FORA ESCA REMEDIATION PROGRAM

Appendix E: Quality Assurance / Quality Control Project Plan

DRAFT FINAL
Group 1 Remedial Investigation / Feasibility Study Work Plan

Volume 2 - Sampling and Analysis Plan

Parker Flats Munitions Response Area Phase II

Former Fort Ord
Monterey County, California

November 13, 2008

Prepared for:

FORT ORD REUSE AUTHORITY

100 12th Street, Building 2880
Marina, California 93933

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Prepared by:

LFR | WESTON SOLUTIONS | Westcliffe Engineers, Inc.

CONTENTS

ACRONYMS AND ABBREVIATIONS III

E-1.0 PLAN OVERVIEW 1
E-1.1 Digital Geophysical Mapping 1
E-1.2 Probability of Detection 2
E-1.2.1 Positioning Delta 2
E-1.2.2 False Positives 2
E-1.3 Design 3
E-1.4 Operation 3

E-2.0 GEOPHYSICAL SURVEY 4
E-2.1 Navigation 4
E-2.1.1 Design DQO 4
E-2.1.2 Operations 4
E-2.1.2.1 Quality Report 4
E-2.1.2.2 Corrective Action 4
E-2.2 Geophysical Instrument 5
E-2.2.1 Design 5
E-2.2.1.1 Certification 5
E-2.2.2 Operations 6
E-2.2.2.1 EM61-MK2 6
E-2.2.2.2 G-858/822 8
E-2.2.2.3 Schonstedt 10
E-2.2.2.4 White's All Metals Detector 11
E-2.2.2.5 Foerster Magnetometer 11

E-3.0 DATA PROCESSING 12
E-3.1 Design 12
E-3.2 Operations 12
E-3.2.1 EM61-MK2 DQOs 12
E-3.2.2 G-858/822 DQOs 13

E-3.2.3 Anomaly Selection DQOs 13
E-3.2.4 Corrective Actions 13

E-4.0 ANOMALY REACQUISITION AND EXCAVATION 13
E-4.1 Anomaly Reacquisition 13
E-4.1.1 Anomaly Reacquisition DQOs 14
E-4.2 Anomaly Excavation 14
E-4.2.1 Anomaly Excavation DQOs 14
E-4.3 Quality Assurance and Quality Control Performance Audits 14
E-4.3.1 Quality Control of Known Items 14
E-4.3.2 Quality Assurance Seeds 15

TABLE

E-1 Quality Control and Verification Summary

APPENDICES

A Navigation System Setup and Operation of Global Positioning System – Real-Time Kinematic
B Geophysical Standard Operating Procedure Checklist
C Project Processing and Deliverable Forms
D Operational Use of the EM61-MK2 Single Unit and Operational Use of the EM61-MK2 Towed Array
E Operational Use of the G-856 Magnetometer and Operational Use of the G-858/822 Magnetometer
F Analog Locator Operations and Analog Locator Operator Checkout
G Quality Control Procedures and Geophysical Data Processing
H Anomaly Reacquisition and Excavation Procedure

ACRONYMS AND ABBREVIATIONS

BADT	Best Available (and Appropriate) Detection Technology
cm	centimeter
DGM	digital geophysical mapping
DQOs	Data Quality Objectives
ESCA RP	Environmental Services Cooperative Agreement Remediation Program
FORA	Fort Ord Reuse Authority
GPS	Global Positioning System
m	meter
MEC	munitions and explosives of concern
mph	miles per hour
MQOs	Measurement Quality Objectives
MRA	Munitions Response Area
mV	millivolt
nT	nanoTesla
nT/ft	nanoTeslas per foot
ODDS	Ordnance Detection and Discrimination Study
Pd	probability of detection
QA	quality assurance
QC	quality control
RTK	real-time kinematic
UXOQCS	Unexploded Ordnance Quality Control Specialist

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E-1.0 PLAN OVERVIEW

The objective of the quality assurance/quality control (QA/QC) project plan is to provide unbiased evidence of the quality of the data acquired and decisions made during the munitions and explosives of concern (MEC) investigations, as evaluated against the measurement performance criteria described in this plan. The measurement performance criteria are called Data Quality Objectives (DQOs). The primary methods used to provide evidence of compliance with DQOs are:

- Prequalification of policies and procedures
- Acceptable performance on test grids
- Auditing of field activities
- Acceptance sampling of completed work

To support project DQOs, individual measurement quality objectives (MQOs) will be implemented to document that the procedures and acquired data can achieve the performance goals. MQOs include the implementation of a geophysical test plot, instrument standardization protocols, and set data collection parameters with pass/fail metrics to monitor and evaluate the geophysical results. QC measurement metrics will be verified during the geophysical test plot prior to further data collection. A summary of the DQOs and MQOs are provided in Table E-1.

The Fort Ord Reuse Authority (FORA) Environmental Services Cooperative Agreement Remediation Program (ESCA RP) is committed to using the Best Available (and Appropriate) Detection Technology (BADT) for locating subsurface MEC. As established by the Ordnance Detection and Discrimination Study (ODDS; Draft Final, Ordnance Detection and Discrimination Study, prepared for U.S. Army Corps of Engineers, Sacramento District, Parsons, December 2001) and subsequent projects, the goal is to use digital geophysical mapping (DGM) for subsurface investigations. Where there are physical impediments to the use of DGM, manual analog detection technologies are used.

E-1.1 Digital Geophysical Mapping

From an operational perspective DGM can be defined as four subsystems:

- Geophysical Survey
- Data Processing
- Anomaly Reacquisition
- Anomaly Excavation

This plan provides DQOs for each of the subsystems and also establishes DQOs for the overall DGM system.

System DQOs depend on all of the subsystems for their success. The system performance is described by the Probability of Detection (Pd) DQO, the Positioning Delta DQO, and the False Positive DQO.

E-1.2 Probability of Detection

Pd is a measure of whether the system successfully detects and recovers applicable MEC and MEC-like targets.

This plan has a multilevel approach to Pd. The first level DQO is the goal of 100% Pd. This means that any MEC, including QC surrogates (i.e., seeds), not detected and removed during operations will automatically trigger the creation of a Corrective Action Report. The project team will do a root cause analysis and determine if changes in equipment and/or procedures are warranted. The second level of Pd was created in recognition of the fact that DGM has inefficiencies and rarely if ever achieves the 100% Pd goal. The DGM processes used at the former Fort Ord are rated between 75 and 85% Pd for targets near or at the detection limits of the equipment. The project's second level DQO for Pd is 85% with a 90% confidence level. If the project as a whole or any part of it drops below this level, then the project must be halted and full design review by the project team completed before work can begin again.

E-1.2.1 Positioning Delta

The Positioning Delta DQO states that the XY positioning provided to the reacquisition team is within a certain range of the actual target. The DQO is that the target must be found within 2 feet of the reported position.

E-1.2.2 False Positives

False Positive (No Contacts) refers to locations that are reported to the excavation team but nothing is recovered during the excavation. The DQO is that every false positive reported in the field must be resolved by the project geophysicist. If the geophysicist is picking close to noise level then the resolution may be reclassifying the target as noise. If it is a large anomaly, then the geophysicist will resubmit the anomaly to the dig team.

DQO	Metric	Measurement
Pd 1st level	100% of MEC in the established detection zone	Detection of seeded items
Pd 2nd level	85% Pd with a 90% confidence	Detection of seeded items
Positioning Delta	The delta will not exceed +/- 2 feet. This DQO is specific to the reported positions of the state-plane coordinates for each data point in the final version of the geophysical data.	Comparison of dig list with excavation report
False Positive	100% of false positives (No Contacts) must be resolved by geophysicist	Comparison of dig list with excavation report

To achieve the project Pd DQOs, each part or subsystem of the DGM system is evaluated from two perspectives:

- Is the subsystem designed to achieve the maximum efficiency possible?
- Is the subsystem operated to achieve the maximum efficiency possible?

E-1.3 Design

The evaluation of design is accomplished through two processes. The first is the prequalification of policies and procedures. This involves the reviewing of the policies and procedures for effectiveness and completeness by a professional in the appropriate field. The second process is the requirement to successfully complete test grids. A test plot grid is where MEC or MEC surrogates are buried in an approximation of the conditions that will be encountered in the project. The DGM system being tested must demonstrate the capability to locate and recover the MEC to the predetermined standard.

E-1.4 Operation

The evaluation of operation is accomplished through auditing. There are two methods of auditing employed. The first is called performance auditing. This is accomplished by burying a MEC or a MEC stimulant within the project boundaries. The system performance is evaluated based on whether the MEC is located and recovered. The second audit method is called a procedural audit. This method is accomplished by checking the field operation of a system component against the policies and procedures for that component. The policies and procedures describe the operating procedure that was established before and used in the test plot process.

Sections E-2.0 through E-4.0 describe each of the four subsystems and components of DGM in terms of design and operation.

E-2.0 GEOPHYSICAL SURVEY

There are two main components of the geophysical survey system:

- Navigation
- Geophysical Instrument

E-2.1 Navigation

E-2.1.1 Design DQO

This document sets a DQO standard for final DGM system positional accuracy and for kinematic positioning error of the navigation subsystem.

DQO	Metric	Measurement
Raw Positional Data	Kinematic positional error at known monuments will not exceed +/- 20 centimeters (cm)	QC audit of positioning system error test records

The proposed navigation subsystem is the Trimble 5700 or equivalent (R8 receiver), which is a real-time kinematic (RTK) Global Positioning System (GPS). The system is proven to meet or exceed the Raw Positional Data DQO.

E-2.1.2 Operations

- All operators will ensure that the RTK correction signal is locked (fixed) before collecting data.
- All operators who set up and operate the navigation subsystem will be trained in the navigation system setup and operation of GPS – RTK policies and procedures (Appendix A of this QAPP). A certification form for each operator will be on file in the main project office (Appendix B of this QAPP).

E-2.1.2.1 Quality Report

Appendix C of this QAPP contains samples of the Project Processing and Deliverable forms. The geophysicist will fill out this report daily and they will be on file in the project office.

E-2.1.2.2 Corrective Action

If the raw positional data does not exhibit RTK signal lock (fix), no data will be collected until the system meets the DQO standard.

E-2.2 Geophysical Instrument

E-2.2.1 Design

Five geophysical instruments (three digital and two analog), which use two different geophysical methods (time-domain electromagnetics and magnetometry) may be used. The three digital geophysical instruments that may be used are the data recording Geonics® EM61-MK2 (0.5-meter[m] by 1-m coils) time-domain metal detector, the Geometrics® G-858/822 digital magnetometer, and the Foerster magnetometer; all digital geophysical instruments record data. The two analog instruments that will be used are the Schonstedt® GA-52/Cx magnetic gradiometer and White's All Metals detector, which will be used for "mag and dig" operations, as necessary.

The selection of these geophysical instruments is based on two factors:

- The results of the ODDS
- Knowledge and experience gained during previous geophysical surveys at the former Fort Ord

The ODDS receiver operating characteristic curves for the various field trial sites indicate that several instruments would be best for the munitions and conditions anticipated at the former Fort Ord. Therefore, the reasons for selecting these five geophysical instruments are as follows:

- Some of the MEC items that were found in previous Fort Ord investigations were large items that had penetration depths greater than 24 inches. During the ODDS, the EM61-MK2 and G-858/822 were determined to be the best tools in detecting larger items at greater depths. However, the majority of the MEC recovered from the Parker Flats Munitions Response Area (MRA) Phase II were non-penetrating items.
- The anticipated types of MEC do not include any items that are completely nonferrous; therefore, either electromagnetic or magnetic techniques can be used. Electromagnetic techniques are preferable because they will help detect munitions that contain nonferrous components (e.g., grenade fuzes and signal illuminations [slap flares]).
- The EM61-MK2, G-858/822, Foerster, Schonstedt, and White's All Metals detector are durable and rugged enough to be used in the field, and they are commercially available.
- The Foerster offers superior field ability compared to the G-858/822. Prior to its selection for use at the Parker Flats MRA Phase II, the instrument will have to demonstrate detection characteristics similar to or better than the G-858/822 and be certified through a prove-out process that will include demonstration on a FORA ESCA RP geophysical test plot.

E-2.2.1.1 Certification

Preexisting Prove-out Grids

Due to extensive intrusive investigations already completed at the Group 1 MRAs it is not anticipated that additional types of MEC will be encountered. The proposed geophysical instruments (EM61-MK2, G-858/822 magnetometer, Schonstedt manual magnetometer, and White's All Metal detector) have all been certified through the ODDS as meeting the detection requirements of the Group 1 MRAs.

The goal of the project is to detect all MEC to their maximum detectable depths using the BADT. The following equation has been developed that describes the maximum detection depths for most MEC items (USACE DID FPRI-005-05.01):

Estimated depth of detection (m)* = 11 x diameter (millimeters)/1000

*measured to the center of mass of the item

Test Plots

The objective of establishing project-specific test plots is both design and operations. The geophysical test plot previously established in the Seaside MRA may be used to show that geophysical instruments are functioning properly. This is appropriate since the types of MEC found in the Parker Flats MRA are consistent with the types found in the Seaside MRA. A geophysical test plot may also be established in the Parker Flats MRA.

