FINAL
Geophysical Test Plot Report

Phase II Seaside Munitions Response Area Removal Action

Former Fort Ord
Monterey County, California

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WESTON SOLUTIONS

Westcliffe Engineers, Inc.

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CONTENTS

TABLES

FIGURES

APPENDICES

ACRONYMS AND ABBREVIATIONS

µsec	microsecond
cm	centimeter
DGM	digital geophysical mapping
DQO	Data Quality Objective
EM	electromagnetic
ESCA RP	Environmental Services Cooperative Agreement Remediation Program
FAR	False Alarm Rate
FORA	Fort Ord Reuse Authority
GPS	Global Positioning System
Hz	hertz (readings/second)
IR	Installation Restoration
Mag	magnetic
MEC	munitions and explosives of concern
mph	miles per hour
mm	millimeter
MRA	Munitions Response Area
MRS	Munitions Response Site
mV	millivolts
nT	nanoTesla
nT/ft	nanoTeslas per foot
ODDS	Ordnance Detection and Discrimination Study
Pd	probability of detection
PVC	polyvinyl chloride
QC	quality control
RF	Radio Frequency
RTK	Real-Time Kinematic
UXO	unexploded ordnance
WESTON	Weston Solutions, Inc.

1.0 INTRODUCTION

In accordance with the "Final Addendum to Final OE-15SEA.1-4 Site-Specific Work Plan, Phase II Seaside Munitions Response Area (MRA) Removal Action", dated January 24, 2008 (ESCA RP Team 2008a) and the "Final Geophysical Test Plot Plan, Seaside Munitions Response Area (MRA)," dated March 7, 2008 ("the Final GTP Plan"; ESCA RP Team 2008b), two geophysical test plot grids were established and geophysically mapped at the Seaside Munitions Response Area (MRA). The primary objectives of the test plot surveys were to 1) provide information that will be used to validate proposed geophysical sensor and navigation instrumentation and personnel protocols, and 2) confirm that the project scope (requiring 85% probability of detection [Pd] at 90% confidence level) and other proposed metrics for Data Quality Objectives (DQOs) are attainable and sufficient to meet the intended project goals. The intended project goals are to successfully map and locate munitions and explosives of concern (MEC) within the Seaside MRA. The survey areas within the Seaside MRA are similar in terms of geology and topography; however, an active power line crosses part of the survey area. To evaluate potential effects from the power lines two test plots were required (one in an open area and the other under the power line). Both electromagnetic (EM) and magnetic (Mag) methods were employed to characterize the local background environment and subsequently map items seeded in the test plot grids. This report documents the test plot results for the Seaside MRA.

2.0 TEST PLOT DESIGN

2.1 Test Plot Construction

The Seaside MRA is comprised of four smaller areas identified as Seaside 1 through Seaside 4, which generally correspond to Munitions Response Sites (MRSs) MRS-15SEA.1 through MRS-15SEA.4, respectively. Test Plot 1 was established in the northern portion of Seaside 2, adjacent to the geophysical quality control (QC) area, and Test Plot 2 was located in the central portion of Seaside 1, near the western boundary. Figure 1 shows an overall location map for the two test plots.

The two geophysical test plots were established in specific areas representative of field conditions expected to be encountered during the full-scale digital geophysical mapping (DGM) in the Seaside MRA. In addition, Test Plot 2 was chosen to include an area located beneath the overhead power line to evaluate the effects of the power line on target detection, location, and possible target discrimination. The shallow soils within each area were previously scraped to remove small metallic debris (clutter) that could potentially influence the geophysical sensors. Test plot grid corners were established by a licensed professional land surveyor. Grid corners for the two test plots were surveyed to +/- 0.20 of a foot with 95% confidence level and staked with 60 penny, 8-inch spikes.

