Initial Review of Collected Data**—Geometrics/Geonics supplied software will be used to make initial review of the data. This step validates that the data collected fall within prescribed recording ranges, and that no data outliers or null-values are present. During this step, all data collection and downloading parameters will be entered into the Data Processing Log (Form C-1).

- **Navigation Data Review**—Positional information collected via GPS/RTS is designed to provide real-time XYZ location solutions at 4 to 10 times per second, concurrent with collection of the sensor data. However, circumstances can arise where the navigational data require post-processing to remove errors in coordinate locations. If positional errors are detected, they will be documented in the Data Processing Log

(Form C-1). If post-processing is required, the vendor software may be used to recalculate or correct the coordinate solutions. Subsequently, these positional data will be used in the data-merging step to create XYZ files.

- **Data Merge/Offset Calculation**—During this step, the sensor data will be integrated with navigation data to create sensor data files with coordinate positions using DAT61 or Magmap if needed. Form factor adjustments of each sensor location (offset) with respect to the GPS antenna are made. Latency corrections based on the navigation QC data are also performed. No visible chevron effects in the data or pseudo-color plots will be seen. The use of appropriate color scaling will be maintained throughout the project. This step creates American Standard Code for Information Interchange (ASCII) XYZ data files containing Easting, Northing, and Sensor values in column format as described above. These files are similar to the USACE Engineering and Support Center, Huntsville (USAESCH) ASCII Data File, and conversion to the ASCII Data File format can be performed upon request.

- **Coverage Assessment—**To verify that complete coverage has been achieved during survey activities, all navigation traverses will be reviewed and documented during the data processing and analysis steps. The areas surveyed and areas missed will be calculated and documented on the Navigation QC Function Log (Form C-4). If missed surveyable areas are present, the gaps will be resurveyed.

- **Deletion of Extra or Erroneous Data**—Extra or erroneous data such as instrument run-ons at the ends of lines, data collected in turnaround areas, data spike, nulls, etc. will be deleted.

- **Site Feature Check**—Additionally, the geophysicist will examine the data with respect to site cultural or natural features (wells, trees, utilities, etc.) observed on site or mapped in the GIS.

- **Base Station Correction**—For data leveling, validated magnetometer data are corrected for diurnal fluctuations using Geometrics MagMap or MagMapper software. This software is designed to remove the ambient background from each sample collected by the G858G sensor. The resultant data set represents only the magnetic field changes that are caused by anomalous objects contained within the survey area. After the previously stated steps are executed and documented in the Data Processing Log (Form C-1), the data are adequately prepared for target detection and analysis. Given the short duration of the GPO surveying, base station data may be excluded. Should the DGM be performed using the G858G, then a base station will be used.

- **Analysis of Data Sampling—**Data sampling statistics will be calculated in Geosoft and entered on the Navigation QC Function Log (Form C-4). These statistics include: velocity, along-track and across-track data spacing, area surveyed, and area of data gaps. The survey platform will maintain a mean speed < 3 mph. Along-track sampling will be ≤ 0.6 feet. Across-track sampling will be ≤ 3.0 feet excluding data gaps due to trees or other obstacles that preclude the survey platform from providing complete coverage. This metric is intended to control data gaps associated with inconsistent track plots that are not associated with trees or other obstructions. For the purposes of this project, minor occurrences will be accepted if they do not exceed 2.5 feet.

- **Analysis of Replicate Data**—The pre-and post-survey replicate data lines will be reviewed for each data set. Data sampling statistics will be calculated in Geosoft and entered on the Navigation QC Function Log (Form C-4). The amplitudes of the responses over standard test items should be within 20 percent, the location accuracy should be within 2.0 feet, and the latency calculation should check with the Navigation Function Test results (USACE, 2003a).

6.1.3 Data Processing

Geophysical data analysis will begin after execution of standard data pre-processing steps (discussed in Section 6.1.2) where field data are verified, cataloged, reviewed, and converted into XYZ files. All activities will be documented on the Data Processing Log (Form C-1).

The digital data will be an ASCII-delimited XYZ file suitable for input into the Geosoft programs. Successive data processing steps include:

- **Statistical Analysis**—All XYZ files will be processed to calculate statistics describing survey coordinates and sensor values. These statistics will be calculated to assist the Site Geophysicist in the assessment of data quality.

- **Data Leveling**—Based on the initial review of the data, the statistical assessment results, and the calibration data, data leveling will be applied to the data. Consistent parameters and processing methods will be used for all channels within each dataset. Consistent processing routines will be used for all datasets throughout the project.

- **Data Cataloging**—After leveling of the XYZ files is completed, all XYZ's will be cataloged into a database. Information in the database will document the sensor types, deployment configurations, navigation methods, crew members, statistical analysis results, etc.

- **Data Gridding**—XYZ files will be interpolated onto right-rectangular, evenly spaced grids. Gridding will initially be performed using the Geosoft minimum curvature function with an initial grid cell size of no larger than 0.75 feet. Interpolated grids will be reviewed by the data processor to determine the completeness and accuracy of prior data manipulation steps. Gridding parameters will be adjusted based on the sampling intervals actually achieved in the data.

- **Data Filtering**—Initial assessment of the data will be performed on grids with no filtering applied to the data. However, a suite of simple data filters is available to enhance target signatures by reducing the effects of high frequency and/or low frequency noise sources. If filtering is needed, it will be optimized to maximize the signal-to-noise-ratio on both weak and strong anomalies. Filter selections and all filtering parameters will be recorded.

6.2 Target Detection

Target detection activities evaluated in the GPO will be used during the production survey. General Shaw procedures for target detection follow.

Targets are detected in a two-step process: (1) initial automated detection and (2) operator-aided detection by a qualified geophysicist. The first step is automated target detection based on threshold analyses. These results will be used for the production surveys. Geosoft's UX Detect will be used for simple threshold detection. Parameters controlling the selection of targets include proximity of adjacent targets, signal power density, co-location of targets on other channels of data, area size, decay constant (Tau) and distribution of anomaly amplitudes.

The second step is manual detection of targets based on systematic visual search of raw and filtered data, on single or multiple channels. This will be accomplished within the Oasis Montaj/UX-Detect software system. At this stage, automatic target detections will be modified, deleted, and/or added by the operator. The automated and operator target detection steps will result in a target list and a set of target parameters, including X, Y, area, proximity to other targets, and signal strength statistics.

The steps of the target detection process are documented in the Data Processing Log (Form C-1) (as well as in the headers of the affected files) to facilitate replication of the target analysis results during QC.

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7.0 Quality Control

Instrument standardization procedures are implemented to ensure accuracy and repeatability of all collected field data. Requirements for instrument standardization, minimum test frequency, and acceptance criteria are outlined in **Table 7-1**Error! Reference source not found..

7.1 Equipment Function Verification

Equipment function verification will be performed to ensure that the geophysical survey equipment is working according to manufacturer's specifications and is appropriate for the intended survey activities. The Site Geophysicist or the QC Geophysicist will review and approve each Sensor QC Verification Log (Form C-3) and Navigation QC Function Log (Form C-4) daily to document the proper equipment function. Additionally, the UXO Quality Control Specialist (QCS) will review the Equipment Verification Log forms as part of the QC program. The forms discussed in this section are included in Appendix C of the *GIP*.

A number of QC tests and will be performed as indicated in Error! Reference source not found.. QC test descriptions and frequencies are as follows:

- **Equipment Warm-Up**—Most instruments require a few minutes to warm up before data collection begins to minimize sensor drift due to thermal stabilization effects. All instruments will be allowed to warm up for at least five (5) minutes before data collection. This procedure will be followed each time the instrument is powered up (e.g., at the start of the day, after breaks, etc.).
- **Record Sensor Position**—At the beginning of the survey, and thereafter at any changes in form factor, or when a sensor is reattached to a pole or cart, the relative positions of the sensors and the sensor heights off the ground will be measured and recorded.
- **Static Background Test**—The Static Background Test and Spike Test monitors the instrument background readings, monitor for electronic drift, and identify potential interference. With the instrument held in static position, measurements are recorded for a period of at least three (3) minutes. The test is performed twice daily, prior to collecting data and after completion of data collection. Static background readings for the EM61-MK2 should remain within 2.5 mV of background (USACE, 2003a). The results of the Static Background Test are documented on the Sensor QC Verification Form (Form C-3).

Table 7-1
DGC QC Tests

Test	Acceptance Criteria	Frequency of Testing			
		Start of Day	Start & End of Day	First Day of Project Only	Equipment Change
Equipment Warm-up	Equipment Specific - typically 5 minutes	X			
Record Sensor Position	+/- 1 inch			X	X
Personnel Test	EM: 2 mV pole to pole (p-p) Mag: 1 nT p-p	X			X
Vibration Test (Cable Shake)	Data spiking not evident in profile		X		X
Static Background Test	EM: 2.5 mV p-p Mag: 1 nT p-p		X		X
Static Spike Test	+/- 10% of standard response after background correction		X		X
Azimuthal Test (magnetics only)	Sensor orientation minimizes drop outs			X	
Height Optimization (magnetics only)	Maximum S/N ratio that reliably detects smallest target objective			X	
6 Line Test	Repeatability of response amplitude +/- 20%, Positional accuracy +/- .5 foot			X	X
Octant Test (magnetics only)	Document heading error for post-processing correction			X	X
2 Line Repeat Data	Repeatability of response amplitude 20%, Positional accuracy +/-2 feet		X		

Notes:

Test frequency and acceptance criteria are based on the contract SOW and the Geophysical Investigation Plan, Data Item Description, MR-005-05 (USACE, 2003a)

EM = electromagnetic
Mag = magnetometer
mV = milliVolt
nT = nanoTesla
S/N = signal to noise ratio

- **Static Spike Test**—The Static Spike Test monitors the impulse response and repeatability of measurements over a standard test item. The standard test item is a standard 2-inch diameter steel trailer hitch ball. At least one minute of data is recorded. Readings for the response of the standard test item should be within 10 percent after subtraction of the sensor baseline response. The test is performed twice daily, prior to collecting data and after completion of data collection. The results of the Static Spike Tests are documented on the Sensor QC Verification Form (Form C-3).

- **Personnel Test**—The Personnel Test is performed to check the influence of personnel carried metallic items (e.g., keys, boots, belt buckles, etc.) on the sensors. With the instrument held in static position, the operator(s) walk around the sensors while measurements are being recorded for a period of at least one (1) minute. The test will be performed daily, prior to collecting data. The Personnel Test will be included in the Static Background Test.

- **Cable Shake Test**—The Cable Shake Test is performed for each sensor at the beginning and end of each day, or following any given instrument change out, to document any cable or connection problems. With the instrument motionless and recording, each data cable is shaken to test for shorts or bad connections. Data collected during the Cable Shake Test should be free from spikes or variations. Cable problems generally require replacement. Connection problems are generally fixed either by cleaning or reconnection. The results of the Cable Shake Tests are documented on the Sensor QC Verification Form (Form C-3).