Geophysical Test Plot Reporting

Initial test plot results will be discussed between the Project Geophysicist and the QC Geophysicist. A report describing the design and initial results of the test plot will be submitted to the Project Team prior to beginning geophysical operations. Feedback will be included in the test plot report. The test plot report will include the following:

- As-built drawing of the test plot including depth and orientation of seeded items
- Representative photographs of the seed items
- Color plots of the DGM data
- Target dig lists showing comprehensive results
- Summary of the test plot results

E-2.2.2 Operations

E-2.2.2.1 EM61-MK2

The policies and procedures for the operation of the EM61-MK2 are provided in Appendix D for this QAPP. The policies and procedures are titled: Operational Use of the EM61-MK2 Single Unit and Operational use of the EM61-MK2 Towed Array.

- All operators who set up and operate the EM61-MK2 will be trained for proficiency in the policies and procedures outlined in Appendix D of this QAPP. A certification form for each operator will be on file in the main project office (Appendix B of this QAPP).
- The QC Geophysicist will conduct periodic audits of compliance with the policies and procedures (Appendix D of this QAPP) as well as spot checks of the daily Project Processing and Deliverable forms for the EM61-MK2 (Appendix C of this QAPP).

DQOs

The following EM61-MK2 DQOs must be met.

DQO	Metric	Measurement
Standard Deviation of background noise	Summed Channel = i.e., < 2 milliVolts (mV)	Run Statistics on all data below a reasonable level (between 7 and 9 mV)
Mean Acquisition Speed	< 3 miles per hour (mph)	Run Statistics on velocity between points in each file (created a "velocity channel")
Along-Track Measurements	Along-track sampling densities should not exceed 0.5 foot	Run Statistics on distance between points in each file
Cross-Track Measurements	The across-track line spacing shall not exceed 3 feet. The surveys will be run to achieve a 2.5-foot spacing. 95% of the data in a grid must meet this metric. 5% of the data may lie between 2.5 and 3 feet. This will allow for variation in spacing reporting caused by rough terrain.	Run Statistics on distance between data lines in each file and a manual review based on gridded data between lines
Standard Response	Response above background to standard object will not vary more than +/- 20%	Standardization tests: QC audit of response test records

Quality Report

Appendix C of this QAPP contains samples of the Project Processing and Deliverable forms for the EM61-MK2.

Corrective Actions

Evaluation of compliance with many of the DQOs is made in the field at the beginning of the day when the QC function tests are performed. The survey may not begin until the equipment meets all of the relevant DQOs and passes all of the required tests.

Other DQOs, such as along-track and cross-track measurements, are evaluated by the data processing operator after the survey has been completed. If there is a violation of the operational DQOs, then a note is made in the project log and a Corrective Action Report is filled out. The grid will not be passed as completed until the Corrective Action Report is resolved. The corrective action resolution may involve a resurvey of the grid, but can also include other remedies as approved by the project team.

E-2.2.2.2 G-858/822

The policies and procedures for the operation of the G-858/822 are in Appendix E of this QAPP (Operational Use of G-856 Magnetometer and Operational Use of G-858/822 Magnetometer).

- All operators who set up and operate the G-858/822 will be trained for proficiency in the policies and procedures outlined in Appendix E of this QAPP. A certification form for each operator will be on file in the project office (Appendix B of this QAPP).
- The operators will fill out the Project Processing and Deliverable forms for the G-858/822 (Appendix C of this QAPP) when data are collected.
- The QC Geophysicist will conduct periodic audits of compliance with the policies and procedures as well as spot checks of the daily Project Processing and Deliverable forms for the G-858/822.

DQO	Metric	Measurement
Standard Deviation of Background Noise	Vertical Gradient = i.e., < 2.5 nanoTeslas (nT)	Run Statistics on all data below a reasonable level (between -10 and +10 nT)
Mean Acquisition Speed	< 3 mph	Run Statistics on velocity between points in each file (created a "velocity channel")
Along-Track Measurements	Along-track sampling densities should not exceed 0.5 foot	Run Statistics on distance between points in each file
Cross-Track Measurements	The across-track line spacing will not exceed 3 feet. The surveys will be run to achieve a 2.5-foot spacing. 95% of the data in a grid must meet this metric. 5% of the data may lie between 2.5 and 3 feet. This will allow for variation in spacing reporting caused by rough terrain.	Run Statistics on distance between data lines in each file and a manual review based on gridded data between lines
Diurnal Data Statement	The base station data should exhibit normal characteristics for such data (background variations of less than 1 nT) between measurements during periods without magnetic storms.	Examine data for spikes
Standard Response	Response above background to standard object will not vary more than +/- 20%	Standardization tests: QC audit of response test records

Quality Report

Appendix C of this QAPP contains samples of the Project Processing and Deliverable forms for the G-858/822.

Corrective Actions

Evaluation of compliance with many of the DQOs is made in the field at the beginning of the day when the QC function tests are performed. The survey may not begin until the equipment meets all of the relevant DQOs and passes all of the required tests.

Other DQOs, such as along-track and cross-track measurements, are evaluated by the data processing operator after the survey has been completed. If there is a violation of the

operational DQOs, then a note is made in the project log. The grid will not be passed as completed until the violation is resolved. Resolution may involve a resurvey of the grid, but can also include other remedies as approved by the project team.

E-2.2.2.3 Schonstedt

The Schonstedt® GA-52/Cx handheld magnetometer has been approved for use at the former Fort Ord as documented in the ODDS. Schonstedts are typically used to locate ferrous anomalies, and are typically used in conjunction with the White's XLT® E Series metal detector.

Schonstedt magnetometer sweeps (i.e., "mag and dig") are particularly effective in areas where vegetation and terrain limit the use of larger digital systems. "Mag and dig" approaches will also be used when there is insufficient difference between MEC at the site and other metallic fragments and debris, such that digital discrimination is ineffective.

Prior to operating an analog instrument (i.e., Schonstedt and White's XLT® E Series), the analog operator will undergo and document the analog checkout procedure as defined in the Analog Locator QC Checkout Policy and Procedure Manual.

The analog instrument will be used during the following operations:

- Analog Locator Daily QC Checkout
- Analog Surveys ("mag and dig")
- Near-Surface Anomaly Detection
- Backhoe Excavations
- Analog Locator QC Surveys

The policy and procedure manual for Analog Locator Operations provides descriptions of these operations.

DQOs

The DQOs for Schonstedt operations are qualitative and depend on consistent use of the policies and procedures identified above.

Quality Report

The following policy and procedure manuals (Appendix F of this QAPP) contain the reporting forms related to the use of analog instruments:

- Analog Locator Operations
- Analog Locator Operator Checkout

E-2.2.2.4 White's All Metals Detector

The White's XLT® E Series handheld all-metals detector is also commonly used for geophysical investigations. White's All Metals detectors are typically used to locate all metal anomalies and are typically used in conjunction with the Schonstedt® GA-52/Cx handheld magnetometer.

White's XLT® E Series handheld all-metals sweeps (i.e., "mag and dig") are particularly effective in areas where vegetation and terrain limit the use of larger digital systems. "Mag and dig" approaches will also be used when there is insufficient difference between MEC and other metallic fragments and debris, such that digital discrimination is ineffective.

Prior to operating an analog instrument (i.e., Schonstedt and White's XLT® E Series), the analog operator will undergo and document the analog checkout procedure as defined in the Analog Locator Checkout Policy and Procedure Manual (Appendix F of this QAPP).

The analog instrument will be used during the following operations:

- Analog Locator Daily QC Checkout
- Analog Surveys ("mag and dig")
- Near-Surface Anomaly Detection
- Backhoe Excavations
- Analog Locator QC Surveys

The policy and procedure manual for analog locator operations, provides descriptions of these operations.

DQOs

The DQOs for Schonstedt operations are qualitative and depend on consistent use of the policies and procedures identified above.

Quality Report

The following policy and procedure manuals (Appendix F of this QAPP) contain the reporting forms related to the use of analog instruments:

- Analog Locator Operations
- Analog Locator Operator Checkout

E-2.2.2.5 Foerster Magnetometer

If the Foerster magnetometer is selected for use at Parker Flats MRA Phase II, a standard operating procedure will be prepared.

E-3.0 DATA PROCESSING

E-3.1 Design

Design encompasses the selection of all algorithms and software used in the data processing subsystem. The data processing engine used is Geosoft Oasis Montaj. This is the industry standard software for preprocessing and post-processing of geophysical data for MEC investigations.

E-3.2 Operations

The policies and procedures for data processing are included Appendix G of this QAPP (Quality Control Procedures and Geophysical Data Processing).

- All operators who conduct data processing will be trained for proficiency in the policies and procedures outlined in Appendix G of this QAPP. A certification form for each operator will be on file in the project office (Appendix B of this QAPP).
- The operators will fill out the Project Processing and Deliverable Forms (Appendix C of this QAPP).
- The QC Geophysicist will conduct periodic audits of compliance with the policies and procedures as well as spot checks of the daily Data Processing and Deliverables Report.

E-3.2.1 EM61-MK2 DQOs

DQO	Metric	Measurement
Electromagnetic Leveling Statement	For any given data set of electromagnetic data, all data channels will be leveled using the same routines and parameters when possible.	Not Applicable
Instrument Latency	Instrument latency will be corrected based on the lags or time differences observed in anomaly peak positions. Corrections will be applied using the appropriate correction routine that accounts for instrument latency time and sensor velocity. "Zig-zag" or "chevron" effects should not be visible in the data maps when plotted at the scales used to detect the smallest amplitude signal for a given MEC item.	Not Applicable
Processing Statement	All leveling and/or filtering routines that are applied to data sets will be evaluated, on a data set by data set basis, to confirm that those routines do not alter the nature of the original measured response.	Not Applicable

E-3.2.2 G-858/822 DQOs

DQO	Metric	Measurement
Magnetic Heading	For proper heading correction there should be no "striping" visible in the vertical gradient data above a 0.2 nT per foot (nT/ft) level between lines and no "striping" visible in total field data above a 0.4 nT/ft level between lines.	Not Applicable
Processing Statement	All leveling and/or filtering routines that are applied to data sets will be evaluated, on a data set by data set basis, to confirm that those routines do not alter the nature of the original measured response.	Not Applicable

E-3.2.3 Anomaly Selection DQOs

DQO	Metric	Measurement
Anomaly Selection	100% of anomalies that are above the project threshold are selected for anomaly reacquisition and excavation.	Visual and manual review by QC Geophysicist

E-3.2.4 Corrective Actions

In the event that it is discovered during data processing that the data from the field does not meet a DQO, then a Corrective Action Report will be filled out. In the resolution of the Corrective Action Report, it will be determined if a resurvey of the affected area is warranted or if the problem can be handled by reprocessing the data.

If the DQO failure is a Pd failure, meaning that MEC or a MEC surrogate was not selected for excavation, then a Corrective Action Report will be filled out. The report must be resolved with a root cause analysis and a proposed solution so as to avoid a repeat of the error. In the event that MEC did not present as a distinct anomaly that could be separated out through any means available, then it will be noted as such. If the number of unresolved MEC detection failures rises to a level where the Pd falls below 85%, then the project must be stopped and a complete design review undertaken before it can be restarted.

E-4.0 ANOMALY REACQUISITION AND EXCAVATION

E-4.1 Anomaly Reacquisition

The policies and procedures for anomaly reacquisition are in Appendix H of this QAPP (Anomaly Reacquisition and Excavation Procedure).

- All operators who conduct anomaly reacquisition will be certified for proficiency in the policies and procedures. A certification form for each operator will be on file in the project office (Appendix B of this QAPP).

E-4.1.1 Anomaly Reacquisition DQOs

DQO	Metric	Measurement
Flag Placement	Flags will placed within 20 cm of the position reported by the geophysicist	Not Applicable
Flag Completeness	100% of reported anomaly positions will be flagged	Not Applicable

E-4.2 Anomaly Excavation

The policies and procedures for anomaly excavation are in Appendix H of this QAPP (Anomaly Reacquisition and Excavation Procedure).

- All technicians will be certified for proficiency in the policies and procedures. A certification form for each technician will be on file in the project office (Appendix B of this QAPP).
- The Senior Unexploded Ordnance Supervisor will conduct periodic audits of compliance with the policies and procedures.

E-4.2.1 Anomaly Excavation DQOs

DQO	Metric	Measurement
Anomaly Excavation	100% of reacquired anomalies will be excavated.	Not Applicable
Reporting	Required information will be entered into the handheld data logger and verified daily.	Not Applicable

E-4.3 Quality Assurance and Quality Control Performance Audits

The primary method for performance auditing is to bury inert MEC or MEC-like items in the path of the survey. Performance is measured by calculating the ratio between seeds that were found and seeds that were not found.

E-4.3.1 Quality Control of Known Items

Quality Control items will be used during the geophysical data collection to quantify positional accuracy of each data set. The QC items will consist of 6-inch rebar spikes or equivalent inserted vertically.

The digital anomaly response from the QC item will be identified during data processing and analysis. Each seed item will be reviewed to quantify positional accuracy by measuring the anomaly target location to the actual geo-referenced location of the rebar spike recorded during the grid survey. The measured offset will be logged for each data set in the geophysical processing form spreadsheet. Offset distance between the anomaly target selection and the actual seed location will not exceed the reacquisition metric. One seed item per DGM data set is anticipated as part of the seeding program.

E-4.3.2 Quality Assurance Seeds

Blind seed items will be placed within areas planned for investigation. The project Unexploded Ordnance Quality Control Specialist (UXOQCS) in consultation with the Remediation Project Manager and Project QA Representative will determine the locations of the seed items.