Test Plot 1 was established within a designated 50-foot by 25-foot grid in an open, flat area oriented with the long axis trending east to west. As shown on Figure 2, 21 seed items (18 inert MEC items, which included nine pipe surrogates and three pieces of steel scrap) of variable size and shape were buried within the test plot grid area to represent MEC previously identified at the Seaside MRA. Table 1 contains the list of seed items used for Test Plot 1. Representative photographs of the 21 seed items are provided in Appendix A.

Test Plot 2 was established within a designated 50-foot by 25-foot grid in an open, flat area oriented with the long axis trending northwest to southeast. The test plot was constructed underneath an overhead power line to test its affects on EM response of the instruments and on target picking and navigation. As shown on Figure 3, 21 seed items (18 inert MEC seed items, which included nine pipe surrogates and three pieces of steel scrap) of variable size and shape were buried within the test plot grid area to represent MEC previously identified at the Seaside MRA. Table 2 contains the list of seed items used for Test Plot 2. Representative photographs of the 21 seed items are provided in Appendix A.

The minimum size target for the test plots was equivalent to a 37 millimeter (mm) projectile. Three grenade fuze assemblies were included in each test plot even though their mass and size were below the minimum size DQO. The grenade fuzes were added because they have been found at the Seaside MRA and it is important to understand the detection limits of the equipment on this type of object.

3.0 DIGITAL GEOPHYSICAL MAPPING

As part of the test plot process, Weston Solutions, Inc. (WESTON) demonstrated the use of EM and Mag surveying methods for the selection of buried ordnance. The following sections describe the instrumentation, data collection, and data processing techniques for the EM and Mag data collected at both test plots.

3.1 Instrumentation

3.1.1 Electromagnetics (EM61-MK2 Single Unit and Towed Array)

The EM61-MK2 surveys were conducted using a Geonics, Ltd., EM61-MK2™ high sensitivity ferrous and nonferrous metal detector. Independent surveys were performed using the single man-towed cart and towed multiple-array units. The EM61-MK2 is battery-powered and operates at a maximum output of 10,000 millivolts (mV). This system consists of two 1 x 0.5 meter air-cored coils with the top coil 28 centimeters (cm) above the bottom coil. The transmitter generates a pulsed magnetic field that induces eddy currents in conductive objects within the subsurface. These currents are proportional to the conductive nature of the material below the instrument. When conductive objects are present below the instrument, the amplitude and decay time of the induced eddy currents vary in response to the size, mass, and orientation of the objects. The bottom receiver coil measures the amplitude of these eddy currents at 216-, 366-, 660-, and 1,266-microsecond (μsec) intervals (time gates) during the decay period. The top coil measures the response at the same 660-μsec time gate as the bottom coil. WESTON collected data from the bottom coil in the standard four-time-gate mode. The four time gates were sampled to obtain the full decay period. The top coil was not used as the differential measurement was not desired and cannot be simultaneously recorded while the four time gates are being measured. The operating height of the standard single unit EM61-MK2 was 16 inches above ground surface and the towed array was 10 inches above the ground surface. The effective detection depth for the EM61-MK2 is a function of target characteristic (i.e., composition, mass, and orientation) and geological noise.

QC function checks were performed following the instrument-operating manual and standard industry practices (discussed below). In addition, prior to the start of the single-unit survey, instrument readings were adjusted (nulled) to a common zero background at a low background area to level data sets according to site-specific conditions. The instrument was set to digitally record and store data at 10 readings per second (10 Hz) in an Allegro data logger. The towed array instruments were set to record and store data at 10 readings per second (10 Hz) in a field laptop. Since this system is not nulled in the field, data corrections are made during the post-processing stage.