- **6 Line Test**—A 50-foot test line is set up and well marked such that the same path can be repeatedly surveyed. Background conditions are evaluated on Lines 1 and 2. Heading effects, repeatability of response amplitude, positional accuracy and latency are evaluated in Lines 3 through 6. The test line is then surveyed as follows:

  – Lines 1 and 2: Survey up and back on the test line at a normal speed.

  – A standard 2 inch trailer hitch ball is placed at the center of the line for Lines 3-6. For multi-sensor form factors, a hitch ball is used for each sensor tack.

  – Lines 3 and 4: The line is surveyed up and back at a normal speed.

  – Line 5: The line is surveyed at a fast speed.

  – Line 6: Coming back, the line is surveyed at a slow speed.

- **2 Line Repeat Data**—The repeatability of geophysical mapping data is monitored by the collection of replicate data. Replicate data will be collected for each data set. Generally, a 50- or 100-foot long replicate data line is established outside of the area to be surveyed and oriented in the general direction of the planned traverses. Start and endpoints of the line are marked with pin-flags and a measuring tape line. A standard test items (2-inch trailer hitch ball) is placed at the center of the line located such that each sensor will pass over one. The line is recorded, up and back, at the start and again at the completion of each data set. The amplitudes of the standard test items should be within 20 percent (USACE, 2003a). The on-line offset of the locations is used to calculate instrument latency.

- **Azimuthal Test (magnetics only)**—For the Azimuthal Test, an area free of geophysical noise is selected. A measurement point and the four cardinal directions are marked on the ground. A sensor head is fixed on the form factor to be deployed. Data are then recorded in a variety of sensor head orientations such that the orientation which minimizes drop outs can be selected. This test is performed once for each system deployment.

- **Octant Test (magnetics only)**—For the Octant Test, a total of eight lines of magnetic data are collected, passing over the same central point. The arrangement of lines is North-South, Northeast-Southwest, East-West, and Northwest-Southeast arranged radically over a marked central point. The difference in the response over the central point documents heading effects. This is the recommended test for establishing heading correction parameters. Typically, this test is performed once over the project duration for each system deployment, however, small changes in heading errors from the same deployed system have been observed to change over short periods of time. Therefore, in most instances, the actual heading corrections applied to any given set of data will need to be optimized during data processing. Should large heading changes be seen during data QC, the test will be re-run for further evaluation of both the equipment and data processing parameters.

- **Height Optimization (magnetics only)**—A test line is established with at least one test object along its length. Data are collected with the instrument using a minimum of three different sensor heights. The goal is to optimize the target signal to noise ratio, and maintain adequate sensitivity.

7.2 Standardization Logs

Standardization for geophysical mapping is ensured through adherence to standard procedures and full documentation. The following logs, which are used to maximize standardization, repeatability, and control of mapping activities, are provided in Appendix C of the *GIP*:

- **Sensor QC Verification Log**—This log (Form C-3) will document the daily calibration of each field sensor. This form documents the results and analysis of the pre- and post-survey Static Test, Static Spike Tests, and Cable Shake Test.

- **Navigation QC Function Log—**This log (Form C-4) will document daily calibration of the Navigation system. Pre-and post-survey results of the 6 Line Test, latency calculation, and detection of location test points and blind seed items are documented.

- **Data Processing Log**—All DGM data from the field will be run through a standard data-processing procedure. This procedure will be the same for all data and will be tracked with the Data Processing Log (Form C-1). This log documents all coordinate transformations, visual data-quality checks, statistical data-quality checks, statistics, interpolation parameters, etc.

- **Field Data Sheet**. The Field Data Sheet (Form C-6) will be used to identify the location of each geophysical survey member on a daily basis. The log will track crew members, equipment, and expected areas to be surveyed. Maps of the areas to be surveyed containing the coordinates of benchmarks in the areas as well as the coordinates of each quadrant corner will be attached to this daily log. Additionally, this will document observations about crew performance, sensor performance, site conditions, and weather changes including notes regarding features and site conditions that could impact the survey either in regard to data coverage and/or data quality.

Additional function tests may be performed as the operator deems necessary. The data from each sensor will be compared with the data collected on previous days. If there is a significant change in results, the instrument will be rechecked. If the difference in data cannot be accounted for, the instrument will be taken out of service until repaired.

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8.0 Prove-Out Report

Shaw will prepare and provide a *Geophysical Prove-Out letter report* to USACE and Ohio EPA for review and approval prior to commencing with AOC-specific geophysical investigation activities. The letter report will describe the GPO and results in accordance with *MR DID-005-05.01* (USACE, 2007b) and Shaw will discuss and finalize survey parameters, DQOs and Pass/Fail criteria during the review and prior to approval of the report. The report will include the following:

- As-built drawing of the GPO plot;
- Pictures or descriptions and locations, depths, and orientations of the seed items;
- Color maps of the geophysical data;
- Summary of the GPO results;
- Description of the proposed geophysical equipment, techniques, and methodologies; and
- Sufficient supporting information (QC and data) to support the recommendations and any other pertinent data used in decision making.

A compact disc will be delivered with the GPO letter report containing the following files:

- GPO letter report (Microsoft Word format);
- All raw and processed geophysical data. All data, except raw sensor data, will be provided in x, y, v1, v2, v3, v4, t comma or tab separated format where x and y are state plane coordinates, vs are sensor values, and t is the time stamp;
- Geophysical maps in their native format (Geosoft Oasis Montaj or ESRI ArcView) or as JPEG or TIFF files;
- Seed item location spreadsheet (Microsoft Excel format); and
- Table of all survey control point locations (Microsoft Access format).

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9.0 References

U.S. Army Corps of Engineers (USACE), 2003a. *Data Item Description – Geophysical Investigation Plan – Munitions Response (MR)-005-05*. December 1, 2003

USACE, 2003b. *Data Item Description – Geophysical Prove-Out (GPO) Plan and Report – MR-005-05A*. December 1, 2003.

USACE, 2007a. *Military Munitions Response Action* – EM1110-1-4089. June 15, 2007.

USACE, 2007b. *Data Item Description – Geophysics – MR-005-05.01*. December 20, 2007

Science Applications International Corporation (SAIC), 2001. *Phase I Remedial Investigation Report for Demolition Area 1 at the Ravenna Army Ammunition Plan, Ravenna, Ohio*. December 2001.

MKM Engineers, Inc. (MKM) 2004a. *Remedial Design/Removal Action Plan for RVAAP-34 Sand Creek Disposal Road Landfill, Ravenna Army Ammunition Plant, Ravenna, Ohio*. March 2004.

MKM, 2004b. *Final OE/UXO Removal & Interim Removal Action Report for the Open Demolition Area 1*. March 2004.

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

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APPENDIX B
PERSONNEL QUALIFICATIONS

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Sandra A. Takata

Professional Qualifications

Ms. Takata is a geophysicist with more than 20 years experience in applied geophysics within the environmental and exploration industries. As a Shaw geophysicist she is responsible for developing the technical approach, proposals and cost estimates, conducting field investigations, data acquisition, and processing and interpretation, as well as report writing. Her experience includes using and interpreting electromagnetic (EM), resistivity, ground penetrating radar and magnetic ground geophysical methods and using and interpreting electromagnetic, very low frequency (VLF) EM, magnetic, and spectrometer airborne geophysical methods. The projects in which she has been involved include structural, mineral, and petroleum exploration investigations, landfill definition, aquitard competency investigations, utility clearance and pipe mapping, digital geophysical mapping (DGM) for unexploded ordnance (UXO) and underground storage tank (UST) locations. Her client base has been government agencies and public holdings worldwide.

Education

Bachelor of Science, Applied Earth Sciences - Geophysics, University of Waterloo, Waterloo, Canada, 1985

Additional Training/Continuing Education

Global Positioning Systems, Findlay - Trimble, 2000
Technical Writing, XXXX, 1999

Experience and Background

05/2002 - present
Senior Geophysicist, Shaw Environmental & Infrastructure, Inc., Science and Engineering, Knoxville, Tennessee

Senior Geophysicist, Geophysics and Mapping, Shaw Environmental, Inc., Knoxville Tennessee
Responsibilities include technical and cost proposal development, field investigations, data processing and interpretation, geophysical modeling, and report writing. Management responsibilities include scheduling projects, development of cost and technical proposals, resolving invoicing issues, controlling budgets, purchasing equipment and liaison with clients, and administration. Projects include the following:

- Radford Army Ammunition Plant, The objectives of this investigation were to determine the extent of a historical landfill and to determine the presence, trend, and pattern of vertical bedrock fractures. These were accomplished using an EM31 to define the landfill which was seen as zones with concentrations of metallic objects and using the electrical resistivity method to collect data to present 2D inversion images to map the relative distribution of the vertical and horizontal apparent resistivty.

- Former Conway Bombing Range, Shaw was under contract to Advent Environmental to provide geophysical services. This UXO project was the first large scale wooded digital geophysical mapping project undertaken with over 1100 acres surveyed. EM61 MK2 and robotic total station Data were collected, QC'd, processed and interpreted. Targets were selected and entered into the project GIS.

- Fort McClellan, Shaw provided MEC QA services to Matrix Environmental. QA activities included review of instrument QC, raw and processed data, target selection and excavation clearance.

- Former Lowry Bombing and Gunnery Range. This UXO project developed from detection through anomaly discrimination of PIGS. Selected buried metal targets in EM and magnetic data, classified the selected targets, QC'd target picks and used Shaw's proprietary Flipbook routine to discriminate between buried metal targets and potential PIGs. Developed a ?rug? survey grid deployment to standardize high-fidelity EM and mag data collection and to make data collection easy and efficient.

- Huntsville Corps Innovative Navigation Project. Reported on the findings of the use of the robotic total station navigation for application in wooded areas. Geophysical data and survey data were collected at a seeded site, were processed and evaluated for spacial accuracy, deployment method and cost effectiveness.

- SERDP Sensor Orientation Project. The on-going project investigates the effect of geophysical sensor orientation on the data collection. Data accumulators are being developed and pitch-roll and yaw information is being analyzed so that these effects can be removed from the data.

- Blimp Deployment of Geophysical Equipment. Studied the feasibility of developing a blimp deployment of geophysical equipment system. Successfully deployed a 4-sensor magnetometer system from a tethered blimp and mapped a seeded test site. This deployment method when fully developed into a remote control system can be used in areas too hazardous for foot surveys (steep topography or hazardous waste), areas where brush removal is costly, in surf zones, and over water.