Seeds will be located using a survey-grade GPS or equivalent within DGM grids. The blind seeds will consist of inert MEC items or equivalent buried no greater than the depth interval at which a 100% Pd was determined for the geophysical instrumentation to be used in that area. The location of the seed items will not be known to the on-site project personnel. QC and QA personnel will review the DGM data against the seed locations. The blind seeds will be detected within the reacquisition metric of the seed survey location.

Blind seed items will also be placed in near-surface investigation area grids as a quality indicator. The UXOQCS will seed the Munitions Debris items in randomly selected grids. The location of the seed items will be recorded in the QC log based on XY position and grid identification. The seed item location will be revisited by the UXOQCS during re-collection surveys in each seeded grid to ensure the seed item was detected and removed by the unexploded ordnance teams.

If any seed item is not picked and excavated, a Corrective Action Report will be initiated as per the 100% Pd DQO. Corrective actions nonconformance reviews will be conducted as presented in Section 11.7 of Volume 2 (Sampling and Analysis Plan) of the Group 1 Remedial Investigation / Feasibility Study Work Plan.

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Table E-1
Quality Control and Verification Summary

Data Quality Objectives / Measurement Quality Objectives	Measurement Verification	Performance
Digital Instrument Survey and Data Acquisition (Geonics EM61-MK2, Geometric G-858/822, Foerster Ferex Mk26)		
Static Background Function Test - Standard deviation of all four EM61-MK2 data channels are < 2 millivolts (mV). Standard deviation of magnetic data < 2.5 nanoteslas (nT).	Calculate standard deviation for pre- and post-survey static background function tests to verify noise levels. Report results on processing form.	Standard deviation of function tests and survey data will be < 2 mV or < 2.5 nT. If static background fails noise metric, determine root cause of ambient noise interference.
Static Response Function Test - Standard deviation of all four EM61-MK2 data channel is < 2 mV. Standard deviation of magnetic data < 2.5 nT. Response between pre- and post-survey tests will not vary more then 20%.	Calculate standard deviation for pre- and post-survey static response function tests to verify noise levels. Compare peak response from pre-survey test and post-survey test to determine percent difference. Report results on processing form.	Standard deviation of function tests and survey data will be < 2 mV or < 2.5 nT. If static response fails noise metric, determine root cause of ambient noise interference. If post-survey static response differs by 20% of pre-survey test, determine root cause of increased or decreased signal from test item.
Cable Connection Function Test - Standard deviation of all four EM61-MK2 data channels are < 2 mV. Standard deviation of magnetic data < 2.5 nT. No visible spikes observed in data.	Calculate standard deviation for pre- and post-survey static background function tests to verify noise levels. Review data profile to verify no spikes were introduced during test. Report results on processing form.	Standard deviation of function tests and survey data will be < 2 mV or < 2.5 nT. If static background fails noise metric, determine root cause of ambient noise interference. If spikes are observed in data, perform further tests to identify connection failure and repair.
Noise Level - Standard deviation of the sum of four EM61-MK2 data channels is < 2 mV. Standard deviation of magnetic data < 2.5 nT.	Calculate standard deviation for pre- and post-survey static background and static response function tests to verify noise levels. Window data set in an anomaly free area and calculate standard deviation to determine dynamic survey noise.	Standard deviation of function tests and survey data will be < 2 mV or < 2.5 nT. If function tests fail noise metric, determine root cause of ambient noise interference. If survey data fail noise metric, determine root cause of increased ambient or dynamic data collection related noise.
Mean Acquisition Speed - Speed during data collection is < 3 miles per hour (mph).	Calculate mean speed across data set using point to point distance and time. Report results on processing form.	Average data set speed will be < 3 mph. If speed exceeds metric, determine root cause of increase. Review along track measurements to ensure adequate data density. Recollect data as necessary based on corrective action.

Data Quality Objectives / Measurement Quality Objectives	Measurement Verification	Performance
Along-Track Measurements - Data points will be spaced < 0.5 feet.	Calculate point to point distance across data set. Report results on processing form.	Average along-track measurements in each data set will be < 0.5 feet. If distance exceeds metric, determine root cause of increase. Recollect data as necessary based on data gap metric or corrective action.
Across-Track Measurements - Survey lanes will not exceed 3 feet.	Use spatial analysis to identify areas where line spacing exceeds metric. Report results on processing form.	Surveys will be run to achieve a 2.5-foot spacing. 95% of the data in a grid must meet this metric. 5% of the data may lie between 2.5 and 3.0 feet. This will allow for variation is spacing reporting caused by rough terrain. Recollect data as necessary based on data gap metric or corrective action.
Navigation/Positioning - Positioning will be < 20 centimeters (cm).	Compare anomalies to known seed locations or monuments and measure offset.	Survey positioning will be < 20 cm. If offsets in a dataset exceed the metric, determine root cause by verifying instrument functionality, terrain considerations, and tree canopy. Recollect data as necessary based corrective action.
Analog Instrument Survey and Data Acquisition (Schonstedt and White's All Metals)		
Survey Speed	Senior Unexploded Ordnance Supervisor (SUXOS) shall observe operations and verify that operator instrument swing speed does not exceed best practices.	There is not a quantitative measure for analog instrument swing speed.
Lane Spacing	The Data Quality Objectives (DQOs) for analog operations are qualitative and depend on consistent use of the policies and procedures identified in this plan.	Individual survey lanes shall not exceed 3 feet in width.
Digital Data Processing and Analysis (Geonics EM61-MK2, Geometric G-858/822, Foerster Ferex Mk26)		
Processing Statement - Anomalies will not be altered by more than 10% from raw data.	Processes identified during geophysical test plot surveys will be used to correct all data.	All leveling and/or filtering routines that are applied to data sets will be evaluated, on a data set by data set basis, to confirm that those routines do not alter the nature of the original measured response by more than 10%. If metric is exceeded, correction parameters may be modified. Changes will be reported in the processing log.

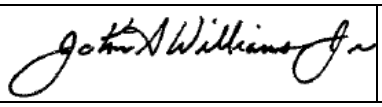
Data Quality Objectives / Measurement Quality Objectives	Measurement Verification	Performance
Leveling/Drift Correction - Low frequency, long wavelength noise will be removed.	Window data set in an anomaly free area and calculate mean response to verify leveling/drift correction.	Mean response shall be within +/- 5 mV or +/- 5 nT. If metric is not achieved, verify leveling/drift correction routine parameters or check ambient noise levels.
Instrument Latency - No chevron effects visible in data set.	Latency tests will be run daily to determine time delays related to the digital instrumentation.	Instrument latency will be corrected based on the lags or time differences observed in anomaly peak positions. Corrections will be applied using the appropriate correction routine that accounts for instrument latency time and sensor velocity. "Zig-zag" or "chevron" effects should not be visible in the data maps when plotted at the scales used to detect the smallest amplitude signal for a given munitions and explosives of concern (MEC) item.
Magnetic Heading Correction - No striping visible in magnetic data.	Conduct magnetic heading tests as needed to determine and subsequently correct for magnetic response changes due to travel direction.	No striping visible in the vertical gradient data above a 0.2 nT per foot (nT/ft) level between lines and no striping visible in total field data above a 0.4 nT/ft level between lines. If metric is exceeded, check magnetic heading tests and parameters used for correction.
Anomaly Selection - All anomalies meeting the approved selection criteria will be added to the dig list	The Quality Control (QC) Geophysicist will review the digital data sets to ensure all anomalies meeting the selection criteria are selected.	100% of all anomalies meeting the selection criteria were selected. Missing or QC anomalies will be added to the dig list.
Field Investigation and Reporting (Geonics EM61-MK2, Geometric G-858/822, Foerster Ferex Mk26)		
MEC Detection - 100% of MEC in the established detection zone.	All metrics will be verified to ensure data achieve measurement quality objectives (MQOs). Use QC seeds to determine detection ability during surveys. Confirm with QC procedures.	All MEC (37mm projectile and greater) will be detected within established detection zone. If MEC is identified, determine root cause by using measurement quality objective results and recollect data as necessary based on corrective action.
False Positives - Reduce number of false positives. Resolve false positives identified as "no contacts".	Review excavation results to identify no contacts. Use field notes to determine terrain variation or cultural interference which may have influenced the digital data.	Resolve 100% of no contacts. Processing and analysis procedures may need to be modified to reduce false positives.

Data Quality Objectives / Measurement Quality Objectives	Measurement Verification	Performance
False Negatives - No false negatives identified in data sets.	Perform post-dig QC steps to verify no MEC was missed during data processing or data collection.	All MEC (37mm projectile and greater) will be detected within established detection zone. If MEC is identified, determine root cause by using measurement quality objective results and recollect data as necessary based on corrective action.
Anomaly Reacquisition - Pin flags will mark the anomaly location within 20 cm of the position reported on the dig list.	Known QC spikes will be within 20 cm of marked/flagged location.	Anomaly reacquisition will be performed on selected digital geophysical mapping (DGM) anomalies throughout the duration of the project. 95% of the locations of reacquired anomalies should lie within 1 meter of their original surface location as marked on the dig list.
Dig List Backcheck - 100% of reported anomaly positions will be reacquired and flagged.	Unexploded Ordnance Quality Control Specialist (UXOQCS) and QC Geophysicist will verify dig list with dig results.	All anomalies will be reacquired. Missing anomalies will be reacquired and investigated.
Anomaly Excavation - 100% of reacquired anomalies will be excavated.	UXOQCS and QC Geophysicist will verify dig list with dig results.	95% of excavated items should lie within an approximate 1-ft radius of their mapped surface location as marked in the field after reacquisition.
Reporting - 100% of anomalies will be resolved.	Required information will be entered into the handheld data logger and verified daily.	No missing investigation information is evident on dig list.
QC Geophysical Surveys (Geonics EM61-MK2, Geometric G-858/822, Foerster Ferex Mk26)		
QC-1 - No MEC remains following excavation.	Verify removal of the source of each DGM anomaly within 3 feet of a flag. Location will be checked using the same instrument used for survey.	All MEC will be recovered during excavation. If the source of the anomaly does not appear to have been removed, the intrusive operation will continue until a significant reduction in signal is observed by the instrument operator.
QC-2 - No additional MEC recovered within original survey area.	Digital resurveying of 16% percent of the DGM investigation areas.	A failure will be constituted by the discovery of MEC or similar item, or five re-acquirable anomalies as a result of the QC survey, or the discovery during the QC process of five non-selected anomalies that should have been selected during the initial survey within a single 100-foot by 100-foot grid (with dimensions similar to a 37 mm projectile or greater). Perform Root Cause Analysis and identify and implement Corrective Action.

Data Quality Objectives / Measurement Quality Objectives	Measurement Verification	Performance
QC-3 - No additional MEC recovered within original survey area.	Analog resurveying of 10% percentage of each 100-foot by 100-foot grid.	A failure will be constituted by the discovery of MEC or similar item, or five re-acquirable anomalies as a result of the QC survey, or the discovery during the QC process of five non-selected anomalies that should have been selected during the initial survey within a single 100-foot by 100-foot grid (with dimensions similar to a 37 mm projectile or greater). Perform Root Cause Analysis and identify and implement Corrective Action.

APPENDIX A

Navigation System Setup and Operation of Global Positioning System – Real-Time Kinematic

WSI *POLICY AND PROCEDURE MANUAL*	
SUBJECT: Navigation System Set-up and Operation of Global Positioning System (GPS) – Real time Kinematic (RTK)	**No**. Op.001.nav.rtk
EFFECTIVE DATE: February 11, 2008	**SUPERSEDES:**
SECTION: Geophysics Group	**DEPARTMENT**: OU 1494
NAME/TITLE: J. Williams/Sr. Technical Manager	
SIGNATURE: 	**DATE APPROVED:** February 05, 2008

1. PURPOSE

This procedure outlines the technical requirements and operational use of the RTK GPS for use in geophysical surveys.

2. APPLICABILITY AND SCOPE

The requirements of this procedure are applicable to all project activities which include the use of the RTK GPS. The instrument is utilized to collect real-time corrected GPS positions used to precisely locate geophysical sensors while collecting data. The data generated is streamed directly into geophysically instruments providing sub-centimeter accuracy of positions.

3. REFERENCES

3.1. TrimbleR7-R8_223A_UserGuide, Trimble Webpage

4. DEFINITIONS

4.1. Central Equipment Stores (CES) - WESTON's central equipment storage location in West Chester, PA. This group is responsible for securing, maintaining, and distributing equipment.

4.2. Real-Time Kinematic (RTK) Global Positioning System (GPS) components:

4.2.1. R8 Global Navigation Satellite System (GNSS) – advanced global positioning tracking receiver capable of acting as a base and rover receiver. Unit is capable of achieving accuracies of +/- 10 mm horizontal and +/- 20 mm vertical accuracy.

4.2.2. HPB450 Series Radio Transmitter – powerful radio capable of broadcasting real-time correction signals from base R8 to rover R8 at 35 watts.

4.2.3. Trimble TSC2 Data Collector – data collector with Survey Controller

software for stakeout and collecting points.

5. SET-UP AND OPERATION

This section outlines the steps for setting up the RTK GPS system in the field for use with geophysical instruments. Be sure to follow all operating manuals for set-up and operation.