3.1.2 Magnetometry (G-858)

Magnetometer surveys were performed using a Geometrics Model G-858 Cesium Vapor Magnetometer. Measurements of the magnetic field were collected using two sensors in gradiometer configuration. A Geometrics G-856 base station magnetometer was used to monitor diurnal variation in the ambient local magnetic field (daily fluctuations of 20 to 60 nanoTeslas [nT]) that occurred during the course of the survey. Prior to surveying, both instruments were time-synchronized and programmed following the manufacturer's instruction manual. The G-858 consoles were programmed to acquire data at a rapid 0.1 second cycle time (10 readings per second). The G-856 base station was set at a fixed location to collect total field readings at 20-second intervals. Navigation with the G-858 was conducted using line and fiducials. The standard height of the magnetometer surveys was 12 inches above ground surface as confirmed in the Height Optimization Test, with a sensor separation of 2 feet (0.6 meter). The vertical gradient survey (sensors separated vertically) was performed. In this application, the vertical gradient is more appropriate. In contrast to the total field, the vertical gradient automatically removes time variations (diurnal effects) and regional magnetic fields, and also enhances the resolutions of complex anomalies into their individual response signatures.

3.1.3 Navigation Interface

A Real-Time Kinematic (RTK) Global Positioning System (GPS) was utilized to position data collected during the EM61-MK2 single and towed array surveys to cm accuracy. The GPS antenna was mounted over the center of the top EM61-MK2 coil and connected to the logging device. This receiver captures real-time differential corrections from a fixed local base station and outputs a National Marine Electronics Association (NMEA) GPS Fixed Data (GGA) message directly into the data logger at 1-second intervals. Direct interfacing between the GPS and instruments utilizes a single clock and streams position information directly into the raw data files. A new GPS antennae mount was being developed and noise tested prior to collecting data using the G-858, therefore, the G-858 data was collected in line and fiducial mode on a Cartesian grid. The relative coordinates were later warped (warped is a term in the Geosoft software platform meaning re-projecting into a new coordinate system) to the appropriate projected coordinates. The geophysical team will validate the performance of the G-858 and RTK at both test plots upon completion of the mounting bracket.

3.2 Data Quality Objectives

This section summarizes the DQOs established for the geophysical test plots. DQOs are an integral part of quality assurance/quality control (QA/QC) and are used to specify the acceptable limits for decisions that establish the quality and quantity of data needed to support production surveys.

3.2.1 Mean Speed

The metric for mean speed is less than 3 miles per hour (mph).

3.2.2 Along-Track Spacing

The metric for along-track spacing is less than 0.5 foot.

3.2.3 Cross-Track Spacing

The metric for cross-track spacing is 2.5 feet, excluding gaps due to obstructions.

3.2.4 Minimum Size MEC

The metric for MEC is a 37 mm buried 16 inches below ground surface.

3.3 Quality Control

3.3.1 Instrument Function Testing

Static background, static spike, and vibration/cable tests were performed daily before and after surveying and during power-on and power-off cycles to confirm the equipment was functioning properly throughout the survey period. The EM61-MK2 and G-858 were tested at a designated QC area during the pre- and post-survey instrument function tests.

3.3.1.1 Static Background

The static background test consisted of collecting data (EM and Mag) at the QC area established for the project for a period of three minutes. The static test enabled the operator(s) to monitor real-time fluctuations in the ambient field that could potentially influence data collection. Normal operating range is +/- 2.5 mV of the mean value.

3.3.1.2 Static Spike

Static spike tests were run in the same position as the static background for a period of three minutes. The only difference is that a metallic object (3-inch bolt – spike object) was placed under the sensor. In the case of the towed array, three bolts were placed at the precise offsets of the EM61-MK2 sensors and inserted into the ground (inside a polyvinyl chloride [PVC] case) to ensure consistency. It is important to note that with Mag readings over a metal object (i.e., 3-inch bolt – spike object), it is impractical to replicate responses between the pre- and post-QC tests due to the high sensitivity of the G-858 sensors, magnetic properties of the spikes, and temporal ambient variations throughout the survey period. The operator monitored the data flow in response to the spike object and for fluctuations greater than 20% from a base value, and checked for consistency.

3.3.1.3 Vibration/Cable Test

The vibration/cable test was performed to measure any potential effect of moving the cables or loose connections during data collection. The vibration/cable test was collected for a period of 1 minute, and is a tool for the operators to evaluate if the connections are in good condition and operating as designed.