- Mentor-Protégé Project. Developed sections pertaining to geophysical deployment strategies including airborne and ground techniques and data processing and visualization methods. Worked with Advent in developing work plans and cost proposals for geophysical work. This project won the 2002 Nunn Perry Award for the most successful DOD funded Mentor-Protégé Programme.

- Former Sangamon Ornance Plant, Illiopolis, Illinois. Developed work plan and interpreted EM (time and frequency domain) data for locating USTs.

- Fort Ritchie, Cascade, Maryland. Provided QA/QC data processing and interpretation of subcontractor EM61 surveys for unexploded ordnance (UXO) in areas identified after initial work conducted in 2001.

- Fort McClellan, Anniston, Alabama. Coordinated the development and reporting of the ground investigation in support of the follow-up of airborne radiological survey for Cobalt 60 and Cesium 137 sources.

- American Home Products, Buenos Aires, Argentina. Provided logistic support for international shipping of equipment. Coordinated staff, equipment and reporting in support of the survey to locate caches of drums.

- Camp Peary, Williamsburg, VA. Provided logistic and technical support for geophysical mapping using the EM61 for MEC. The work included a GPO, DGM, reacquisition and QC of excavations.

- Seneca Army Depot, Romulus, NY. Provided data processing and QC support of DGM for MEC targets. Data were collected using a towed EM61 MKII array in areas near the former Open Burning/ Open Detonation Grounds.

- Fort Ord, Monterey, CA. Provided logistic and technical support for GPR and DGM work. Wrote GPO plan and report and assisted in target selection based on the DGM data.

- Fort Sill, OK. Selected QC targets for DGM in support of MEC removal. Provided excavation QC support.

- Isleta Pueblo Ordnance Impact Area, Albuquerque, NM. Provided support on several sites at Isleta. Work ranged from interpreting GPO data through DGM, reacquisition and excavation QC phases supporting RI work. Other sites involved interpreting NRL MTADS and ORNL ORAGS data and following through reacquisition and excavation QC.

- Laguna Pueblo, Albuquerque, NM. Interpreted ORNL ORAGS data and followed through reacquisition and excavation QC. The goal was to evaluate the nature and extent of MEC using an RI approach.

01/1999 - 05/2002
Geophysicist, IT Group, Knoxville, Tennessee

Geophysicist, Geophysics Group, IT Corporation, Knoxville Tennessee
Responsibilities include technical and cost proposal development, field investigations, data processing and interpretation, geophysical modeling, and report writing. Management responsibilities include scheduling projects and personnel, controlling budgets, and liaisoning with clients and staff. Projects include the following:

- Fort McClellan, Anniston, Alabama. Provided subcontractor oversight for airborne radiological survey for Cobalt 60 and Cesium 137 sources. Successfully mapped areas for ground follow-up.

- Fort Ritchie, Cascade, Maryland. Provided QA/QC data processing and interpretation of subcontractor EM61 surveys for unexploded ordnance (UXO).

- Former Sangamon Ornance Plant, Illiopolis, Illinois. Conducted and interpreted magnetic, EM (time and frequency domain) and resistivity for burn-bed characterization.

- Fort Detrick, Frederick, Maryland. Conducted geophysical investigation to locate an erosional contact using SP, VLF, magnetic and resistivity methods.

- Sampson State Park, Seneca County, New York. Interpreted EM and magnetic data to delineate a landfill.

- Wabash Landfill, Wabash, Indiana. Conducted and interpreted EM and magnetic data to delineate the landfill boundary and to determine the presence of waste migration pathways.

- Mentor-Protégé Project. Developed a two-day presentation on geophysical theory and field procedures for frequency- and time-domain EM, magnetic and ground penetrating radar techniques. Compiled a geophysical manual for the program.

- Hickam Air Force Base, Oahu, Hawaii. Conducted and interpreted geophysical investigations to determine UST locations using EM (time and frequency domain), magnetics, and ground-penetrating radar (GPR). Sample location utility clearance work was also performed. Total station data were collected for future relocation of the survey.

- Bellows Air Force Station, Oahu, Hawaii. Conducted and interpreted geophysical investigations to determine UST locations as a follow-up to the airborne survey. Methods include EM (time and frequency domain), magnetics, and GPR. Total station data were also collected for future relocation of the survey.

- West Loch Naval Base, Oahu, Hawaii. Conducted time-domain EM survey and interpreted the data to confirm the presence of a pipeline.

- Linde FUSRAP, Tonawanda, New York. Conducted and interpreted geophysical investigations to locate utilities and buried metal. Methods include EM (time and frequency domain), magnetics, and GPR.

- Fort Detrick, Frederick, Maryland. Conducted geophysical investigation to determine landfill locations. Time-domain EM data were collected and interpreted to complete the objective for this survey.

- Former Naval Base, San Juan, Puerto Rico. Conducted and interpreted geophysical investigations to determine UST locations and extent of a landfill area. Geophysical survey methods used include EM (time and frequency domain) and magnetics. Total station data were also collected for future relocation of the survey.

- Wake Island Air Force Base, Wake Island. Processed, presented, and interpreted EM (time and frequency domain), magnetic, and GPR data to locate USTs and pipelines.

- Tinker Air Force Base, Oklahoma City, Oklahoma. Interpreted seismic data to locate possible holes in a shallow clay aquitard. Created models to demonstrate data signatures associated with these conduits for groundwater migration interpretation.

- Bellow Air Force Base, Oahu, Hawaii. Provided support for the selection of the survey vendor and the technical approach for an airborne geophysical survey performed to locate USTs.

- Shaw Air Force Base, Sumter, South Carolina. Conducted EM and natural gamma ray downhole geophysical surveys to map clay layers in a sandy medium. Processed the geophysical data and reported the results.

06/1985 - 12/1997
Manager Special Projects - Geophysicist, Aerodat Limited, Mississauga, Canada

Manager, Special Projects and Development, Senior Geophysicist, Aerodat Limited, Mississauga, Ontario. Prepared case histories and promotional materials. Developed policies and job descriptions for human resources project. Trained geophysicists in basic and high level data processing, procedures, and data quality analysis. Provided technical support for geophysicists. Beta-tested new software and processing procedures. Managed projects. Interpreted and processed survey data both in the office and in the field. Other position held with this company included:

Assistant Manager, Data Processing, Senior Geophysicist. Developed and administered departmental policies for processing procedures, quality control, and product standardization. Scheduled geophysicists and consultants. Trained processing team and clients in data processing techniques and geophysical theory. Liaison for the department with suppliers, hardware support companies, and field operations. Maintained communication with clients. Wrote utility programs for data manipulation. Interpreted and processed data both in the field and in the office.

Projects Supervisor, Geophysicist. Coordinated and trained a team of geophysicists. Wrote data processing manual. Ensured high standards for final map products. Served as liaison with the clients, managed projects and staff, processed and interpreted data

Geophysicist. Processed high-sensitivity airborne magnetic, EM, spectrometer, VLF and flightpath data. Utilized basic processing procedures as well as sophisticated techniques such as Fast Fourier Transform (FFT) processing, shadow imaging and EM inversions. Provided customers with high quality maps, digital data, and technical support. Projects included mining and petroleum exploration, structural mapping, and environmental applications. The client base was both government and public companies, domestic and foreign.

05/1984 – 09/1984
Geophysical Assistant, Noranda Exploration Limited, Bathurst, Canada

Geophysical Assistant, Noranda Exploration Limited, Bathurst, New Brunswick. Conducted ground geophysical surveys, processed and plotted magnetic, horizontal loop EM (HLEM), gravity and VLF data.

05/1983 - 09/1983
Geological Assistant, Geocanex Limited, Toronto, Canada

Studied assessment files and geological reports for gold exploration. Wrote reports on possible targets.

09/1982 - 12/1982
Teaching Assistant, University of Waterloo, Waterloo, Canada

Prepared study material for second and third-year petrography labs.

01/1982 - 05/1982
Geological Assistant, Ontario Geological Survey, Engineering and Terrain, Toronto, Canada

Studied, correlated, and reported on core samples and downhole geophysical data for the Ontario Oil Shales Project. Surveyed and inspected drill sites.

Publications/Presentations

Sandra Takata, Mark Kick, Lester Tyrala, Martin Miele, Colin Chang, Sally Lamb, Tight Location Requirements for Geophysical Investigations on Urban Sites Using RTS, SAGEEP, Philadelphia PA, 2008

Martin Miele, Jeremy Flemmer, Charles Nycum, Sally Lamb, Sandra A. Takata, Reconnaissance Geophysical Investigations for the Assessment of Levee Conditions at the Canal Ranch Levee Sacramento River Delta, SAGEEP 2007, Denver CO, 2007

Sandra Takata, Martin Miele, Lester Tyrala, Finn Michelsen, Cost-effective Geophysical Approaches for Various Geotechnical Problems, GeoFrontiers paper., TX, 2005

Martin J. Miele, Ji Ma, Sandra A. Takata, John P. Dolynchuk, Mark Sellers, Larry Fowler, Digital Geophysical Mapping in Wooded Conditions using an Integrated EM61 MKII and Robotic Total Station Navigation Vehicular-Towed Deployment System, SAGEEP, Atlanta GA, 2005

Linda Hughes, Sandra Takata, Martin Miele, John Dolynchuk, Geographic Information Systems (GIS) and Geophysical Data Management for Munitions and Explosives of Concern (MEC) Investigations, Shaw Symposium, 2005

Jack Foley, Robert Mehl, Sandra Takata, Martin Miele, Increasing UXO Geophysical Survey Capabilities with Robotic Total Station Technology, SAME, , 2003

Sandra Takata, Jeffrey Hackworth, Doug McConnell, Airborne and Ground Geophysical Surveys for Locating and Mapping Underground Storage Tanks at Bellows Air Force Station, Hawaii: An Integrated Approach., SAGEEP, Denver, CO, 2001

Richard Manz, Sandra Takata, Jennifer Sonnichsen, Locating Underground Storage Tanks Using Aerial Geophysical Survey Methods at Bellow Air Force Base, Hawaii, PERC, Honolulu, HI, 2000

Charles P. Nycum

Professional Qualifications
Charles Nycum has more than six years experience conducting geophysical site investigations at DoD facilities. He is currently the site geophysicist supporting MEC removal actions at Former Fort Ord, CA. Charles has also worked as a Senior Geophysicist supporting various Munitions Response task orders at Former Fort Ord, Former Lowry Bombing and Gunnery Range, Former Seneca Army Depot, Former Conway Bombing Range, Former Crows Landing, Former Camp Robinson and Isleta Bombing Range. Charles worked at both Yuma and Aberdeen Proving Grounds demonstrating multiple sensor and navigation platforms. Previously, he worked with Parsons Engineering as lead data processor at Former Fort Ord and was involved in MEC related tasks at Camp Robinson, AR and Amchitka Air Field, AK. Also, he has been involved in designing, implementing, and managing geophysical investigations to characterize subsurface conditions and locate waste disposal structures, contaminant plumes, and utilities.