5.1. An established control point (of necessary accuracy) must be known before starting an RTK survey. Set up the base unit tripod over the control point and level the tripod.

5.2. Place the base receiver on the tripod and connect the power to Port 1 on the receiver. The receiver should turn on as soon as power is applied. Confirm that the satellite led on the front display is blinking yellow at one second intervals.

5.3. Set-up the second tripod and assemble the radio antenna and connect it to the tripod. Connect the coaxial cable to the back of the radio and connect the power cable to an external battery.

5.4. Turn on the datalogger and open Survey Controller software.

5.4.1. Click on Configuration – Controller – Bluetooth

5.4.2. Make sure Bluetooth is turned on and select the corresponding serial number (located beneath the base receiver on barcode) and click connect, then accept. Return to main menu. Make sure data logger is displaying the satellite number and power display of the receiver.

5.4.3. Select Survey – RTK – Start Base Station

5.4.3.1. Under the point name click – List and then select the point you have entered for the control point in which you are set-up over (note the station index marked). Click Start, the data logger will begin to start the receiver and tell you when you can proceed to the next step. Make sure that the radio is transmit led (TX) is blinking every second.

5.4.4. Power up the rover receiver, and connect to it via Bluetooth via step 5.4.2 except find the corresponding serial number for the rover receiver and connect, then click accept.

5.4.5. Once the logger connects to the rover receiver (showing the satellite count and battery power on the logger screen), go to Survey – RTK – Start Survey. The controller will search for a base station broadcast and display the station index (if this is the same as the one you entered when you started the base) click accept. The survey will begin, wait for initialization (< 5 seconds) and confirm RTK fix by the display at the bottom of the logger (will display RTK fix and you horizontal and vertical accuracy). You are now ready to survey.

5.4.6. Configuration file must be uploaded to the R8 rover receiver in order to stream the NMEA string into the geophysical data collector. Connect the Lemo-9 pin to Port 1 on the R8 Rover receiver and the female serial DB9 cable to the corresponding connection on the geophysical sensor. Open the chat mode or terminal screen on the geophysical survey logger and verify NMEA string is communicating with the geophysical data collector. You are now ready to collect data.

6. Navigational QC Check

6.1. Weston Solutions, Inc. performs navigational accuracy checks daily during the latency test performed to measure instrument delay time. This is performed by traversing a survey spike of known coordinates with the geophysical sensor(s) in two directions. The surveyed peak amplitude location must be within 1 foot of the actual survey spike. If differences are noticed, first make sure the operator is surveying directly over the spike, and then check the rover receiver by mounting the R8 rover on the range pole and navigate to the same point and determine the offset. If still unacceptable make sure step 5 was followed correctly. All reporting will be carried out in the daily latency reporting. QC seed items are sometimes planted in geophysical grids, these serve as a secondary test on navigational accuracy.

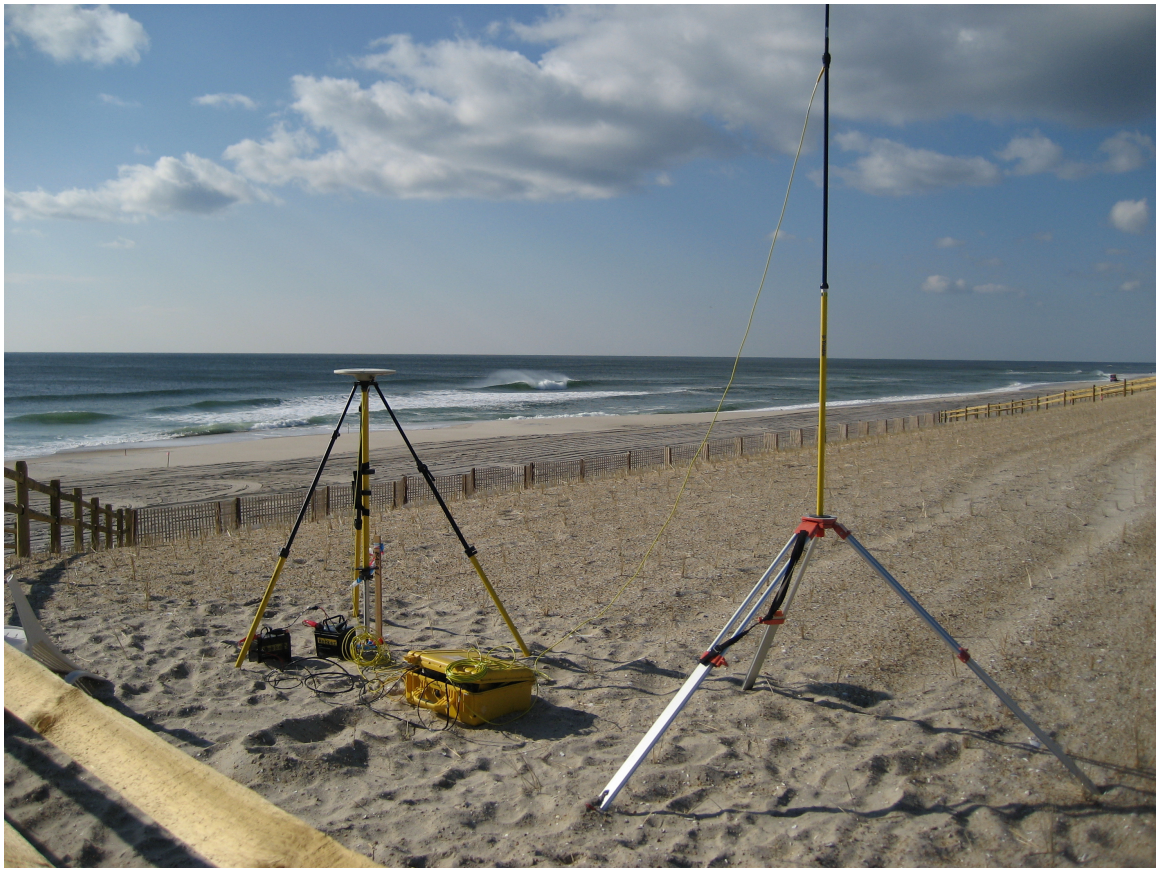
Applicable References:

Trimble R7-R8_223A_UserGuide, Trimble Webpage

Project Specific Work Plan - Data Quality Objectives (DQO) with established metrics

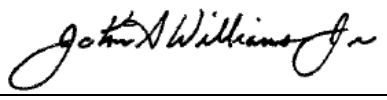
Review/Revision Date:	J. Williams - 02/04/08
Original Prepared By/Date:	M. Saunders – 01/14/2008
Revision #1 –	

Photo 1 Field Set-up of the RTK GPS



APPENDIX B

Geophysical Standard Operating Procedure Checklist

WSI *POLICY AND PROCEDURE MANUAL*	
SUBJECT: Geophysical SOP Checklist	**No**. Op.001.SOPCertChcklst.
EFFECTIVE DATE: May 13, 2008	**SUPERSEDES:**
SECTION: Geophysics Group	**DEPARTMENT**: OU 1494
NAME/TITLE: J. Williams/Sr. Technical Manager	
SIGNATURE: 	**DATE APPROVED:** May 13, 2008

By placing my signature below, I certify that I have read the following (checked) Geophysical Standard Operating Procedure (SOP) and fully understand its procedures and requirements. The procedures set forth therein can only be superseded by site-specific work plans, or as directed by the Project Geophysicist or QC Geophysicist.

- ☐ **Op.001.nav.rtk**: Navigation System Set-up and Operation of Global Positioning System (GPS) – Real Time Kinematic
- ☐ **Op.001.em61mk2.ta**: Operational use of the EM61-MK2 Towed Array
- ☐ **Op.001.em61mk2.su**: Operational use of the EM61-MK2 Single Unit
- ☐ **Op.001.G856.mag**: Operational use of G-856 Magnetometer
- ☐ **Op.001.G858.mag**: Operational use of G-858 Magnetometer
- ☐ **Op.001.Analog Locator Operations.su**: Analog Locator Operations
- ☐ **Op.001.Analog Operator Checkout.su**: Analog Locator Operator Checkout
- ☐ **Op.001.QCdat**: Quality Control Procedures and Geophysical Data Processing Anomaly Selection
- ☐ **Op.001.reac**: Anomaly Reacquisition and Excavation Procedure

Print Name:_____ Signature:_____

Company: _____ Date: _____

APPENDIX C

Project Processing and Deliverable Forms

Daily Notes

Project	Date
Mare Island DGM	3/13/2006

Days Weather
PC 50

Daily Notes

0630 Onsite
0700 H&S meeting
0800 Team JH and TF planting seeds in entire PMA/SSA. GT putting final touches on EM towed array.
1230 Navy seeded SSA and PMA area

No data collected
Onsite:
M. Saunders
G. Turner
T. Fitzgerald
J. Hunter

Equipment Used
RTK GPS

Daily Mag Acreage	Total Mag Acreage	Daily EM Acreage	Total EM Acreage
	0		0

EM Data Processing

Date of Survey: 4/3/2006 Team ID: Team 1

File Name: 0403_EM_TowedArray Internal QC Performed On: 4/4/2006

Geosoft Database: 0403_EM_TowedArray.gdb Weston QC Performed On: 4/26/2006

Instrument: EM61-MK2 Towed Array Weston QC Initals: JAW

Drift Correction ☑ Were QC evaluation tests performed ☑

Latency Coil AM: 0.3

Latency Coil PM: 0.3

Velocity: 2.1 < 2.5 mph

Mean Sample Seperation: 0.31 < 0.5 ft

Channel Analyzed: Clipped Area

Noise Mean: 0 Noise Standard Deviation: 0 < 3.0

Target Selection ☐ Target Selection Database:

Target Selection Threshold:

Processing Notes:

Latency Coil 1 = 0.25
Latency Coil 2 = 0.3
Latency Coil 3 = 0.3

Not able to determine good Noise mean and St Dev due to large dynamic values present in the data.

Seed in DGM Area ☑

Seed ID:	QC143	Anomaly ID:	Closest Anomaly
Seed Easting:	1855528.294	Anomaly Easting:	1855527.51
Seed Northing:	13826257.425	Anomaly Northing:	13826256.98
Seed Depth:	0	Anomaly Distance:	0.90148821414 <2 ft
Seed Orientation:	Vertical	Anomaly Orientation:	WSW
Acres Surveyed:	1.798	Total Acres Surveyed to Current Date	1.798

Mag Data Processing

Team ID	Team 1	**Internal QC Performed On:**	3/16/2006
Survey Date	3/15/2006	**Weston QC Performed On:**	4/4/2006
Geosoft database	0315_MagCart.gdb	**Weston QC Initials:**	JAW
Instrument	MagCart		

Data Processing

Drift Correction ☐ **Diurnal Correction** ☑

Latency 0

Dynamic Background Levels

Clipping Values:

	Mean	Std. Dev. <3.0
Background Noise:	0	0

Target Selection

Target Database U-Hunter Software

Initial Target Screening Level U-Hunter Software

Seed Characterization

Seed ID: QC144

Target ID: Closest Anomaly

Target Offset Distance: 1.1936 **< 2.0ft**

Offset Direction: NW

Data Sampling

Velocity (<= 2.5 mph) 2.32

Sample Separation (<=0.5 ft) 0.28

Processing Notes: No Latency Correction Required

Acres Surveyed 1.38 **Total Acres Surveyed** 1.38

EM QC Report

Survey Date	4/3/2006		
Team ID	Team 1	Internal QC Performed On:	4/5/2006
Geosoft db	0403_EM_TowedArray_QC.gdb	Weston QC Performed On:	4/26/2006
Instrument ID	EM61 MK2	Weston QC Initals:	JAW
Sensor Number	Blue		

Static Background Test

	Pre-Survey				Post-Survey			
	CH1	CH2	CH3	CH4	CH1	CH2	CH3	CH4
Maximum	0.68	0.41	0.25	0.22	0.59	0.42	0.33	0.33
Minimum	-0.36	-0.27	-0.16	-0.16	-0.37	-0.36	-0.17	-0.16
Mean	0.1	0.07	0.05	0.03	0.09	0.08	0.05	0.05
Std. Dev. < 2.0	0.13	0.09	0.07	0.06	0.13	0.1	0.07	0.07

Static Spike Test

	Pre-Survey				Post-Survey			
	CH1	CH2	CH3	CH4	CH1	CH2	CH3	CH4
Maximum	317.46	234.55	143.53	6.43	379.89	275.65	174.06	7.9
Minimum	-212.12	-113.25	-66.19	-4.21	-251.64	-124.55	-88.89	-4.37
Mean	87.9	54.6	35.8	1.77	93.14	60.61	37.65	1.75
Std. Dev. <2.0	99.57	66.42	41.47	2.02	110.52	72.28	42.95	2.12

Cable Connection Test

	Pre-Survey				Post-Survey			
	CH1	CH2	CH3	CH4	CH1	CH2	CH3	CH4
Maximum	0.5	0.44	0.3	0.2	0.99	0.52	0.27	0.24
Minimum	-0.3	-0.2	-0.16	-0.15	-0.39	-0.18	-0.16	-0.16
Mean	0.09	0.08	0.05	0.03	0.13	0.09	0.06	0.03
Std. Dev. <2.0	0.14	0.1	0.07	0.06	0.18	0.11	0.08	0.06

Comments:

Values displayed are the drift corrected values for the Pre and the Post QC Survey. Static Spike test indicates object used for QC object (2 inch trailer balls fixed in a 2x4, positioned on the coils) was too great a response. Different object to be used next time. - MS

GEOPHYSICS DAILY
EM61-MK2 Towed Array CHECKLIST

Date:

Team ID:

Team Members:

Weather:

Approx Survey Area:

☐ Warm-up Instruments

☐ Check Coil Offsets

Quality Control Tests AM

QC Filename:

☐ Static Test (1 min.) Line Number:

☐ Static Spike (1 min) Line Number(s):

☐ Cable Shake (30 sec.) Line Number:

☐ Latency Loop Line Numbers:

☐ Repeat Lines Collected Line Numbers

Quality Control Tests PM

Remember to increment your AM and PM Lines in your AM and PM QC Files!!!!