3.3.1.4 Standardization Test

The standardization test was performed whenever the instrument was moved to a separate location and powered on. A 1-minute static test and 1-minute static spike test were performed outside the immediate survey area and repeated before powering down the equipment at the same location. These tests were performed to ensure equipment was operating within standard operating ranges during movement of the equipment from site to site.

Statistical outputs of the static background, static spike, and cable connection tests display acceptable noise levels as indicated by the standard deviation for each test (+/- 2.5 instrument units). Good repeatability between tests both pre- and post-survey and among consecutive days was observed. The results for these tests can be located in Appendix B.

3.3.1.5 Repeatability Lines

Repeat lines were performed for each survey (both EM and Mag) to verify the repeatability of results. The repeat lines are displayed as graphical outputs of the sensor amplitude and navigational tracks. When there is a discrepancy the location is flagged. The repeatability for the test plots met acceptable limits. The results for these tests are presented in Appendix B.

3.3.2 Instrument Latency

To determine temporal lags (or latency effects) inherent to these specific instruments, single- and multi-point bidirectional navigation tests were performed. A single-point navigation loop test was used to determine latency within the EM61-MK2 single unit. The test consisted of traversing one steel spike in one bi-directional loop (cloverleaf). Similarly, the EM61-MK2 towed array utilized three steel bolts (one for each sensor) in two surveyed lines up and back over the bolts. These tests allowed the processing geophysicist to determine the appropriate time lags and corrections needed to accurately position the collected data. In addition to identifying instrument latency affects, the single-point test quantified navigational accuracy of the GPS. Latency results can be found on the processing notes, which are located in Appendix B.

3.3.3 Navigational Accuracy

A new survey-grade monument was established by a licensed California surveyor prior to test plot geophysical activities to geo-reference the geophysical data to North American Datum 83 California Zone IV US survey feet units. The RTK GPS base station was set up over one of the existing survey monuments with the supplied northing and easting coordinates. The base station then provided differentially corrected data to the rover unit mounted above the EM61-MK2 within cm accuracy. As an additional check, geophysical data were collected over known locations (surveyor nail/monument) in the test plots during the survey to validate navigational precision.

3.3.4 Magnetometer Tests

Magnetometer sensor tests for azimuth and height optimization were performed to evaluate dropouts and magnetic heading error and to optimize sensor height above ground surface, respectively. The azimuth test revealed that the sensor orientation and line collection direction did not induce “dead zones” or dropouts in the data. An azimuth test is performed with the operator spinning around a central location recording readings. An octant test was not conducted due to field procedure limitations. The results for these tests can be located in Appendix C.

3.3.5 Six-Line Tests

To determine background response and temporal time lags inherent to these specific geophysical instruments at different data collection speeds, six-line tests were conducted for each instrument. The results of the six-line tests are provided in Appendix C.

3.4 Survey Design

Prior to seeding the test plots, background surveys were performed over both test plot locations with the EM61-MK2 and G-858. The objectives were to evaluate the initial disposition of the selected areas and to identify preexisting anomalies (for avoidance and later target selection).

Subsequent to background survey analysis, inert ordnance or seed items were buried by the QC Geophysicist within the test plot grids under the supervision of qualified unexploded ordnance (UXO) technicians. The grid was then resurveyed using the EM61-MK2 single unit and towed array and the G-858. Both background and seeded test plot surveys followed data acquisition metrics established in the Final GTP Plan.

3.5 Data Acquisition

Surveying was performed in accordance with the Final GTP Plan. These metrics are consistent with industry standards and were established to ensure high-quality data are collected daily. The following metrics were applied to the data acquisition at the test plots:

- Across Track Separation: <2.5 feet
- Sample Separation: <0.5 foot
- Velocity: <2.5 mph

At the completion of the EM61-MK2 and G-858 surveys, data stored in the data loggers were downloaded to a field computer for review by the WESTON geophysicist. The data were reviewed for completeness and accuracy. After QC function tests and data metrics were checked to be within the DQOs, the processing geophysicist began to process the survey data.