Education
Master of Science, Earth Sciences, University of California, Santa Cruz, California, 2005
Bachelor of Science, Earth Sciences/Geophysics, University of California, Santa Cruz, California, 1996

Registrations/Certifications/Licenses
JAVA Programmer, 1997, Inactive, Nationwide

Experience and Background

10/2003 - Present
Staff Geophysicist, Shaw Environmental & Infrastructure, Inc., Science & Technology, San Jose, California

- Senior Geophysicist: Involved in all stages of the project life cycle including report writing and site management. This includes instrument selection/deployment and personnel supervision/training. Most commonly used geophysical methodologies include; time domain EM, magnetics, conductivity, ground penetrating radar, and some experience using seismic and resistivity methods. Mostly applied to environmental and engineering problems.

- Staff Geophysicist: Both field and geophysical data processor using the same methodologies described above. Extensive work on various MEC projects involving the use of both Mag and EM systems integrated with both GPS and Leica Robotic Tracking Station.

02/2001 - 10/2003
Staff Geophysicist, Parsons, Monterey, California

- Lead Geophysical Data Processor: Mainly tasked for processing and analysis of near surface geophysical data for mapping buried ordnance using ground based electromagnetic and magnetic systems. Job tasks also included quality control, programming, survey design, instrument and personnel training.

- Geophysical team leader and field geophysicist: Fieldwork which consisted of geophysical surveying using both time domain EM and magnetic sensors integrated with RTK GPS. Also assisted in initial data quality control, survey design, soil sampling, positional surveying, and personnel training.

06/1998 - 02/2001
Staff Geologist, JCP Geologists, Fremont, California

- Staff Geologist: Preparation of Natural Hazard Disclosure Reports using Federal, State, and County-level geologic maps, seismic maps, CDF Fire Hazard, and FEMA Flood maps for Santa Cruz, Monterey, Riverside, and San Bernardino Counties.

- Job functions included Hazard assessment and determination, FUD research and disclosure, automation of map based interpretation using GIS and other methods, and researching various governmental policies and publications. Also, client consultation regarding geologic hazard, seismic hazard, planning and mitigation issues.

Professional Affiliations
Environmental and Engineering Geophysical Society, 2004

Charles J. Thomas

Professional Qualifications

Mr. Thomas has over 40 years of experience in the explosive field and over 25 years of experience in the Unexploded Ordnance (UXO) field. He has worked as a UXO Tech III up to the Project Manager on UXO projects. He specializes in the UXO Quality Control on UXO projects and has been UXO Safety and Senior UXO Supervisor on numerous projects. He is proficient in all aspects of explosives and explosive demolition of MEC’s.

As a UXO Quality Control Specialist, he is responsible for planning, execution, and compliance of the UXO Quality Control operation. Specific duties include, developing, assessing the effectiveness of, and maintaining the Quality Control Plan (QCP) and related procedures; reviewing and approving the qualifications of the technical staff and subcontractors; planning and ensuring the performance of the preparatory, initial, follow-up and complication inspection of each definable feature of work; identify quality problems and verify that appropriate corrective action is implemented; ensure that QC records are generated and retained as prescribed in the QCP; inspect cleared grids to ensure quality; ensure that work is completed safely and within contract guidelines.

Ordnance that has been encountered as a UXOQCS, are, bombs, rockets, projectiles, mortars, hand grenades, pyrotechnic rounds, both foreign and domestic.

In addition, he has 15 years of experience using explosives in the underground mining industry.

Additional Training/Continuing Education

8-Hour HAZWOPER Refresher, 2006
8-Hour HAZWOPER Refresher, Shaw Environmental & Infrastructure, 2004
10-Hour Construction Safety Course, AGC Online Institute, 2004
Fall Protection Training, Earth Trek Climing Center, Columbia, Maryland, 2002
8-Hour HAZWOPER Refresher, 2002
Fork Lift Operation, Shaw Environmental & Infrastructure, 2002
Chain Saw Operation Safety, Forest Application Training, Inc., 2001
Health/Safety, Leadership, and Legal Aspects, (Kaho's olawe), 8-Hours, PUXB, 2001
8-Hour HAZWOPER Refresher, 2001
8-Hour Refresher, UXB International, 2000
40-Hour HAZWOPER Health & Safety Training, UXB International, 2000
8-Hour HAZWOPER Refresher, UXB International, 2000
8-Hour Refresher, Human Factors Applications, Inc., 1999
UXO Refresher Training, Kaho's Olawa Island Reserve, 1999
8-Hour Rrfresher , Human Factors Applications, Inc., 1998
Hazard Waste Management, EarthTech, 1998
Hazwoper 8-Hour Supervisor Course, Rocky Mountain Education Center, 1996
8-Hour Refresher, Human Factors Applications, Inc., 1994
40-Hour OSHA Hazardous Waste Training, 1993
Hazardous Waste Management, U.S. Army, Tooele Army Depot, 1993

First Aid/CPR Training, 1992
U.S. Navy Underwater Swimmers School, Key West, Florida, 1961

U.S. Navy EOD School, 1961

Registrations/Certifications/Licenses
USACE Construction Quality Manager, 2006, N/A, Active, Nationwide, 03/2011
ATF Explosive User/Blaster, 2004, N/A, Active, Nationwide
EOD Technician - Master, 1970, N/A, Active, Nationwide
EOD Technician - Senior, 1966, N/A, Active, Nationwide
USACE UXO Certification, 1996, 0035, Active, Nationwide

Experience and Background

05/2002 – Present
UXO Quality Control Supervisor, Shaw Environmental & Infrastructure, Inc., Monroeville, Pennsylvania

Responsible for the planning, execution and compliance of the QC operations. Duties include, developing, assessing the effectiveness of, and maintaining the QCP and related procedures; reviewing and approving the qualifications of the technical staff and subcontractors; plan and ensure the performance of the prepatory, initial, follow-up and completion inspection of each definable feature of work; identify quality problems and verify that appropriate corrective action is implemented; ensure that QC records are generated and retained as prescribed in the QCP; inspect cleared grids to ensure quality; ensure that work is completed safely and within contract guidelines.

The following is a summary of key projects:
<u>UXO Quality Control Supervisor/UXO Safety Officer, Former Camp Robinson, U.S. Army Corps of Engineers, Little Rock, Arkansas, Camp Robinson, Arkansas, 01/2005 - Present</u>
Responsible for the planning, execution and compliance of the QC operations. Duties include, developing, assessing the effectiveness of, and maintaining the QCP and related procedures; reviewing and approving the qualifications of the technical staff and subcontractors; plan and ensure the performance of the prepatory, initial, follow-up and completion inspection of each definable feature of work; identify quality problems and verify that appropriate corrective action is implemented; ensure that QC records are generated and retained as prescribed in the QCP; inspect cleared grids to ensure quality; ensure that work is completed safely and within contract guidelines. Also control all safety issues including on-site training, safety briefs, vehicle and heavy equipment safety inspections and maintained a database on all personnel on site.

<u>UXO Technician III, Webster Field, Naval Facilities Engineering Command, Atlantic Division, Pax River, Webster Field, Maryland, 01/2005 - 12/2005</u>
UXO Avoidance. The objectives of this Task Order were to investigate each of the identified debris piles, for Munitions and Explosives of Concern (MEC) items, remove the Asphalt/Brick/Concrete (ABC) materials, remove off-site the remaining material after the removal of MEC and ABC material, and restore the disturbed areas to a stable nature. Site activities will include the installation of erosion and sediment (E&S) controls, clearing and grubbing, installation of access roads and material screening/staging areas, material screening, transportation and disposal of the waste, regrading and site restoration.

UXO Technician III, Camp Lejune, USMC, Jacksonville, North Carolina, 12/2004 - 12/2004
UXO Avoidance

UXO Technician III, Ravenna Arsenal, U.S. Army Corps of Engineers, Ravenna, Ohio, 11/2004 - 12/2004
UXO Avoidance.

UXO Quality Control Supervisor, TERC II Contract, Fort Ord, U.S. Army Corps of Engineers, Fort Ord, California, 01/2003 - 01/2004
Ensured the quality control on this 700-acre surface clearance, which involved 20,000 pounds of scrap, plus follow-on work. Over the course of this project, he received no negative Quality Assurance Memo 948 forms by the Corps? UXO safety lead.

Responsible for the planning, execution and compliance of the QC operations. Duties include, developing, assessing the effectiveness of, and maintaining the QCP; plan and ensure the performance of the prepatory, initial, follow-up and completion inspection of each definable feature of work; identify quality problems and verify that appropriate corrective action is implemented; ensure that QC records are generated and retained as prescribed in the QCP; inspect cleared grids to ensure quality; ensure that work is completed safely and within contract guidelines.

UXO Quality Control Supervisor, TERC Contract, Camp Hale, U.S. Army Corps of Engineers, Leadville, Colorado, 01/2003 - 01/2003
Ensured the quality control on this 460-acre surface clearing effort involving 500 pounds of OE and a dozen blow-in-place items. This project received no negative Quality Assurance Memo 948 forms by the Corps? UXO lead.

Responsible for the planning, execution and compliance of the QC operations. Duties include, developing, assessing the effectiveness of, and maintaining the QCP; plan and ensure the performance of the prepatory, initial, follow-up and completion inspection of each definable feature of work; identify quality problems and verify that appropriate corrective action is implemented; ensure that QC records are generated and retained as prescribed in the QCP; inspect cleared grids to ensure quality; ensure that work is completed safely and within contract guidelines.

06/2001 - 05/2002
UXOQCS, IT Corporation (The Shaw Group Inc. acquired substantially all of the operating assets of The IT Group, Inc. on May 23, 2002), Monroeville, Pennsylvania

Please see job description above.

The following is a summary of key projects:
UXO Quality Control Supervisor, Fort Ritchie, USACE Baltimore District, Fort Ritchie, Maryland, 06/2001 - 02/2002
Responsible for the planning, execution and compliance of the QC operations. Duties include, developing, assessing the effectiveness of, and maintaining the QCP; plan and ensure the

performance of the preparatory, initial, follow-up and completion inspection of each definable feature of work; identify quality problems and verify that appropriate corrective action is implemented; ensure that QC records are generated and retained as prescribed in the QCP; inspect cleared grids to ensure quality; ensure that work is completed safely and within contract guidelines.

Senior UXO Supervisor, Kaho'olawe Island Reserve, U.S. Navy, Kaho'olawe Island Reserve, Hawaii, 11/1999 - 05/2001
Supervised 15 UXO 8 man Teams, conducting varied and concurrent UXO removal operations. Managed the selection, review, application, and control of appropriate course of action in the performance of UXO clearances and safety procedures. Also responsible for managing of: compliance with standard operating procedures, explosive safety, UXO search and detection techniques, UXO access, identification, movement and relocation procedures and conducted UXO safety briefs and assessments. Was the UXO safety escort for movement control of personnel in the work area.