QC Filename:

☐ Static Test (1 min.) Line Number:

☐ Static Spike (1 min) Line Number(s):

☐ Cable Shake (30 sec.) Line Number:

☐ Latency Loop Line Numbers:

Survey Filename(s):	Operator(s):	Line Numbers:

Survey Notes:

GEOPHYSICS DAILY MagCart Checklist

Date:

Team ID:

Team Members:

Weather:

Approx Survey Area:

☐ Warm-up Instruments

☐ Check Sensor Offset Measurements

QC Filename: Dataset1 (Always put all QC in Dataset 1)

Quality Control Tests AM

☐ Static Test (1 min.) Line Number:

☐ Spike Test (Jig 1 min) Line Number:

☐ Cable Shake (30 sec.) Line Number:

☐ Latency Loop Line Number:

Quality Control Tests PM

☐ Static Test (1 min.) Line Number:

☐ Spike Test (Jig 1 min) Line Number:

☐ Cable Shake (30 sec.) Line Number:

☐ Latency Loop Line Number:

☐ Repeat Lines Collected (PUT GRID ID's with line #)

Survey Filename(s):	Operator(s):	Line Numbers:

Survey Notes:

MAG QC Report

Survey Date	3/15/2006	**Sensor Number**	1
Team ID	1	**Sensor Serial #**	C498
Geosoft db	0315_MagCart_QC.gdb		
Internal QC Performed On:	3/16/2006		
Weston QC Performed On:	4/4/2006		
Weston QC Initials:	JAW		

Static Background Test					
AM Mean	392.91		**PM Mean**	396.98	
AM Std Dev	0.53	**<2.0**	**PM Std Dev**	0.16	**<2.0**

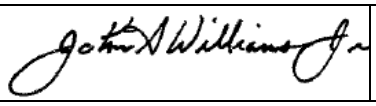
Static Spike Test					
AM Mean	555.7		**PM Mean**	559.93	
AM Std Dev	0.31	**<2.0**	**PM Std Dev**	0.61	**<2.0**

Cable Connection Test					
AM Mean	393.49		**PM Mean**	395.8	
AM Std Dev	2.18	**<2.0**	**PM Std Dev**	0.18	**<2.0**

Comment: Switched out Sensor 1 and replaced with C498. Deviation in AM Cable Test is personnel walked to close to sensor, note PM cable test is OK along with sensor 2 AM cable test. MS.

APPENDIX D

Operational Use of the EM61-MK2 Single Unit and Operational Use of the EM61-MK2 Towed Array

WSI *POLICY AND PROCEDURE MANUAL*		
SUBJECT: Operational use of the EM61-MK2 Single Unit		**No**. Op.001.em61mk2.su
EFFECTIVE DATE: February 11, 2008		**SUPERSEDES:**
SECTION: Geophysics Group		**DEPARTMENT**: OU 1494
NAME/TITLE: J. Williams/Sr. Technical Manager		
SIGNATURE:		**DATE APPROVED:** February 5, 2008

1. PURPOSE

This procedure outlines the technical requirements and operational use of the Single Unit EM61-MK2 TDEM for use in geophysical surveys.

2. APPLICABILITY AND SCOPE

The requirements of this procedure are applicable to all project activities which include the use of the EM61-MK2. The instrument is utilized to collect transient electromagnetic signals from the subsurface up to a depth of four feet (unofficial estimate). The data generated are collected concurrently with a navigational system (RTK or total station) and stored on an Allegro CX field computer.

3. REFERENCES

3.1. EM61-MK2 Operating Manual, Geonics Limited.

4. DEFINITIONS

4.1. Central Equipment Stores (CES) - WESTON's central equipment storage location in West Chester, PA. This group is responsible for securing, maintaining, and distributing equipment.

4.2. EM61-MK2 components:

4.2.1. Bottom 1 m x 0.5 m coil (including wheels)

4.2.2. Top 1 m x 0.5 m coil

4.2.3. Backpack with electronics box, batteries and chargers

4.2.4. Two meter cable to connect electronics box with Bottom Coil

4.2.5. Pig tail connector to connect Bottom Coil to Top Coil

4.2.6. Handle

4.2.7. Navigational mount

4.2.8. Allegro CX Data Logger (battery charger, data link and download cables)

5. SET-UP AND OPERATION

This section outlines the steps for setting up the EM61-MK2 system in the field for the acquisition of geophysical data using a Global Positioning System (GPS). Be sure to follow all operating manuals for set-up and operation.

5.1. Assemble EM61-MK2 according to operating manuals.

5.2. Interface the EM61-MK2 with a navigational system for precise location data. Connect serial cable from navigational system into Port 2 on the Allegro CX.

5.3. Set-up the specific data collection software (Dat61MK2 or NAV61MK2) on the Allegro CX field computer.

5.3.1. Set the appropriate data collection rate (sampling rate, i.e. 10 Hz for MEC mapping).

5.3.2. Set the EM61-MK2 to interface with COM1 and the navigation device to interface with COM2.

5.3.3. Adjust line increments and stations start as needed.

5.4. Perform 10-15 minute warm-up of EM61-MK2 according to ambient temperature.

5.5. Perform spot check readings to locate an area free of noise and representative of background to null the instrument and perform QC function tests.

5.6. Perform Pre-survey QC function tests (see separate QC SOP) which usually consists of a 2-3 minute Static Test (remain stationary with no object – record readings), Static Spike (remain stationary with a metallic object [i.e. 5-6 inch ½ diameter rebar] beneath coil – record readings), and 0.5-1 minute Cable Vibration Test (remain stationary with no object moving cables – record readings). Note any spikes or abrupt changes in data.

5.7. Perform Latency Test

5.8. If all QC data is verified, collect data, according to operating manual.

5.8.1. If a Geophysical Prove-out survey is required, data acquisition will be performed following the guidance established in the Site Specific GPO Work Plan.

5.8.2. For production surveys, data acquisition will be performed following the

guidance established in the Site Specific Geophysical Investigation Plan (GIP).

Applicable References:

Geonics, Ltd., 1996, www.geonics.com/em61.html.

Geonics, Ltd. 1999. *Operating Manual for EM61-MK2 61 High Sensitivity Metal Detector*.

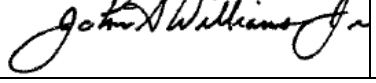
McNeill, J.D. 1980. "*Electromagnetic Terrain Conductivity Measurements at Low Induction Number*." Technical Note TN-6, Geonics, Ltd., Mississauga, Ontario.

Plugge, D., R. J. Selfridge, and R. Young. 2003. *Planning Geophysical Prove outs for Munitions Response Projects.* Huntsville, Ala.: U.S. Army Engineering and Support Center.

USAESCH (U.S. Army Engineering Support Center, Huntsville). 2003. Munitions Response Data Item Descriptions (DIDs). Revised 1 December 2003.

Project Specific Work Plan - Data Quality Objectives (DQO) with established metrics

Review/Revision Date:	J. Williams - 02/04/08
Original Prepared By/Date:	M. Saunders – 01/14/2008
Revision #1 –	

WSI *POLICY AND PROCEDURE MANUAL*		
SUBJECT: Operational use of the EM61-MK2 Towed Array		**No**. Op.001.em61mk2.ta
EFFECTIVE DATE: February 11, 2008		**SUPERSEDES:**
SECTION: Geophysics Group		**DEPARTMENT**: OU 1494
NAME/TITLE: J. Williams/Sr. Technical Manager		
SIGNATURE:		**DATE APPROVED:** February 5, 2008

1. PURPOSE

This procedure outlines the technical requirements and operational use of the EM61-MK2 Towed Array for use in geophysical surveys.

2. APPLICABILITY AND SCOPE

The requirements of this procedure are applicable to all project activities which include the use of the EM61-MK2 Towed Array. The instrument is utilized to collect transient electromagnetic signals form the subsurface up to a depth of four feet (unofficial estimate – dependent on size of target). The data generated from the multiple EM61-MK2 are collected concurrently with a navigational system (RTK or total station) and stored on a field computer running MagLogNT software from Geometrics.

3. REFERENCES

3.1. EM61-MK2 Operating Manual, Geonics Limited.

3.2. MagLogNT operating manual, Geometrics Inc.

4. DEFINITIONS

4.1. Weston Geophysics Group - WESTON's geophysics team in West Chester, PA. This group is responsible for securing, maintaining, and distributing equipment.

4.2. EM61-MK2 Towed Array components (number of EM61-MK2 units dependent on particular array configuration (usually 3 or 4 units):

4.2.1. Bottom 1 m x 0.5 m coil

4.2.2. Top 1 m x 0.5 m coil

4.2.3. Electronic boxes

4.2.4. 7 meter cables to connect electronic boxes with Bottom Coil.

4.2.5. Sync Cable?

4.2.6. Pig tail connectors to connect Bottom Coil to Top Coil

4.2.7. Navigational mount

4.2.8. Panasonic Toughbook with MagLogNT software.

4.2.9. Towed Array pieces made of fiberglass and fiberglass nuts and bolts to assemble the array.

4.2.10. Tow vehicle – usually a John Deere Gator or Kubota Utility Vehicle.

5. SET-UP AND OPERATION

This section outlines the steps for setting up the EM61-MK2 system in the field for data collection. Be sure to follow all operating manuals for set-up and operation.

5.1. Assemble Towed Array components according to labeled pieces and color coding.

5.2. Assemble EM61-MK2s according to operating manuals and configure on the Towed Array according to the specific project objectives (i.e. line spacing).

5.3. Interface the one of the EM61-MK2 with a navigational system and mount for precise location data.

5.4. Connect the main tow beam on the receiver hitch on the tow vehicle. Be sure to attach safety cabling from the tow beam to the back of the tow vehicle in case the hitch becomes dislodged during survey (it won't pull by the electronics cables it will pull by the safety cabling).

5.5. Connect all 7 meter cables from the multiple EM61-MK2s along the main tow beam and into the back of the tow vehicle and connect to the electronics boxes in the appropriate interface. Be sure to enclose the cables in some protective covering and tape so everything is tight against the beam.

5.6. Connect the electronic boxes cables into an interface device (either a 4 port serial hub or PCMCIA adapter). Then connect the cable from the serial hub into the USB port on the field computer.

5.7. Set-up the MagLogNT software on the field computer. The most important thing is that the port settings are the set correctly. If using the serial hub the ports are usually 5, 6, 7, and 8. Set MagLogNT to interface with all the units according to their port assignments, be sure to make certain you know which EM61-MK2 unit is connected to which port. The same procedure is followed for setting up the GPS port assignment. See Photo 5.1 for an example of one of the Towed Array configurations

5.7.1. Set the appropriate data collection rate (sampling rate, i.e. 10 Hz for MEC jobs).

5.8. Perform 10-15 minute warm-up of EM61-MK2 according to ambient temperature.

5.9. Perform Pre-survey QC (see separate QC SOP) which usually consists of a 2-3 minute Static Test (remain stationary with no object – record readings), Static Spike (remain stationary with a metallic object beneath coil – record readings), and Cable Vibration Test (remain stationary with no object moving cables – record readings). Note any spikes or abrupt changes in data.

5.10. Perform Latency Test

5.11. If all QC data is verified, collect data, according to operating manual.

Applicable References:

Geonics, Ltd., 1996, www.geonics.com/em61.html.

Geonics, Ltd. 1999. *Operating Manual for EM61-MK2 61 High Sensitivity Metal Detector*.

McNeill, J.D. 1980. "*Electromagnetic Terrain Conductivity Measurements at Low Induction Number*." Technical Note TN-6, Geonics, Ltd., Mississauga, Ontario.

Plugge, D., R. J. Selfridge, and R. Young. 2003. *Planning Geophysical Prove outs for Munitions Response Projects.* Huntsville, Ala.: U.S. Army Engineering and Support Center.

USAESCH (U.S. Army Engineering Support Center, Huntsville). 2003. Munitions Response Data Item Descriptions (DIDs). Revised 1 December 2003.

Project Specific Work Plan - Data Quality Objectives (DQO) with established metrics

Review/Revision Date:	J. Williams - 02/04/08
Original Prepared By/Date:	M. Saunders – 01/14/2008
Revision #1 –	

Photo 5-1 Four coil configuration of the EM61-MK2 Towed Array

APPENDIX E

Operational Use of the G-856 Magnetometer and Operational Use of the G-858/822 Magnetometer

WSI *POLICY AND PROCEDURE MANUAL*		
SUBJECT: Operational use of G-856 Magnetometer		**No**. Op.001.G856.mag
EFFECTIVE DATE: February 27, 2008		**SUPERSEDES:**
SECTION: Geophysics Group		**DEPARTMENT**: OU 1494
NAME/TITLE: J. Williams/Sr. Technical Manager		
SIGNATURE:		**DATE APPROVED:** March 10, 2008

1. PURPOSE

This procedure outlines the technical requirements and operational use of the G-856 Magnetometer for use in geophysical surveys.