Project Manager, Pueblo Chemical Depot, U.S. Army Corps of Engineers, Pueblo Chemical Depot, Colorado, 06/1999 - 07/1999
Responsible for all facets of a project valued at over $9 million. Given full authority to compose and publish project-related work plans and reports.

UXO Safety Officer, Pueblo Chemical Depot, U.S. Army Corps of Engineers, Pueblo Chemical Depot, Colorado, 01/1998 - 06/1999
Controlled all safety issues including on-site training, OSHA physical appointments, OSHA 8-hour refresher, safety briefs, vehicle and heavy equipment safety inspections and maintained a database on all personnel on site.

Senior UXO Supervisor, Fort Sheridan, U.S. Army Corps of Engineers, Fort Sheridan, Illinois, 10/1997 - 12/1997
In charge of all OE removal and statistical sampling and full authority to compose final reports. Published all project-related plans and reports independently without oversight.

UXO Supervisor/UXO Safety Officer, Pueblo Chemical Depot, U.S. Army Corps of Engineers, Pueblo Chemical Depot, Colorado, 04/1996 - 10/1997
Supervised UXO personnel conducting UXO clearances and disposal operations. Controlled all safety issues involving site personnel and equipment.

UXO Specialist, HFA Inc. Projects, U.S. Army Corps of Engineers, HFA Inc. Projects, 09/1993 - 12/1995
Conducted UXO clearances at Tooele Army Depot, UT, Ft. Ord, CA, Camp Croft, SC, and Ft. Devens, MA.

UXO Specialist, EOD World Service, United States of America, Kuwait, 01/1992 - 03/1993
UXO Team supervisor, responsible for UXO clearance of foreign and U.S. ordnance in the America sector. Ordnance encountered: bombs, rockets, mortars, projectiles, mines, and grenades.

03/1973 - 04/1976
Master EOD Technician, Naval EOD School, Indian Head, Maryland

Instructed military officers and enlisted personnel, both foreign and domestic, in ordnance reconnaissance, identification, and rendering safe for surface and underwater explosive devices.

07/1970 - 03/1973
Master EOD Technician, U.S. Navy, Cecil Field, Florida

Supervised EOD Team members conducting ranges clearances and providing technical escort for special weapons movements. Ordnance encountered: bombs, rockets, projectiles, and special weapons including AUW's.

06/1966 - 07/1970
Senior EOD Technician, EOD Unit 1, Pearl Harbor, Hawaii

EOD Team member deployed to the Western Pacific including Viet Nam. Rendered safe and disposed of a large variety of foreign and domestic ordnance items. Ordnance encountered: Bombs, mines, projectiles, and IED's.

11/1964 - 06/1966
EOD Technician, Naval Underwater Weapons Station, Newport, Rhode Island

EOD Team Member performing recovery of underwater drill mines and torpedoes. Maintained the UXO demolition and burn range. Ordnance encountered: Naval underwater mines, bombs, rockets, and grenades.

01/1962 - 11/1964
EOD Technician, EOD Unit 2, Charleston, South Carolina

EOD Team Member participating in range clearances and underwater operations. Ordnance encountered: bombs, projectiles, and mines.

APPENDIX C
DIGITAL GEOPHYSICAL MAPPING FORMS

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FORM C-1
DATA PROCESSING LOG

SITE:_________________ **Survey Date:**___________

Sensor:________________

AREA:_________________ **Crew:**__________________

Sensor Verification QC Log

Navigation Verification QC Log

Initial Review

Navigation Correction

Data Leveling / Diurnal Correction

Data Cataloging and Coordinate Conversion

Data Filtering

Data Location Plot Review

Comments

Shaw GP

____
Init. Date

Shaw QC

____
Init. Date

Log files

Field data files

Initial (x,y,z) files

Processed (x,y,z) files

FORM C-2
Area / Grid
Dig List Form
Ravenna Army Ammunition Plant

Shaw Environmental & Infrastructure, Inc.

SW Corner:	Dates of Survey: Dig List Date: Shaw GP Approval:

Coordinates in WGS84 Universal Transverse Mercator

Easting(X)	Northing(Y)	Target Peak Response (units)	Target ID	QC Code

Pick List Cut Line:

FORM C-3
SENSOR QC VERIFICATION LOG
EM-61 MK2 OR G858 DATA

Area: ___________ Location i.d.: ___________ QC Check by: ___________
Dataset: ___________ Survey Date: ___________ Date: ___________

Static Test

Sensor #1

	Pre Survey					Post Survey					Metric
	CH 1	CH 2	CH3	CH4	G858	CH 1	CH 2	CH3	CH4	G858	
File Name	.gdb					.gdb					
Line #:											
Min:											
Max:											
Mean:											TBD
Std:											TBD

Comments: ____

Static Spike Test

Sensor #1

	Pre Survey					Post Survey					Metric
	CH 1	CH 2	CH3	CH4	G858	CH 1	CH 2	CH3	CH4	G858	
File Name	.gdb					.gdb					
Line #:											
Min:											
Max:											
Mean:											TBD
Std:											TBD

Comments: ____

Cable Shake Test

Sensor #1

	Pre Survey					Post Survey					Metric
	CH 1	CH 2	CH3	CH4	G858	CH 1	CH 2	CH3	CH4	G858	
File Name	.gdb					.gdb					
Line #:											
Min:											
Max:											
Mean:											TBD
Std:											TBD

Comments: ____

FORM C-4
NAVIGATION QC FUNCTION LOG

QC Check: ______________
Date: ______________

Area.: ________
Dataset: ________
Location ID: ________
Survey Date: ________

2-Line Repeat Data Test

Comments:

	Pre Survey		Post Survey		Metric
	Latency Correction		Latency Correction		TBD
Sensor #1					
Sensor #2					
	Anomaly Amplitude mV/nT	Distance Offset (ft)	Anomaly Amplitude mV/nT	Distance Offset (ft)	
Sensor #1					TBD
Sensor #2					TBD

Known Location QC Points Detected

Comments:

Location ID	
Easting	
Northing	
Anomaly Offset	
Dist. (ft)	
Direction	

Location ID		Metric
Easting		
Northing		
Anomaly Offset		
Dist. (ft)		<=2-ft
Direction		

Data Sampling

Comments:

Along Track / Across Track Sampling		Metric
Along Track (ft)		<=0.5-ft
Across Track (ft)		<=3-ft
Total Area Surveyed (acres)		
This Data Set		

FORM C-5
SURVEY REWORK FORM

AREA: ___________________
DATA SET:________________
DATE:____________________

SITE GEOPHYSICIST

____
Signature Date

Tracking	**Reason For Rework**
Survey Crew:	Equipment Failure/Malfunction
Survey Instrument:	Data error/Loss
Navigation:	Navigation Error
Orig. Survey Date:	Survey Error
Area to Rework:	Other

Comments:

Description of Rework Requested

Attachment: Data Coverage Map Showing Area For Rework

Shaw® Shaw Environmental, Inc.

FORM C-6
FIELD DATA SHEET

☐ QC checked by ________ ☐ QC checked by ________

Date: ________ Date: ________

Project Name:

Project Location:

Geophysical Contractor:

Design Center POC: ________________________

Project Geophysicist:

Site Geophysicist:

Survey Area ID: **Survey Date:**

Field Team:

Survey Type: ☐Grid ☐Meandering Path ☐Transect ☐Other ______________

Coordinate System: ☐UTM ☐State Plane NAD 83 ☐Local ☐Other _____________ **Unit of Measure:** **☐meters ☐feet**

Sketch of Survey Area:

Terrain:
☐Level ☐Moderate Slope ☐Steep
☐Rolling ☐Ruts ☐Gullies
☐Rocky ☐Swampy ☐Dangerous

Tree Cover: **Tree Height:**
☐None ☐Light ☐Medium ☐Thick

Brush:
☐None ☐Light ☐Medium ☐Thick

Weather:
☐Sunny ☐Cloudy ☐Drizzle
☐Rain ☐Thunderstorms ☐Hail
☐Fog ☐Humid ☐Snow

Instrumentation: ______ **Pack S/N:** **Top Coil S/N:** ______**Bottom Coil S/N:**

Navigation: **Laser S/N:** **Remote S/N:** **Tx S/N:**

AM Calibration: **File Name:**
☐Equipment Warm-up (~5 min.)
☐Sensor Positions (+/-1 inch) **Prism Offset:** 0"
☐Personnel Test (2 mV)
L0: Static Background (2.5 mV) Ch3= mV
L1: Cable Shake (No data Spikes)
L2: Static Spike (+/- 20% Std) ___mV
L3: Repeatability (+/- 20%, +/- 20cm Position)

PM Calibration: **File Name:**
☐Equipment Warm-up (~5 min.)
☐Sensor Positions (+/-1 inch) **Prism Offset:** 0"
☐Personnel Test (2 mV)
L0: Static Background (2.5 mV) Ch3= mV
L1: Cable Shake (No data Spikes)
L2: Static Spike (+/- 20% Std) ___mV
L3: Repeatability (+/- 20%, +/- 20cm Position)

FIELD DATA SHEET

Survey Information:

Raw Data File Name(s):

QC Points:

Location 1: ________________ Easting: __________ Northing: ________

Location 2: ________________ Easting: __________ Northing: ________

Location 3: ________________ Easting: __________ Northing: ________

Location 4: ________________ Easting: __________ Northing: ________

Location 5: ________________ Easting: __________ Northing: ________

Location 6: ________________ Easting: __________ Northing: ________

Time

Metallic Surface Features Encountered

Processing Notes **:**

FORM C-7
ANOMALY TRACKING SHEET

Page ____ of ____
Area____________
Sector________ Grid________
Survey Instrument ____________ Instrument ID ___________ Units _____ Background__________

Anomaly ID.	Original Survey			Relocation Survey			QC Clearance					Notes
	East (ft)	North (ft)	Peak Amp	Offset (ft)	Direction	Peak Amp	Final Amp	Code	Crew Initials	QC Initials	Date	

Reacquisition metric: 2.0 feet offset. Clearance Code: 1- Good correlation; 2-Anomaly removed - hot rock or minimal metal; 3- Terminated at bedrock; 4-Terminated at max clearance depth; 5- Terminated due to non-movable subsurface feature (specify).

FORM C-8
FALSE NEGATIVE REPORT FORM

SITE:____________________
AREA:____________________

Date:____________________

SITE GEOPHYSICIST

____
Signature Date

CC: Shaw UXOQCS
Shaw QA Geophysicist
Shaw Project Geophysicist
Shaw Project Manager

Item type, Location, Depth, Orientation, Weight, Etc.