2. APPLICABILITY AND SCOPE

The requirements of this procedure are applicable to all project activities which include the use of the G-856 Magnetometer. The instrument is utilized as a magnetic basestation to collect magnetic data used to diurnally correct the G-858 magnetometer data.

3. REFERENCES

3.1. G-856 Magnetometer Operating Manual, Geometrics, Inc.

4. DEFINITIONS

4.1. Central Equipment Stores (CES) - WESTON's central equipment storage location in West Chester, PA. This group is responsible for securing, maintaining, and distributing equipment.

4.2. G-856 Magnetometer components:

4.2.1. One proton-precession magnetometer

4.2.2. One Geometrics data logging console

4.2.3. Aluminum pieces to assemble data collection staff

4.2.4. Optional external battery

4.2.5. Download Cable

5. SET-UP AND OPERATION

This section outlines the steps for setting up the G-856 Magnetometer system in the field for the acquisition of monitoring daily magnetometer data.

5.1. Assemble G-856 Magnetometer according to operating manuals.

5.2. It is not necessary to perform a warm-up of the G-856.

5.3. Set-up the specific data collection software on the data collection console

5.3.1. Synchronize the G-856 and G-858 clocks within 1 second.

5.3.2. Set the appropriate data collection rate (sampling rate, i.e. 1 reading every 20 seconds is sufficient for collecting diurnal data).

5.3.3. Erase any previous data on the instrument in order to ensure enough room from the current data.

5.3.4. Start logging data on the G-858 console.

5.4. At the end of the day stop data collection and download data utilizing MagMap2000 software from Geometrics.

Applicable References:

Geometrics, 2000. Total *Field Magnetometer Performance Published Specifications and What They Mean*: Technical Report TR-120, Geometrics, San Jose, CA.

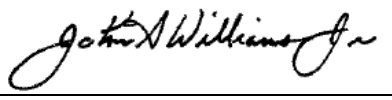
Geometrics, 2001. *G-856 Magmapper Operation Manual*.

Smith, K., 1997. *Cesium Optically Pumped Magnetometers*: Technical Report M-TR91, Geometrics, San Jose, CA.

USAESCH (U.S. Army Engineering Support Center, Huntsville). 2003. *Munitions Response Data Item Descriptions (DIDs)*. Revised 1 December 2003.

Project Specific Work Plan - Data Quality Objectives (DQO) with established metrics

Review/Revision Date:	J. Williams - 03/10/08
Original Prepared By/Date:	M. Saunders – 03/03/2008
Revision #1 –	

WSI *POLICY AND PROCEDURE MANUAL*		
SUBJECT: Operational use of G-858 Magnetometer		**No**. Op.001.G858.mag
EFFECTIVE DATE: February 27, 2008		**SUPERSEDES:**
SECTION: Geophysics Group		**DEPARTMENT**: OU 1494
NAME/TITLE: J. Williams/Sr. Technical Manager		
SIGNATURE:		**DATE APPROVED:** March 10, 2008

1. PURPOSE

This procedure outlines the technical requirements and operational use of the G-858 Magnetometer for use in geophysical surveys.

2. APPLICABILITY AND SCOPE

The requirements of this procedure are applicable to all project activities which include the use of the G-858 Magnetometer. The instrument is utilized to collect magnetic data from the subsurface up to a depth of four feet (unofficial estimate). The data generated are collected concurrently with a navigational system (RTK or total station) and stored on a Geometrics field computer.

3. REFERENCES

3.1. G-858 Magnetometer Operating Manual, Geometrics, Inc.

4. DEFINITIONS

4.1. Central Equipment Stores (CES) - WESTON's central equipment storage location in West Chester, PA. This group is responsible for securing, maintaining, and distributing equipment.

4.2. G-858 Magnetometer components:

4.2.1. Two Cesium magnetometer sensors

4.2.2. One Geometrics data logging console

4.2.3. Aluminum pieces to assemble data collection staff

4.2.4. Battery pack

4.2.5. Navigational mount

5. SET-UP AND OPERATION

This section outlines the steps for setting up the G-858 Magnetometer system in the field for the acquisition of geophysical data using a Global Positioning System (GPS). Be sure to follow all operating manuals for set-up and operation.

5.1. Assemble G-858 Magnetometer according to operating manuals.

5.2. Interface the G-858 Magnetometer with a navigational system for precise location data. Connect serial cable from navigational system into the RS-232 Port.

5.3. Perform 10-15 minute warm-up of G-858 Magnetometer according to ambient temperature. Check the magnetometer system settings to ensure "RF 1 & 2 and Bright 1 & 2 are reading within specified limits as per the values below:

RF should be below 60% - Optimum is 35%

Brightness should ALWAYS be 50% +/- 2%

COLD should always be 50% +/- 2%

Signal usually is about 25% but is dependent on the environment.

5.4. Measure distance between top and bottom sensors from center to center of each sensor (typically 1 meter, but project dependent). A pin flag affixed to the bottom sensor at the instrument height (determined from the height optimization test) allows the operator to maintain a constant height by using the pin flag as a guide.

5.5. Set-up the specific data collection software on the data collection console

5.5.1. Set the appropriate data collection rate (sampling rate, i.e. 10 Hz for MEC mapping).

5.5.2. The G-858 Magnetometer utilizes "Datasets" to store data. There are only five Datasets available.

5.5.2.1. Collect all QC data in Dataset 1.

5.5.2.2. Collect all Survey files in Datasets 2-5

5.5.3. Adjust line increments and stations start as needed per survey file.

5.6. Perform Pre-survey QC function tests (see separate QC SOP) which usually consists of a 2-3 minute Static Test (remain stationary with no object – record readings), Static Spike (remain stationary with a metallic object [i.e. 5-6 inch ½ diameter rebar] beneath coil – record readings), and 0.5-1 minute Cable Vibration

Test (remain stationary with no object moving cables – record readings). Note any spikes or abrupt changes in data.

5.7. Perform Latency Test – Magnetometer data does not exhibit latency effects as other instruments, but it is suggested that several latency test be run early in your project to verify and document this result.

5.8. If all QC data is verified, collect data, according to operating manual.

5.8.1. If a Geophysical Prove-out survey is required, data acquisition will be performed following the guidance established in the Site Specific GPO Work Plan.

5.8.2. For production surveys, data acquisition will be performed following the guidance established in the Site Specific Geophysical Investigation Plan (GIP).

Applicable References:

Geometrics, 2000. Total *Field Magnetometer Performance Published Specifications and What They Mean*: Technical Report TR-120, Geometrics, San Jose, CA.

Geometrics, 2001. *G-858 Magmapper Operation Manual*.

Smith, K., 1997. *Cesium Optically Pumped Magnetometers*: Technical Report M-TR91, Geometrics, San Jose, CA.

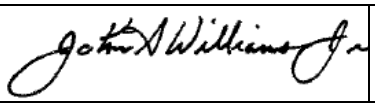
USAESCH (U.S. Army Engineering Support Center, Huntsville). 2003. *Munitions Response Data Item Descriptions (DIDs)*. Revised 1 December 2003.

Project Specific Work Plan - Data Quality Objectives (DQO) with established metrics

Review/Revision Date:	J. Williams – 03/10/08
Original Prepared By/Date:	M. Saunders – 03/03/2008
Revision #1 –	

APPENDIX F

Analog Locator Operations and Analog Locator Operator Checkout

WSI *POLICY AND PROCEDURE MANUAL*		
SUBJECT: Analog Locator Operations		**No**. Op.001.Analog Locator Operations.su
EFFECTIVE DATE: February 29, 2008	**SUPERSEDES:**	
SECTION: UXO Service Line	**DEPARTMENT**:	
NAME/TITLE: J. Williams/Sr. Technical Manager		
SIGNATURE: 	**DATE APPROVED:** February 5, 2008	

1. PURPOSE

This procedure outlines the requirements for analog locator operations.

2. APPLICABILITY AND SCOPE

The analog locator will be used during the following operations:

- Analog Locator Daily QC Checkout
- Analog Surveys ("mag and dig")
- Near-Surface Anomaly Detection
- Backhoe Excavations
- Final 10% Analog Locator QC Surveys

The following section provides descriptions of these operations.

3. OPERATIONS

Analog Locator Daily QC Checkout

The UXO Technicians will conduct a daily instrument standardization check by placing the instrument over a standard item prior to commencing daily field activities. The standard item will be buried with the item description, depth and orientation annotated on a wooden stake marking where the item is located. The standard item will remain in the same location until the block of grids has been completely investigated.

An Analog Locator Checkout and Return Form will be filled out daily by equipment operators to record the results of the analog locator QC checkout and document the condition of the equipment.

Analog Locator Surveys

Analog locator surveys (i.e., "mag and dig") will be performed in areas that cannot be surveyed using the digital techniques. "Mag and dig" sweeps are particularly effective in areas where vegetation and terrain limit the use of larger digital systems. The "mag and dig" approach will also be used in areas where metallic fragments and debris make digital discrimination from MEC ineffective.

UXO Technicians will use the procedure described in Section 4.0 of this SOP to conduct analog locator surveys. The location of any MEC items that are located by using this method will be recorded with a GPS (or other survey method if under vegetation canopy) and all collected field data will be recorded in personal digital assistant's (PDAs).

Near-Surface Anomaly Detection

Near-surface anomalies are those subsurface anomalies that can be excavated using hand tools. Throughout the excavation, the UXO Technician will use a magnetometer to check and verify the location of the anomaly.

Backhoe Excavations

Some anomalies are more deeply buried and require excavation using heavy equipment (i.e., backhoe). Prior to the arrival of the heavy equipment, the UXO Team Leader will ensure that a cleared entrance and egress path is available for the heavy equipment. Once on-site, the heavy equipment will be used to excavate the earth overburden from the suspect anomaly. The distance to the anomaly will be checked with the magnetometer during the excavation.

Final 10% Analog Locator QC Surveys

Quality control surveys will be performed after intrusive operations have been completed. A 10 percent QC survey will be performed by the UXOQCS using the analog instrument for all grids originally surveyed digitally. The discovery of any UXO or UXO-like item sufficient in size to represent a 37mm projectile or larger will constitute a failure of the grid (area) being investigated. Results of the 10 percent analog locator QC survey will be documented by the UXOQCS in the daily quality control (QC) report.

4.0 ANALOG LOCATOR SURVEY PROCEDURE

The following procedure will be used by equipment operators to conduct "mag and dig" operations with a handheld analog locator:

- The UXO Team Leader will direct personnel to establish individual search lanes approximately 3 feet wide and to begin searching each lane using a handheld analog locator.

- The equipment operator will start at one end of each lane and move forward toward the opposing baseline.

- During the forward movement, the UXO Technician will move the magnetometer back and forth in a sweeping motion from one side of the lane to the other. Both forward movement and the swing of the analog locator are performed at a pace that ensures that the entire lane is searched and that the instrument is able to appropriately respond to subsurface anomalies.

- Whenever a subsurface anomaly or metallic surface object is encountered, the technician will halt and investigate the anomaly or place a flag for later investigation. Throughout this operation, the UXO Team Leader will closely monitor individual performance to ensure these procedures are being performed with due diligence and attention to detail.

6.0 ANALOG LOCATOR QUALITY CONTROL REPORTS

The quality control reports and forms used to document the QC activities listed in this policy and procedure manual are as follows.

FIELD SUPERVISOR REVIEW SHEET

I have read the Project Work Plan and Standard Operating Procedure (SOP) UXO Technicians Analog Locator QC Checkout. I understand it. To the best of my knowledge the processes described in the Work Plan and this SOP can be done in a safe, healthful, and environmentally sound manner. I have made sure all persons assigned to this process are qualified, have read and understand the requirements of the Work Plan and SOP, and have signed the worker's statement for this process. If necessary, I will conduct an annual review of the Work Plan and SOP. If deviations from this SOP are necessary, I will ensure that project activities are stopped until the SOP is revised and approved. If unexpected safety, health, or environmental hazards are found, I will ensure that project activities are stopped until the hazards have been eliminated.

SUPERVISOR'S NAME	SIGNATURE/DATE

FIELD TEAM REVIEW SHEET

Each field team member shall sign this section after site-specific training is completed and before being permitted to work on-site.

I have read the Project Work Plan and Standard Operating Procedure for UXO Technicians Analog Locator QC Checkout. I have received the hazard control briefing. I understand them. I will follow the Work Plan and SOP unless I identify a hazard not addressed in it or encounter an operation I do not understand. If that occurs, I will stop site activities and notify my immediate supervisor of the problem.