Circumstances of Discovery and Disposition of Item

Relevant Site Conditions (Culture, Noise, Geology, Terrain, etc.)

Review of Relevant Survey Design, Site Survey and Navigation Data, Data Processing, Anomaly Selection, and Detection Limits

Recommendations

APPENDIX D
GLOSSARY OF GEOPHYSICAL TERMS

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Across Track Sampling—Across track sampling is the distance between adjacent lines and are determined based on the objectives of the survey. For full coverage surveys, typically < 3 feet is used (excluding data gaps due to trees or other obstacles that preclude the survey platform from providing complete coverage). For transect surveys offsets between lines may vary and are typically, widely spaced to characterize an area more general terms.

Along Track Sampling—Along track sampling is the intervals along a line in which a geophysical and navigational reading are recorded. Typically spacings are < 0.6 foot. This is to insure that data are spaced close enough to detect the items of interest.

Analytic Signal – Mathematically the analytic signal is the square root of the sum of the squares of the derivatives in the x, y, and z directions (dx, dy, dz): analytic signal = square root (dx*dx + dy*dy + dz*dz). It locates the inflection point of a magnetic dipole signature and simplifies the interpretation by placing a peak response at this location.

Anomaly - A feature distinguished in geophysical data which is different from the general surroundings. A departure from the expected or normal.

Data Leveling - For magnetic data leveling, validated magnetometer data are corrected for diurnal fluctuations to remove the ambient background from each sample collected by the G858G sensor. The resultant data set represents only the magnetic field changes that are caused by anomalous objects contained within the survey area. For EM61-MK2 data, instrument drift is corrected based on the initial review of the data, the statistical assessment results, and the calibration data. As much as possible, consistent processing routines are used throughout a project

Digital Geophysical Mapping (DGM) – DGM is the surveying using geophysical instrumentation such as the Geonics EM61-MK2 and Geometrics G858G which have the capability of digitally recording the readings. These surveys maybe conducted with a navigation system (e.g. GPS) or fiducially (manual navigation).

Geophysical Prove-out (GPO) - The GPO are activities used to assess and document the performance of the geophysical instrumentation, navigation system, and field deployment form-factor as well as to assess the most optimal data processing techniques and anomaly selection criteria given the local soil, site conditions, and targets of interest.

Geophysical Prove-Out (GPO) Plot - The site where testing of equipment, deployment, processing techniques and selection criteria are performed. The plot is seeded with known items (expected to be encountered during the DGM) at various depths and orientations and the locations are documented. These items are used to assess the detection and selection parameters and limitations.

Gridding—Data are interpolated onto right-rectangular, evenly spaced grids. Gridding is performed using the Geosoft minimum curvature function with parameters dependent on the sampling intervals. Gridding allows for reviewing the geophysical data in plan view in the project's coordinate system.

Latency – An offset created either by the act of buffering and recording of data in digital systems or the slight variation in data collection based on the direction of travel or the combination of the two. The 2-line test is used to measure any (if any) offset of the system with respect to a known target location. This can be measured either in distance or time and a consistent correction is applied to the data.

Magnetic Survey – Anomalies in the earth's magnetic field are caused by remnant or induced magnetism. Remnant magnetism is caused by naturally occurring magnetic materials such as mafic or volcanic rock. Induced magnetic anomalies result from the induction of a secondary magnetic field in a ferromagnetic material (e.g., MEC, pipelines, buried metallic debris) by the earth's magnetic field. These changes in the magnetic field are measured at predetermined intervals at the site.

Reacquisition – Targets selected for excavation and further evaluation are relocated typically using the same navigation system and geophysical instrument used during the DGM. The navigation system is used to find the location as documented on the dig list and the geophysical instrument is used to refine the target location.

Target – Targets are anomalous signatures that meet the criteria for detection of possible MEC items as determined during the GPO. Typically, target detection is based on threshold analyses. Other parameters controlling the selection of targets include proximity of adjacent targets, signal power density, co-location of targets on other channels of data, area size, decay constant (Tau) and distribution of anomaly amplitudes.

Time-Domain EM - A pulse of current in the transmitter coil generates a primary magnetic field that induces eddy currents in nearby metallic conductors, as described by Faraday's law of induction. These eddy currents produce secondary magnetic fields that are measured by the time-dependant, decaying voltage they produce in the receiver coils. The internal electronics of the EM instrument are designed such that readings are taken in a very narrow time window following transmitter turn-off. The measurement secondary fields in the absence of a primary field allows for the high sensitivity measurements obtained with the system. Since the current ring diffuses down and outward, readings taken immediately after current shut-off are most affected by near-surface conditions and the later readings by the electrical properties of the deeper subsurface. The application of near-surface time-domain EM techniques with instruments such as the EM61-MK2, includes detecting and mapping metallic objects (buried pipes, cables, drums, MEC and tanks), and mapping the boundaries of landfill, pits or trenches containing buried metallic debris.

APPENDIX E
COMMENT RESPONSE TABLE

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DOCUMENT: "DRAFT GEOPHYSICAL INVESTIGATION PLAN for the RVAAP-34 SAND CREEK DISPOSAL ROAD LANDFILL, RVAAP-03 OPEN DEMOLITION AREA #1, and RVAAP-28 MUSTARD AGENT BURIAL SITE"

REVIEWER: EILEEN T. MOHR, OHIO EPA NEDO DERR

DATE: APRIL 28, 2009

CMT #	PAGE #/ LINE #	COMMENT	RECOMMENDATION	RESPONSE
O-1	General	There are numerous references in both the WP and Appendix A to the GPO that will be conducted. In some places it indicates that the GPO will determine the equipment to be utilized, yet there are also numerous references to the equipment that will be used during these studies, namely the Geonics EM61 MKII and the Geometrics G858G.	Please rectify the disconnect in both documents. It appears that the equipment has already been selected, and the GPO is going to be used to verify that the proper equipment has been selected. While there isn't an issue with the "pre-selected" equipment (as long as it can be justified, plus see question below), there should be consistency in the document. Please go through the document and find the numerous applicable references and make needed changes.	From past experience, both Shaw's and within the industry, the EM61 MKII and the G858G are the most likely geophysical instruments to be selected and in fact will be the only 2 tested at the GPO. As well, the selection of either the EM61-MKII or the G858G coupled with either an RTS or GPS will be most likely driven by each AOC site conditions. In the workplan text an indication of the instrumentation has been included (based on the site visit) but will need to be confirmed during the GPO.
O-2	General	An EM-31 study is not recommended/discussed in this workplan.	Provide further justification for not conducting concurrent EM-31 study which has been previously done at RVAAP.	The EM-31 is a frequency Domain Electromagnetic instrument that is not effective for mapping MEC. It does not have the resolution of either the EM61 MK2A or the G858G magnetometer.
O-3	General	There is no mention of when the HASP will be received.	Provide details as to when the HASP will be received. (No need to add to text just let us know.) The HASP needs to be in place prior to work commencing on this project. There are several references to it	Agreed. The HASP will be prepared after the workplans have been finalized. It is Shaw's intention to provide a site specific HASP that will incorporate the final scope of work defined by the workplans. The HASP will be

			throughout this document, but no stand-alone HASP.	provided for review and concurrence by stakeholders prior to the execution of any work at the site.
O-4	General	Consider adding a glossary to the WP or App A that defines some geophysical terms.	For example (not all inclusive): latency, latency correction, reacquisition, heading effects, form factor, chevron effects, data fidelity, feedback process, etc..	A preliminary glossary will be inserted into the report to better define geophysical terminology.
O-5	Document Distribution Page	Correct Ohio EPA acronym in 3 places.	OEPA to Ohio EPA	The acronym will be revised to “Ohio EPA” as requested.
O-6	Page iii	Addition requested.	Add Ohio EPA to the acronym list.	Ohio EPA will be added to the acronym list.
O-7	Page 1-1, line 8	The report document page indicates that transect surveys will also be conducted at Sand Creek.	Add Sand Creek to line 8.	Sand Creek will be added to Line 8 so that it reads “….transect surveys will be performed to delineate the ODA1 and Sand Creek boundaries as necessary.”
O-8	Page 1-2, line 15	Change requested.	Change fuses to fuzes.	“Fuses” will be changed to “Fuzes”.
O-9	Page 1-2, line 15	Addition requested.	Add elements after percussion.	The word “rounds” will be added after percussion in the sentence.
O-10	Figure 1-3	Clarification requested.	Clarify the approximate site boundary for SC and why the study area is so far from the RR ballast. Is there any potential waste in this area? Shouldn’t the boundary go closer to the RR tracks? Or is this a	The boundaries of the AOC were taken from the RD/RA report. No known investigations have occurred along the former rail bed and it has not been determined if waste is present. It is assumed that the AOC

			function of topography?	boundaries had already been agreed upon between the Army and Ohio EPA unless additional information identified during proposed field activities indicates otherwise. Shaw recommends further discussion with Ohio EPA and the Army if there are concerns or questions regarding the study boundaries of the AOC.
O-11	Page 1-4, lines 22-23	Text change and addition requested.	Actually there is a (trip?) report that does specify that a drum and several empty cans were dug up to the west of the runway. Check for the source and add the information to the text. Also, clarify "at the site" on line 22 to indicate that it was an area to the west of the current study area.	The text will be revised to read "…may have been buried west of the current study area."
O-12	Page 1-6, line 12	Clarification requested.	How is "well above background" defined?	"well above background" responses are those that are potentially items of interest which will not be confused with system noise.
O-13	Page 1-6, lines 23-24	Clarification requested.	How was 2.5 feet determined to be a "minor" occurrence?	Minor occurrences are ones where although the ideal line spacing was not achieved, the data quality remains good and will still meet the survey objective.
O-14	Page 1-7, lines 211-	Clarification requested.	Please clarify whether the detection distances listed in this workplan are	The limits for all DQOs were taken from the table in the SOW and are among new

	17		accepted standards.	standards being developed by the Huntsville Corps. If there were no metrics from the SOW then the ones from the DIDs were inserted. DQOs are refined during the GPO process and discussed in the GPO report and in turn are approved by the Corps.
O-15	Page 1-7, lines 26-27	Clarification requested.	Any potential for encountering 40 mm rounds at any of these AOCs?	At present, Shaw is unaware of the potential presence of 40 mm rounds at the sites designated for survey under the workplan. If there is a possibility for 40mm's at the site, please provide reference so that Shaw can review and adjust workplan as necessary. Shaw's geophysical survey teams will be accompanied by MEC technicians so if unexpected MEC is encountered it can be assessed and avoided in the field.
O-16	Page 1-7, line 28 to page 1-8, line 2	Clarification requested.	Please clarify that the geophysical techniques employed during these studies will be achieving depths greater than those listed. For example there are a couple depths of 2.7 feet and 3.3 feet listed, which are well below any "general" 4 foot clearance depth.	The detection depths listed are rule of thumb (from DIDs) depths for specific items. These are partially dependent on site conditions (soils, topography, proximity of individual items, etc.) and the item's composition (ferrous vs non-ferrous, amount of metal, etc.). Note that typically, larger items can be detected at depths greater then smaller ones.
O-17	Page 1-7, line 28 to	Clarification requested.	Clarify how the most probable munitions	These munitions were selected after reviewing the histories of the sites as well as

	page 1-8, line 2		were selected.	documentation of found items. If the project team has any suggestions for changes/additions it would be best to discuss prior to the GPO survey so that the workplan can be adjusted accordingly.
O-18	Page 1-8, line 13	Text change.	Change “or” to “of.”	P 1-8, L 14 -“or” changed to “of”. Text revised to “coverage consisting primarily of grass.”
O-19	Page 1-8, lines 6-23	Text change.	Please go back to the most recent approved reports or workplans that have a brief geological discussion/soil history. Insert more recent information. For example, we haven’t used the Kammer resource in quite a while.	Agreed. Section 1.3.1.8 will be revised to incorporate more recent text geological and soil information. The source will be cited in the revised text after selecting the most appropriate.
O-20	Page 1-8, lines 24-26	Clarification requested.	Has groundwater mounding been observed at ODA1?	Historically groundwater at the site has been observed at depths ranging between 14 to 16 bgs. Temporary surficial ponding has been observed at the site on occasion but it is unsure if this is related to actual groundwater mounding or just a result of slow drainage through isolated hetereogenous soil deposits. The proposed geophysical survey program will be adjusted in the field based on site conditions to account for any ponding present at the time of execution.
O-21	Page 1-9, line 4	Revision requested (if needed).	It is my recollection that there is a lot of RR ballast and slag leading back to the Sand	Agreed. The text will be revised to state: “…roads accessing the Sand Creek site are

			Creek Dump Site. If this is correct, please revise the text. If not, let me know.	primarily gravel, unimproved dirt, slag, and railroad ballast because of the presence of the former railroad track."
O-22	Page 1-10, line 15	Revision requested (if needed).	It is my recollection that there is a lot of RR ballast and slag leading back to the sand Creek Dump Site. If this is correct, please revise the text. If not, let me know.	Agreed. The text will be revised to state: "The Sand Creek site is accessible via roads consisting primarily of gravel, unimproved dirt, slag, and railroad ballast because of the presence of the former railroad track."
O-23	Page 1-12, line 1	Text revision.	Remove bullet on first line.	Bullet removed.
O-24	Page 1-14, line 14	Text revision.	Can probably remove reference to craters at this site.	Text will be revised to read "vegetation and burn areas."
O-25	Page 1-17, line 36	Text clarification requested.	The text references that the amplitudes of the standard test items should be within 20%. Is this the accepted standard?	Yes, this is an accepted industry standard.
O-26	Page 1-18, line 15	Text clarification requested.	The text references that the amplitudes of the standard test items should be within 20%. Is this the accepted standard?	Yes, this is an accepted industry standard. However, Lines 7-16 on Page 18 will be removed from text because it is redundant. (see P 1-17, lines 28-37).
O-27	Table 1-1	Clarification.	Are these the accepted standards? Please cite source.	These are standards which are a hybrid of the table of metrics in the SOW provided to Shaw by the Army and the DID MR-005-05 Attachment B.

O-28	Page 1-21, lines 27-28	The text references airborne data.	Please remove from revised text unless this is a possibility.	Lines 27-28 will be removed as requested.
O-29	Page 1-22, lines 17-18	Clarification requested.	How was 2.5 feet determined to be a “minor” occurrence?	See response to Comment O-13
O-30	Page 1-22, lines 22-24	Clarification.	Are these the accepted standards? Please cite source(s).	These are standards which are a hybrid of the table of metrics in the SOW provided to Shaw by the Army and the DID MR-005-05 Attachment B.
O-31	Page 1-26, lines 28-31	Text addition requested.	Add Ohio EPA to the review team.	Text will be revised to include the Ohio EPA. “Shaw will convene a review team consisting of Shaw’s Project Manager, the USACE Project Manager, the Project Geophysicist and QC Geophysicist, USACE technical and QA staff and the Ohio EPA …”
O-32	Page 1-27, line 8	Text addition requested.	Add Ohio EPA.	Test will be revised to include Ohio EPA. “the USACE and Ohio EPA will receive…”
O-33	Page 1-27, line 10	Text addition requested.	Add Ohio EPA.	Test will be revised to include Ohio EPA. “…make recommendations to USACE and Ohio EPA.”
O-34	Page 1-27, line 12	Text addition requested.	Add Ohio EPA.	Text will be revised to include Ohio EPA. “… approval from the USACE and Ohio EPA.”
O-35	Page 1-27, line 19	Text addition requested.	Add Ohio EPA.	Text will be revised to include Ohio EPA. “… provided to the USACE and Ohio EPA.”

O-36	Page 2-1, line 5	Text revision requested.	Change Sandra to Sand.	Text will be revised to "RVAAP-34 Sand Creek"
O-37	Page 2-1	Text addition requested.	Add MKM IRA Report at ODA1 to the list of references cited.	MKM's report will be added to the References.
		APPENDIX A		
O-38	General	There are numerous references in both the WP and Appendix A to the GPO that will be conducted. In some places it indicates that the GPO will determine the equipment to be utilized, yet there are also numerous references to the equipment that will be used during these studies, namely the Geonics EM61 MKII and the Geometrics G858G.	Please rectify the disconnect in both documents. It appears that the equipment has already been selected, and the GPO is going to be used to verify that the proper equipment has been selected. While there isn't an issue with the "pre-selected" equipment (as long as it can be justified, plus see question below), there should be consistency in the document. Please go through the document and find the numerous applicable references and make needed changes.	See response to Comment O-1.
O-39	General	An EM-31 study is not recommended/discussed in this workplan.	Provide further justification for not conducting concurrent EM-31 study which has been previously done at RVAAP.	See response to Comment O-2.
O-40	General	Consider adding a glossary to the WP or App A that defines some geophysical terms.	For example (not all inclusive): latency, latency correction, reacquisition, heading effects, form factor, chevron effects, data fidelity, feedback process, etc..	See response to Comment O-4.

O-41	Title page	Text change requested.	Change Planta to Plant.	Text will be changed from "Planta" to "Plant"
O-42	Table 2-1	Clarification requested.	Please clarify how these munitions items were selected.	See response to Comment O-17
O-43	Page 2-2, 18	Text addition requested.	Add Ohio EPA to the list of those reviewing and approving the GPO report.	Text will be revised to include Ohio EPA. "A GPO report will be prepared and submitted to the USACE and Ohio EPA for approval."
O-44	Page 2-2, line 27	Text change requested.	Change text to read: " …of items known to be at the installation."	Text will be revised to "…of items known to be at the installation."
O-45	Page 2-3, line 12	Text clarification.	The text states …."well above background noise." How is this defined?	See response to Comment O-12.
O-46	Page 2-3, lines 22-23	Clarification requested.	How was 2.5 feet determined to be a "minor" occurrence?	See response to Comment O-13.
O-47	Page 2-4, line 20	Text clarification.	Add USACE and Ohio EPA to the stakeholders needing agreement with the DQOs.	Text changed to "It is intended that once the QA (USACE), Ohio EPA and Project Geophysicists agree on the DQOs…"
O-48	Page 3-1, lines 6-10	Text change.	Please go back to the most recent approved reports or workplans that have a brief geological discussion/soil history. Insert more recent information.	Agreed. Section 1.3.1.8 will be revised to incorporate more recent text geological and soil information. The source will be cited in the revised text after selecting the most appropriate.
O-49	Page 3-1, lines 19-23	There is no mention of when the HASP will be received.	Provide details as to when the HASP will be received. (No need to add to text, just let us know.) The HASP needs to be in place	Agreed. The HASP will be prepared after the workplans have been finalized. It is Shaw's intention to provide a site specific HASP that

			prior to work commencing on this project. There are several references to it throughout this document, but no stand-alone HASP.	will incorporate the final scope of work defined by the workplans. The HSAP will be provided for review and concurrence by stakeholders prior to the execution of any work at the site.
O-50	Page 4-1, line 13	Clarification requested.	(Table 2-1) Please clarify how these munitions items were selected.	See response to Comment O-17.
O-51	Page 4-2, fig 4-1	Clarification requested.	It appears that the azimuth and PIG have the same symbol.	No symbol is required for Azimuth. The symbol in the legend by Azimuth will be removed.
O-52	Page 4-2, fig 4-1	Change potentially needed.	If anything changes on Table 2-1, provide change on figure.	Agreed. Comment noted. Any changes to the Table 2-1 will be incorporated into Figure 4-1 and a revised figure provided to stakeholders.
O-53	Page 5-2, lines 17 and 20	Acronym NMEA is used.	Please define the first time it is used and add to the acronym list.	Text will be revised to "…outputs a pseudo-National Marine Electronics Association (NMEA) coordinate stream…" NMEA will be added to the acronym list.
O-54	Page 5-2, line 35	Text revision.	Can probably remove reference to craters at this site.	Text will be revised. "…soil changes, vegetation, burn areas, etc."
O-55	Page 5-3, line1	Clarification requested.	Please clarify why target re-location will not occur.	Reacquisition (which includes relocation) is not part of the scope of work provided to Shaw by the Army.

O-56	Page 5-4, lines 15-18.	Clarification requested.	Please clarify why the full survey data will be displayed as single line profiles rather than gridded which is typically the case.	Rather then resurveying the GPO plot in transect mode, by analyzing profile data from the full coverage survey as single lines, parameters for transect surveying, processing and target picking can be assessed.
O-57	Page 5-5, lines 16-17	Clarification requested.	Please clarify why anomaly location acquisition will not occur.	Anomaly relocation and reacquisition are not part of the scope of work provided to Shaw by the Army.
O-58	Page 6-4, lines 7-9	Clarification requested.	Are these the accepted standards? Please cite source(s).	Yes. See response to Comment O-27.
O-59	Page 7-1, table 7-1, 6 and 2 line test	Clarification requested.	Are these the accepted standards? Please cite source(s).	Yes. See response to Comment O-27.
O-60	Page 7-2, line 24	Clarification requested.	Is within 2.5 mV of background the standard default?	Yes. See response to Comment O-27.
O-61	Page 7-3, lines 26-27	Clarification requested.	Is 20% the accepted standard?	Yes. See response to Comment O-27.
O-62	Page 8-1, line 2	Text addition requested.	Add Ohio EPA.	Text will be revised to include Ohio EPA. "…provide a letter report to USACE and Ohio EPA describing the GPO…"
O-63	Page 8-1	Additional text needed.	Will the GPO report need to be approved prior to the commencement of AOC-	Yes, the report needs to be approved before commencing with the DGM portion of the

			specific field activities? Or is there a way to discuss what was learned from the GPO, whether it worked or not (etc.) and then make a decision on moving forward?	project. USACE, Shaw and Ohio EPA) will discuss and finalize survey parameters, DQOs and Pass/Fail criteria during the review.
O-64	Page 9-1	Text revision requested.	Change Sandra to Sand.	Text will be revised. “Sandra” will be changed to “Sand”.
O-65	Page 9-1	Text addition requested.	Add MKM IRA Report at ODA1 to the list of references cited.	MKM’s report will be added to the Reference List.