WORKER'S NAME (Print)	SIGNATURE/DATE	SUPERVISOR'S NAME	SIGNATURE/DATE

ANALOG LOCATOR CHECKOUT AND RETURN PROCEDURE

Month _____

Instrument _____

Serial No. _____

Work Site _____

Operator's Signature	Comments	Date	CHECKOUT PROCEDURE	Check case for damage; open case	Check instrument for damage	Open battery compartment	Install batteries	Audio switch in "A" position	Power up; adjust sensitivity control	Set volume control	Verify digital display	Report to test grid	Test grid results; Pass/Fail	RETURN PROCEDURE	Clean instrument	Open battery compartment	Remove and store batteries	Close battery compartment	Return instrument to storage case	Return case to storage area
		1																		
		2																		
		3																		
		4																		
		5																		
		6																		
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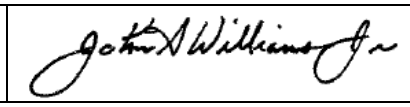
		31																		

WSI *POLICY AND PROCEDURE MANUAL*		
SUBJECT: Analog Locator Operator Checkout		**No**. Op.001.Analog Operator Checkout.su
EFFECTIVE DATE: February 29, 2008	**SUPERSEDES:**	
SECTION: UXO Service Line	**DEPARTMENT**:	
NAME/TITLE: J. Williams/Sr. Technical Manager		
SIGNATURE:		**DATE APPROVED:** February 5, 2008

1. PURPOSE

This procedure outlines the requirements for analog locator operator checkout.

2. APPLICABILITY AND SCOPE

The Geophysical Test Plot will be used as the analog locator operator checkout area. The Geophysical Test Plot Plan identifies the approximate number and type of items buried in the test plot. Equipment operators must successfully locate the required number of targets prior to commencing field data collection.

3. TEST OPERATIONS AND REPORTING

Prior to collection of field data, each equipment operator will be certified in the established test plot. To achieve certification, each operator must demonstrate the ability to locate 85% of target items. The UXO Technician Analog Locator Qualification Form will be used to record the results of the test and will serve as a record of the individual's analog locator qualification history.

Failure to locate 85% of the items will require a root cause analysis. After corrective action, operators may be reprocessed through the test plot to demonstrate their ability to reach the required levels of detection.

Upon successful completion of the test, certification of the operators/equipment will be recorded by the UXOQCS on the Analog Locator Qualification Form and documented in the daily quality control (QC) report on the day that certification occurs.

Review/Revision Date:	L. Temple - 01/22/08
Original Prepared By/Date:	S. Young – 01/14/2008
Revision #1 –	

Attachment A

ANALOG LOCATOR QUALIFICATION FORM

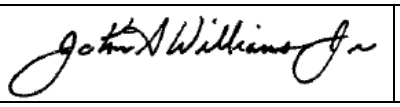
Name:	Member ID:	Team #	Date:
Analog Locator Unit Serial Numbers: 1. 2.			

Item No.	Target Located?		Location of Target		Radial Error of Target Location (in)	Comments
	Yes	No	Northing (ft)	Easting (ft)		

UXOQCS Name:	Signature:	Date:

APPENDIX G

Quality Control Procedures and Geophysical Data Processing

WSI *POLICY AND PROCEDURE MANUAL*		
SUBJECT: Quality Control Procedures and Geophysical Data Processing		**Op:** 001.QC dat
EFFECTIVE DATE: March 13, 2008		**SUPERSEDES:**
SECTION: Geophysics Group		**DEPARTMENT**: OU 1494
NAME/TITLE: J. Williams/Sr. Technical Manager		
SIGNATURE:		**DATE APPROVED:** March 13, 2008

1. PURPOSE

This procedure outlines the technical requirements and procedures for geophysical data processing and basic QC metrics established for geophysical projects.

2. APPLICABILITY AND SCOPE

The requirements of this procedure are applicable to all project activities which include the use of the EM61-MK2 and G-858 magnetometer either single sensor or array configuration. The data processing steps and QC metrics outlined in this SOP require intermediate knowledge of Geosoft Oasis Montaj (main geophysical processing software used by Weston Solutions, Inc.)

3. REFERENCES

3.1. Oasis Montaj Manual version 6.4, 2008.

4. DEFINITIONS

4.1. Geosoft Oasis Montaj - WESTON's main processing software for all electromagnetic data and magnetometry data collected during field survey.

5. QUALITY CONTROL

This section outlines the basic concepts and techniques used to measure and process QC data. Table 5-1 illustrates the basic list of QC tests that are run at every project and the frequency in which they are to be performed. The tests will now be explained below.

5.1. Equipment Warm-up – All geophysical equipment must be warmed up for at least 5 minutes dependent on ambient temperature. This allows the sensors to regulate themselves.

5.1.1. For the Mag G-858 execute the SELF TEST “Magnetometer Test” to confirm that values for the Battery, Lithium, RF, Bright, Cold, and Signal are appropriate with normal warm up values documented in the Magmapper Ops Manual.

5.2. Record Sensor Positions – All sensor positions and navigation system offsets will be recorded daily on the field notes. This will allow the processing geophysicist to accurately locate all sensors in space.

Table 5-1 - QC Tests for Geophysical Surveys

Test Description	Acceptance Criteria	Power On	Beginning of Day	End of Day	1 Line per Day
Equipment Warm-Up	Equipment Specific (5-15 minutes)	**X**			
Record Sensor Positions	±1 inch (2.54 cm)		**X**		
Personnel Test	EM-61 2mVp-p, Mag 3nT p-p		**X**		
Vibration Test	Data profile does not exhibit spikes		**X**	**X**	
Static Background	Background: EM61-MK2 +/- 2.5 mV,		**X**	**X**	
Static Spike	20% of standard item response		**X**	**X**	
Repeat Data	Repeatable ±20% of response amplitude, ±20 cm for positional accuracy				**X**

Note: Static and cable Vibration Tests must be performed with the sensor in a fixed "static" position. It is recommended that a non metallic jig or stand be used for this procedure. It is imperative that the operator avoid moving or influencing the sensor during these tests.

5.3. Personnel Test – Operators of the equipment should check themselves for influence on the sensor readings by approaching the sensors and noting the readings before and after (operators should remove all metal from the person before running this test). This test does not need to be recorded but should be ran everyday to ensure the operator does not have any metallic items that may interfere with the survey (i.e. metal grommets on boots are a typical factor).

5.4. Vibration Test (Cable Test) – the operator collects data and moves cables and electronics to note any possible fluctuations (may indicate a broken wire or an electronic interference from some data loggers).

5.5. Static Background – the operator collects data for a period of 3 minutes over a background area. The purpose is to identify any variations in the collected signal. The amplitude should remain constant within +/- 2.5 mV for EM and 3 nT/m for MAG.

5.6. Static Spike - the operator collects data for a period of 3 minutes over a spike object (usually a 2 in. pipe or 2 in. trailer ball). The purpose is to identify any variations in the collected signal. The amplitude should remain constant within +/- 2.5 mV for EM and 3 nT/m for MAG.

5.7. Repeat Data – the operator collects data over a predetermined survey line (original line) and then collects a separate line over the same position (repeat line). The data is then compared and the repeat line must have an amplitude within 20% of the original line and navigational accuracy within +/- 20 cm. Note a QC repeat survey is different from a repeat line. Quality Control repeat surveys are a repeat of a predetermined portion of a survey area where the data is collected again and selected targets and processed results are compared. Quality Control repeat surveys are project specific requirements and not required for all surveys.

5.8. Height Optimization Test – this test is performed at the beginning of the project to determine the optimal operating height of the data collection instrument. The test is performed by measuring the response of a calibration object (usually the smallest item of interest at your site) and varying the depths of this object to determine the height that yields the highest signal to noise quality.

5.9. Instrument Specific Tests – there are several instrument specific tests associated with magnetometry that also need to be performed at the beginning of the project.

5.9.1. Azimuth Test – the test is performed if using the line and fiducial method and is performed by placing the sensor over a background area and rotating around this point in the cardinal directions and recording the results. The results are entered into a heading table and used to correct heading errors associated with affects from direction of survey.

5.9.2. Octant Test – the test is performed when the instrument is interfaced with a navigational system. A background spot is marked on the ground and the operator traverses in all cardinal directions (at least 10 feet on either side of the spot). The database is then analyzed and a heading correction table is automatically generated from the data.

6. DATA METRICS

6.1. Sample Rate – the sampling rate will be conducive to the target size expected. For example on MEC projects with small MEC a sampling rate of 10 Hz (hertz – samples/second).

6.2. Sample Separation – the sample separation will not exceed 0.5 feet along line. Sample separation is calculated through Oasis Montaj's Sample Separation Calculation tool. This tool creates a map and lets the processing geophysicist examine if sample separation metrics are exceeded.

6.3. Velocity – velocity less than 3.0 mph will be maintained at all times. Optimal velocity has been noted around 2.0-2.5 mph. Velocity is calculated through Oasis Montaj's Velocity Calculation tool. This tool creates a channel in the survey database and lets the processing geophysicist examine if velocity metrics are exceeded. Logging velocity can also be monitored during data collection when using MagLogNT and NavTrack61MK2.

6.4. Line Spacing – also know as across line spacing is the distance of one survey line to the previous survey line measured perpendicular (normal) to each other. The maximum line spacing allowed is 2 feet.

6.5. Navigation Accuracy – navigation accuracy will be checked and documented daily by using a known point. This accuracy check is performed during the latency test as the latency test already makes use of known items and the location. The location accuracy of the peak response after latency correction will be with 1 foot of the actual location.

6.6. Diurnal Correction – this correct applies specifically to magnetometry data. Diurnal data will be monitored separately using a BaseStation (G-856) to monitor the daily natural magnetic background fluctuations. The data are used to apply a correction to the collected total field data with the G-858 sensors. The correction removes the daily diurnal effects from the data and is applied during the export process of the magnetometry data.

6.7. Drift Correction – drift correction is applied to remove the fluctuation ("drift") in the instrument thought the survey. Instruments (especially the EM61-MK2) are noted to drift thought the day due to mainly temperature related issues in the day, which causes the electronics box to warm or cool affecting the response of the instrument. Drift is determined by using the no response signals (background – non amplitude signals) and applying a non-linear filter to the collected data, this filter can be changed to a zero-order trend, first order trend, second order trend removal, median or a combination of all the above. There are several ways to determine the drift of your survey. A statistical breakdown of your survey can be run illustrating the breakdown of your survey and will more adequately allow the processing

geophysicist to determine drift parameters to apply. Collecting a "tie-line" in the field at the end of the survey. A tie-line is a separate line collected from the end of the survey (most recently collected data) perpendicular across the survey to the first survey line. This will allow the processing geophysicist to create a tie-line channel and use this data to run the drift correction.

6.8. Processing DQO statement - All drift correction and/or filtering routines that are applied to datasets will be evaluated, on a dataset by dataset basis, to confirm that those routines do not alter the nature of the original measured response. All data processing steps will be recorded in the database audit log or a separate data processing form.

6.9. EM61-MK2 Sum Channel – Weston utilizes a Sum Channel (sum of the individual drift corrected channel data 1-4) to grid datasets and select targets. Weston has noticed that by using the Sum helps to eliminate smaller noise induced targets.

6.10. Magnetic Analytic Signal – the analytical signal is a result of taking the X, Y, and Z derivative and using those grids to calculate the Analytic Signal grid. The Analytic Signal grid can be thought of the measured rate of change over an anomaly. It collapses dipole signatures to a single point (usually located at the inflection point) and is used to select targets.

7. TARGET SELECTION

Targets will be selecting using the 4 channel sum for Electromagnetic data and the analytic signal channel for magnetometry data.

7.1. Initial Target Selection Threshold – the initial target selection threshold will be determined using the GPO/Test Plot data and determining what threshold is needed to select the smallest MEC item at the detection depth for the instrument. After the initial target selection threshold is determined, that threshold must be used throughout the project. The threshold can be changed after digging has commenced and the threshold is deemed to low, a project meeting must take place with all decision makers present and supporting evidence presented to raise the threshold. The threshold cannot be changed unless all stakeholders in the project are in agreement.

7.2. Target Selection - the Project Geophysicist will perform an automatic anomaly selection based on the Stack or Analytic Signal channel using UX-Detect Blakely algorithm within Oasis Montaj and the agreed upon selection threshold. A review of decay profiles (for the appropriate channels in EM data) at all suspect and/or low-amplitude anomalies will be performed to remove anomalies from the list not exhibiting response characteristics typical of buried metallic objects. A manual review of the remaining anomalies will be conducted to center the anomaly response as needed. All corrected geophysical data and anomaly locations will be exported to a database according to DID guidelines.

8. TYPICAL DATA PROCESSING SCENERIO

8.1. Initial Field Processing - Initial field processing will include data file QC review and correction of the following:

8.1.1. File/Grid or mile mark identification and location

8.1.2. Precision of the navigational data – An initial QC check will be performed on data collected using a 2-Point Function Test, which will be conducted on the established QC site near the GPO grid at the beginning and end of each work day. This data will be reviewed on a daily basis for precision of the navigational field data relative to known, geo-referenced items.

8.1.3. Checking navigational data for comprehensive coverage – The data will be reviewed to locate gaps in survey coverage in the data set that may require additional fill-in.

8.1.4. Reviewing data sets and QC tests with respect to signal to noise levels and acceptance criteria.

8.1.5. Removal of data dropouts and spikes associated with interference sources.

8.1.6. Begin initial data processing after all QC tests have been deemed valid.

8.2. Data Processing

8.2.1. Gridded plots for sum of the EM time gates/channels (Stack channel) will be prepared and transposed on electronic site base maps. The plots will be used to mark the horizontal dimensions of subsurface anomalies using Oasis Montaj™ (UX-detect) geophysical software. The crew will perform a comprehensive data analysis as described above to produce digital target tables, target maps, and identify and evaluate all geophysical anomalies detected by the geophysical instrument. Initially, the project geophysicist will process and interpret the four channels conducting a collective review of the respective decay characteristics. A summation of appropriate channels will be performed and the Stacked or Analytic Signal data will be processed. The final output will include processed data for the Stack or Analytic Signal (based on signal-to-noise ration [SNR] statistics for the site) and will include an automatic/manual anomaly selection. The Oasis software database audit log will also be reviewed as part of the QC process.