REVIEWER: **Katie Elgin – Camp Ravenna**

DATE: **May 1, 2009**

A-1	General	Change all “Ravenna Training and Logistics Site (RTLS)” references to “Camp Ravenna Joint Military Training Center (Camp Ravenna)”.		It was referenced once in Site Description (p 1-2, l 18). This section will be deleted but any other references to RTLS will be changed to “Camp Ravenna”.
A-2	Pg 1-2, Section 1.3.1	-Change ‘Site Description’ to ‘Facility and Site Descriptions’. -Replace lines 13-18 with general approved facility description.		The intent of the workplan is to address specific individual sites. Consequently, the text includes descriptions of the individual sites to be surveyed. To avoid confusion, the header will remain “Site Descriptions” and the first paragraph will be deleted (Lines 13-18).
A-3	Pg 1-3,	• The creek looks like a lake because the streams lines are not continuous.		• Figure 1-1 will be revised to show the stream as continuous.

	Figure 1-1	Recommend continuing the stream line and identifying the symbol in the figure key. • The culvert is not a 'former culvert' as the culvert is still present (it just needs repaired). Recommend identifying that structure as a 'culvert'. Also change 'Railroad' in figure key to 'Former Railroad'. • "Sand Creek Dump Subsurface Removal Areas Site Map" To my knowledge, we are not doing any removal as part of this investigation phase. Change to "Sand Creek Investigation Area Map".		• Reference to the culvert in Figure 1-1 will be revised to "collapsed culvert". The culvert essentially no longer exists. The soils associated with the culvert have all washed downstream leaving just a crushed piece of corrugated metal with ballast lying around it. The culvert will need to be replaced rather than repaired and based on the inactive status of the railroad and the RVAAP. The "Railroad" label will be changed to "Former Railroad". • The title on Figure 1-1 will changed to "Sand Creek Disposal Area Site Plan".
A-4	Pg. 1-4, Line 1-5	"The ODA1 full coverage DGM area is approximately 8.6 acres within the NACA Test Site (RVAAP-38) that was used during the 1940s for the open burning and open detonation (OB/OD) of munitions, explosives, and related debris. The material was brought to the site, burned or detonated for demolition purposes, and the resulting scrap and debris pushed to the sides of the area when ODA1 became cluttered. Because of this, it is expected that the boundaries	Suggested revised text: "The full coverage DGM investigation area for ODA1 is approximately 8.6 acres and extends beyond ODA1 into the NACA Test Area (RVAAP-38). ODA1 was used during the 1940s for the open burning and open detonation (OB/OD) of munitions, explosives, and related debris. The material was brought to the site, burned or detonated for demolition purposes, and the resulting scrap and debris pushed to the sides. Because of these activities and	The intent of the geophysical survey is to identify areas that may have residual MEC which includes possible kick out areas and areas around ODA 1 where push out of scrap material may have occurred. The text will be revised to state: "The full coverage for the proposed DGM investigation area for ODA1 is approximately 8.6 acres and extends beyond ODA1 into the NACA Test Area (RVAAP-38). ODA1 was used during the 1940s for the open burning and open detonation (OB/OD) of munitions, explosives, and related debris.

		of ODA1 site may extend beyond the current delineation into areas that were used for plane storage in the surrounding NACA site." Here it sounds like NACA was used for OB/OD activities and that resultant munitions debris was pushed around the area when ODA1 became full. I thought the reason we were doing a geophysical survey here was to identify potential kickouts not because debris was pushed to the sides around NACA.	the potential for munitions kickouts, there is a potential for the boundaries of ODA1 to extend beyond the current delineation into the NACA site."	The material was brought to the site, burned or detonated for demolition purposes, and the resulting scrap and debris pushed to the sides. Because of these activities and the potential for munitions kickouts, there is a potential for the boundaries of ODA1 to extend beyond the current delineation into the NACA site."
A-5	Pg 1-4, Line 19	"The MABS area (Figure 1-2) is open and flat." At this point this area is the area of investigation not necessarily the defined mustard site. Please revise text	Suggested revised text: "The potential MABS area to be investigated as part of this project is open and flat."	Text revised to "The potential MABS area to be investigated as part of this project is open and flat."
A-6	Pg 1-4, Line 20	"Two strips, one north and one south of the access road, comprise the site:" Change 'access road' to 'crash strip'.	Suggested revised text: "Two strips, one north and one south of the concrete crash strip, comprise the site."	Text revised to "Two strips, one north and one south of the concrete crash strip, comprise the site."
A-7	Pg. 1-4, Line 23	"One hundred fifty-five (155) mm projectile shrapnel has been found in the area but to date no material related to mustard agents has been recovered from the site." How does the 155mm shrapnel relate to the mustard site? This is most likely related to ODA1. Please delete the		Disagree with the requested deletion. The 155mm shrapnel found at MABS may very well be associated with ODA1 activities. However, the shrapnel was encountered in the indentified MABS area to be surveyed and should be carried there until a more definitive determination can be made. The historical information was taken from

		reference.		previously approved site write ups and investigations. To our knowledge, no definitive information has been provided that states the 155 mm shrapnel is part of ODA1. Regardless of where the shrapnel originated from, it is identified as being in the MABS area for the intent of the document (a geophysical survey) so that field teams are 1) aware it was found in the survey area, 2) can identify it or others in the field , and 3) safety precautions can be developed in the unlikely event more similar items are encountered. In the event it is determined to be from ODA1, the site descriptions can be revised after the fact.
A-8	Pg. 1-5, Figure 1-2	Please identify the highlighted areas on this map as investigation areas.		The map legend will be edited to indicate the highlighted areas are the proposed investigation areas.
A-9	Pg 1-7, Line 25	"Past, current, and future use is addressed in Section 1.3.1." Current and future uses of these sites are not identified in Section 1.3.1.		The site descriptions will be revised to include the following current and future uses for the sites: Sand Creek –"The site is currently not being used outside of occasional foot traffic and natural resource management. No changes are expected for future use." ODA1 - "The site is currently not being used and has been delineated as a no

				training/limited access because of the MEC risks. No changes are expected for future use.” MABS – “The investigation area is currently being used for national guard training. The future use of the site will be dependent on the results of the geophysical survey.” Please provide any revisions to these current and future uses for each site if the Army does not concur.
A-10	General	Make sure to coordinate with OHARNG on access and schedule for these sites when doing field work as this is OHARNG property and is used for training. The NACA area (which encompasses ODA1 and the mustard site investigation areas) is heavily trained on during annual training periods and PTAE periods. Military mission takes precedence but with proper notice we can work you in and hopefully facilitate your schedule.		Shaw will work with the OHARNG to co-ordinate all activities. Shaw understands that military missions are of high importance and will provide site access requests with proper notice.
A-11	Pg. 1-9, Line 3	“Some undeveloped roads and large culverts are known to be present near the Sand Creek site. The roads accessing the Sand Creek site are chiefly gravel and unimproved dirt.” Access to Sand Creek is via a former railroad, not an	Suggested revised text: “A former railroad bed consisting of ballast material and a large metal culvert are located in the vicinity of the Sand Creek site. The former railroad bed provides access to the Sand	See response to Comment O-21.

		undeveloped road.	Creek site."	
A-12	Pg. 1-9, Line 5	"An asphalt covered road and a former concrete runway provides access to ODA1 and MABS sites." The access road to ODA1 and the mustard site is gravel covered. Also, the NACA crash strip is not a runway.	Suggested text revision: "A gravel-covered road and a former concrete crash strip provide access to ODA1 and the MABS investigation sites."	Text revised to "A gravel-covered road and a former concrete crash strip provide access to ODA1 and the MABS investigation sites."
A-13	Pg. 1-9, Line 12	"…and remnants of a railway track…" This is a former railroad track.	Change to "…and remnants of a former railroad track…"	Text revised to to "…and remnants of a former railroad track…"
A-14	Pg 1-10, Line 13	"Minor clearing and grubbing may be required at the ODA1 site depending on the final area to be surveyed." All vegetation clearing and/or disturbance activities must be coordinated with the OHARNG/Camp Ravenna environmental office. Also, please specifically describe the brush clearing activities to be performed.		Shaw intends to coordinate clearing activities with OHARNG prior to work in the field. At ODA 1, it may be necessary to remove larger brush areas to facilitate the geophysical survey in the event kick out areas extend beyond the current open area at ODA 1. Brush and vegetation removal at Sand Creek will be more extensive in order to accommodate the geophysical survey. It is expected that small trees, scrub brush, and hanging vegetation may have to be removed to complete the survey. Final transect lines will be determined in the field and the proposed clearing areas discussed with OHARNG prior to the commencement of work.
A-15	Pg. 1-10,	"The Sand Creek site is accessible via an	Suggested revised text: "The Sand Creek	See response to Comment O-22.

	Line 15	unimproved road." This statement is incorrect. The Sand Creek site is accessible via a former railroad track.	site is accessible via a former railroad track."	
A-16	Pg. 1-10, Line 17	"Clearing activities at the Sand Creek site will be minimized to the extent possible to allow for execution of work. Brush and Vegetation will be left where fallen. Applicable permits will be obtained." -Again, all brush clearing activities must be coordinated with the OHARNG/Camp Ravenna environmental office. Please specifically describe the brush clearing activities to be performed. -What applicable permits will be obtained? Please clarify.		See response to Comment A-14. Depending on the size of the area to be disturbed and the site activities, it may be necessary to file a NOI for the Sand Creek. In addition, minor intrusive work may extend to areas within wetlands boundaries along the creek which may result in additional notifications.
A-17	Pg. 3-2, Line 12	"… however, any vegetation will be cleared prior to surveys to the extent necessary with previous approval from RVAAP and the Army." Brush clearing activities must also be coordinated with and approved by the OHARNG/Camp Ravenna environmental office. Please indicate.		See response to Comment A-14. Text will be added to include OHARNG/Camp Ravenna Environmental Office. Text revised to "…with previous approval from the RVAAP, the Army and the OHARNG/Camp Ravenna Environmental Office."