8.3. Quality Control of Target Selection

8.3.1. A quality control of selected targets is performed by measuring selected targets over known QC points (usually grid corner spikes or implanted QC seeds within the grid)

9. ANOMALY SELECTION

Targets will be selecting using the Stack channel for Electromagnetic data and the analytic signal channel for magnetometry data.

9.1. Gridded plots for sum of the EM time gates/channels (Stack channel) will be prepared and transposed on electronic site base maps. For the Magnetometer data, grid plots of the vertical gradient, analytic signal or total field (as defined in the Work Plan) will be prepared and transposed on electronic site base map. The plots will be used to mark the horizontal dimensions of subsurface anomalies using Oasis Montaj™ (UX-detect) geophysical software. The crew will perform a comprehensive data analysis as described above to produce digital target tables, target maps, and identify and evaluate all geophysical anomalies detected by the geophysical instrument. Initially, the project geophysicist will process and interpret the four EM channels conducting a collective review of the respective decay characteristics. A summation of appropriate channels will be performed and the Stacked (EM) or Analytic (MAG) Signal data will be processed. The final output will include processed data for the Stack or Analytic Signal (based on signal-to-noise ration [SNR] statistics for the site) and will include an automatic/manual anomaly selection. The Oasis software database audit log will also be reviewed as part of the QC process.

9.2. Initial Target Selection Threshold – the initial target selection threshold will be determined using the GPO data and determining what threshold is needed to select the smallest MEC item at the detection depth for the instrument. After the initial target selection threshold is determined, that threshold must be used throughout the project. The threshold can be changed after digging has commenced and the threshold is deemed to low, a project meeting must take place with all decision makers present and supporting evidence presented to raise the threshold. The threshold cannot be changed unless all stakeholders in the project are in agreement.

9.3. Target Selection - the Project Geophysicist will perform an automatic anomaly selection based on the Stack or Analytic Signal channel using UX-Detect Blakely algorithm within Oasis Montaj and the agreed upon selection threshold. A review of decay profiles (for the appropriate channels in EM data) at all suspect and/or low-amplitude anomalies will be performed to remove anomalies from the list not exhibiting response characteristics typical of buried metallic objects. A manual review of the remaining anomalies will be conducted to center the anomaly response as needed. All corrected geophysical data and anomaly locations will be exported to a database according to Appendix C of the USACE DID guidelines.

9.4. Quality Control of Target Selection

9.4.1. A quality control of selected targets is performed by measuring selected targets over known QC points (usually grid corner spikes or implanted QC seeds within the grid).

10. PREPARATION OF TARGET DATA BASE AND DIG INFORMATION

10.1. Exporting Target Information – all targets that have passed geophysical manual review and are to be selected for reacquisition and digging must be exported with the necessary reporting information as mandated by the DID.

10.1.1. Reacquisition Sheets – reacquisition sheets are supplied to the reacquire team so targets can be tracked as they are reacquired in the field using the same navigational method used to collect the data.

10.1.2. Navigation Target Location File – a comma delimited file containing target ID, Northing, and Easting (in that order with no header info) to be uploaded into the navigation data collector for reacquisition.

10.1.3. UXOFast Upload File – a predefined formatted excel file that is used to upload targets to UXOFast.

10.1.4. Target Dig Map – map of the grid area (if the scale is applicable) showing target locations and name for aid in reacquisition and digging.

Applicable References:

USAESCH (U.S. Army Engineering Support Center, Huntsville). 2003. Munitions Response Data Item Descriptions (DIDs). Revised 1 December 2003.

Project Specific Work Plan - Data Quality Objectives (DQO) with established metrics

Table 1 Typical DQO for DGM (Subject to Revision per Site Specific Work Plan)				
Typical DQO Parameters		**Typical Metric**	**How QC metrics are measured**	**Rationale**
1	Standard deviation of background noise	EM - (summed channel) = i.e. <2 mV. Mag Analytic Signal	Run statistics on all data below a reasonable level (i.e. between 7 and 9 mV)	Decreased Noise=lower False Positives
2	Mean acquisition speed	= i.e. <2.5mph	Run statistics on velocity between points in each file (created a "velocity" channel)	To provide appropriate data density to resolve smaller items.
3	Along track measurements [Note : 1]	= i.e. <0.5ft, across track = i.e. <3 ft	Metric based on mean speed during GPO.	Lower speed = less "vibration" and system noise
4	Sum of positioning errors	= i.e. < 1 foot	Developed navigation test appropriate to sensors Control points AM track plots PM track plots	
5	Instrument Latency	No chevron patterns in interpretation maps	Evaluation (visual review) of gridded data.	To reduce duplication of and introduction of false positive anomaly selections
6	Consistency of processing parameters within a dataset	Identical for each channel within a dataset	Analyst applies common set of parameters (leveling and drift routine filters), for processing all channels within dataset.	All signals to undergo standardization to support anomaly prioritizations. [Note : 2]
7	Signal to noise variance	= i.e. < lesser of 5% or 5mV	Random review of 3 small (less than 100mV) and 3 large (greater than 100mV) anomalies per dataset	To compare preprocessed and final processed peak responses.
8	Automated anomaly selections based on sum of channels or AS.	Verify we maintained peak response characteristics in the event anomaly is ambiguous	All automated anomaly selections will be based on sum of all channels and reviewed by a geophysicist	1-To confirm low amplitude anomalies are not "processed-out" 2- To facilitate anomaly prioritization if needed.

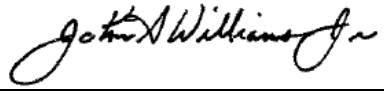
	Typical DQO Parameters	Typical Metric	How QC metrics are measured	Rationale
9	Random anomaly review	Reacquisition = i.e. < 2 feet	A random sample of anomalies (i.e. 2 per acre) to be reacquired and confirmed.	To demonstrate anomaly reproducibility (random reacquisition) and anomaly detections (blind QA items), both to within 2 feet, the data would be defensible in supporting project objectives.
10	Placement of Blind seed item within the Grid.	Tests Detection and Selection of anomaly (i.e. within 2 feet of known location)	The QA geophysicist places blind seeds throughout the survey area at a rate of 1 per 2 acres.	To confirm quality of detection and accuracy/precision of navigation.

Note:
1- Some (team decision) flexibility is required, to allow gaps (over entire survey area) up to an acceptable limit relative to design metrics and stated objectives.
2- Some exceptions with complex data or parsed sections affected by cultural interference

Review/Revision Dates:	J. Williams - 02/04/08
Original Preparer/Date:	M. Saunders – 01/17/08
Revision #1 –	

APPENDIX H

Anomaly Reacquisition and Excavation Procedure

WSI *POLICY AND PROCEDURE MANUAL*	
SUBJECT: Anomaly Reacquisition and Excavation Procedure	**No**. Op.001.reacrev3
EFFECTIVE DATE: May 21, 2008	**SUPERSEDES:** Op.001.reacrev2
SECTION: Geophysics Group	**DEPARTMENT**: OU 1494
NAME/TITLE: J. Williams/Sr. Technical Manager	
SIGNATURE: 	**DATE APPROVED:** May 21, 2008

1. PURPOSE

This procedure outlines the technical requirements and procedures for performing anomaly reacquisition and excavation of selected geophysical targets.

2. APPLICABILITY AND SCOPE

The requirements of this procedure are applicable to all project activities which include the excavation and investigation of selected geophysical targets.

3. REFERENCES

3.1. None

4. PROCEDURES

4.1. Target Anomaly Flagging

4.1.1. Upload of selected targets into navigational data logger as provided by the Geophysicist.

4.1.2. Set up the Real Time Kinematic (RTK) - Global Positioning System (GPS) in accordance with Weston Op.001.nav.rtk rev 1.

4.1.3. Perform instrument checkout in accordance with Weston Op.001.Analog Operator Checkout.su

4.1.4. Proceed to Control Point (i.e., Fort Ord 36) and verify the accuracy (offset less than 0.1 ft).

4.1.5. Using the dig sheet information proceed to reacquire the anomaly targets identified marking each location with a non-metallic flag bearing the unique target ID. (ie. SCA W130 - 12). Place the flag within 0.1 feet of the target coordinates as determined on the RTK..

4.1.6. The Unexploded Ordnance (UXO) Dig Team will use the appropriate hand held instrument, depending on the type of instrument used for the digital geophysical mapping survey (EM61-MK2 data – All Metals, G-858 data – Schonstedt to investigate an area 3 feet around each flag to confirm the anomaly response. The UXO Team will note any offset from the flag to the excavated anomaly or anomalies and log accordingly.

4.2. Excavation of Target Anomalies

4.2.1. Once the target anomalies are flagged as described in Section 4.1, the Dig Team will begin anomaly excavation activities.

4.2.2. The Dig Team will upload the selected target anomalies onto the Personal Digital Assistant (PDA) (UXOFast program).

4.2.3. The Dig Team will proceed to each flagged anomaly. One of the team members will bring up the Target ID on the UXOFast program to begin data collection.

4.2.4. The Dig team will excavate each anomaly location flag or the spray painted location.

4.2.5. Hand held instruments such as a Schonstedt or White will be used to assist the excavation work. The handheld instruments will be tested in the Geophysical Test Plot.

4.2.6. The excavation team will investigate all anomalies within 3 feet of the flag or spray painted location. Do not move the flag location in the event that multiple items are recovered from this area. Off-sets shall be measured from the original flagged location.

4.2.7. All anomalies will be identified and logged into the PDA running the UXOFast software.

4.2.7.1. Target characteristics logged include but are not limited to; Item type (Munitions and Explosives of Concern (MEC), Munitions Debris (MD), cultural debris, QC item), item description (concrete, practice grenade), offset from flagged location, weight of item, depth, hole cleared, comments, etc. Once the data is entered, SAVE the entry.

4.2.7.2. If the target anomaly is a MEC item, the Dig Team will notify the Senior UXO Supervisor who will then determine the course of action.

4.2.8. After logging an excavated item, the UXO techs will continue to sweep the anomaly location for additional items and arrive at two possible situations:

4.2.8.1. If no further items are found within the radius of the flagged location, the hole is considered completed (cleared).

4.2.8.2. If different, additional items are found they are logged under the same target but given a different suffix (-1, -2, -3, etc) and logged as described above.

4.2.8.2.1. The Dig Team will proceed with excavation and removal of buried debris to the depth required in order to clear the hole.

4.2.8.2.2. The Dig Team will remove all items from the excavation hole. Items will not be placed back into the hole even if they are not MEC-related.

4.2.8.2.3. If the hole cannot be cleared due to extensive debris or the presence of an in-place object (e.g., a pipeline), the hole will be logged as "Not Cleared" and the Dig Team will inform the Senior UXO Supervisor of this finding. The hole may be investigated at a later time using heavy equipment (such as a backhoe or dozer).

4.2.9. The Dig Team shall handle all items recovered based on the type as specified in the work plan and explosive safety submission (ESS).

4.2.10. The Dig Team will then spread the spoils/excavated dirt into a thin lift and check the material for the presence of metal debris using a Schonstedt and/or White handheld instruments. The excavation will not be backfilled until the spoils have been checked and verified not to contain MEC or other metal debris.

4.2.11. Once the spoils have been checked, the Dig Team will backfill the hole.

4.2.12. If no anomalies are found the Dig Team the flag will be left at the original location and note the anomaly location as a "No Contact". No Contacts will be reviewed by the Geophysicist and checked as part of the QC-1 process.

4.3. Common Questions Encountered During Digging Procedures

4.3.1. What if the UXO Techs come to a flag and their instrument response is outside the sweep radius?

4.3.1.1. The UXO tech will check to see if any additional flags are near the response they are detecting. If there is, that response is due to that other flagged location. If there are no additional flags then the Dig Team will log that item under the flag location in which they started and mark the offsets accordingly. The offset failure will be identified by the QC geophysicist and an examination of the geophysical data will be performed to identify the reason for the failure. The offset failure distance is anything outside 2 feet of the original flagged location. Note the target is only considered a failure if there are no items dug within two feet of the flagged location. If additional items are found outside the two foot radius they are not failures.

4.4. Download and review of Dig Data

4.4.1. Upon returning from the field the UXO techs will turn in all PDA's and the site geophysicist (or designated person) will "*Send*" all the logged data onto the SQL UXOFast server.

4.4.2. The Site Geophysicist will review all the data for consistency and check the agreement with geophysical data (does the logged item "make sense" with the amplitude of the target).

4.4.3. The UXO QC Specialist and Senior UXO Supervisor will review any targets identified to be MEC or MD and review the entry information for consistency and accuracy.

4.4.4. Upon completing the QC procedures the targets will be made viewable to all parties via Teamlink.

4.4.5. The following morning and prior to using the PDA's, the Geophysicist (or designated person) will "*Get*" all the tables for the PDA's in order to "*Sync*" all the units with the same information.

Review/Revision Date:	J. Williams – 6/23/08
Original Prepared By/Date:	M. Saunders – 3/14/08
Revision #3	