3.6 Data Processing

3.6.1 Preprocessing of Raw Data

The raw EM61-MK2 single unit and G-858 field data were processed using DAT61 MK2 and MagMap 2000 software, respectively. The base station (G-856) data were reviewed and diurnal corrections were applied to the mobile G-858 data. Prior to the vertical gradient calculation, data dropouts were linearly interpolated and the total field data were corrected for diurnal drift on each sensor. The G-858 data were collected in line and fiducial mode and the line offsets were entered into MagMap 2000 before exporting. The EM61-MK2 towed array data were collected using MagLog software and preprocessed using MagMap 2000 software. Data were then exported in Geosoft XYZ file format for post-processing.

3.6.2 Geophysical Processing

3.6.2.1 EM61-MK2 Data Processing

Raw XYZ files were imported into Geosoft Oasis Montaj processing software. Data were checked for navigational accuracy, line distribution, and coverage. Latency values obtained from the pre- and post-survey QC tests were applied to the data, correcting for any temporal lags seen in the data. A Geosoft script was run to automatically progress through the processing steps. The script was used to drift-correct the data using a median statistical technique. The statistical approach calculates the median for each time gate in a 100 fiducial window, and then subtracts that value from each data point. The four time-gate channels were then summed into a new single channel designated as the “Stack” data channel. Velocity and sample separation were calculated for each data set and were recorded in the processing notes provided in Appendix B.

The Stack data channel was then gridded using a grid cell size of 0.25 foot with a search radius of two feet and blanking distance of 2.25 feet. Subsequent to gridding, the targets were selected for the data, by running the Blakely Peak algorithm in Geosoft. A grid cutoff value of three times the standard deviation of the background was used on each data set to select targets. Background was calculated by windowing a polygon of data typical of a quiet area. Target review consisted of manually reviewing all selected targets and removing multiple targets associated with large anomalies. Targets were also moved (where necessary) to the location of the maximum amplitude associated with a given anomaly. A decay analysis was also run to remove targets that had an atypical decay between their four time-gate channels. An atypical decay is when an anomaly undergoes a decay that does not decrease with time, but shows an increase in any of the time-gate channels. After the review process was completed, the targets were subset into a target database for subsequent dig-sheet reporting. Navigation and target picking accuracy were checked by selecting the target over one of the four known survey control markers in the test plot grid and calculating the distance between the two; these values were recorded in the processing notes provided in Appendix B. Table 3 summarizes the details of the EM61-MK2 data processing parameters using Geosoft.

3.6.2.2 Magnetometry Data Processing

Raw XYZ files were imported into Geosoft Oasis Montaj software. Data were checked for navigational accuracy, line spacing, and coverage. Latency values obtained from the pre- and post-survey QC tests were applied to correct for any temporal lags seen in the data (note: according to the manufacturer, the G-858 does not display latency effects; however, latency QC tests were still performed as a monitoring tool). A Geosoft script was run to automatically progress through the processing steps. The script included calculating statistics (velocity and sample separation).The analytic signal grid was generated using the vertical gradient data. Vertical gradient data were used in contrast to the total field because the vertical gradient automatically removes time variations (diurnal effects) and regional magnetic fields, and also enhances the resolution of complex anomalies into their individual response signatures. No heading corrections were applied because the data did not exhibit stripping or other heading errors (a comparison test between the total field and the vertical gradient was not performed; therefore, no comparisons can be made). Subsequent to gridding, the targets were selected for the data by running the Blakely Peak algorithm on the analytic signal. A grid cutoff value of three times the standard deviation of the background was used on each data set to select targets. Background was calculated by windowing a polygon of data typical of a quiet area. A manual review of the targets was performed to eliminate multiple picks and move targets to the center of their dipole signature. (Note that not all targets were characterized as dipole anomalies in the gradient data. Some seed items [typically those that were oriented vertically or at a partial angle] appear as monopoles.)

4.0 RESULTS

4.1 Background Surveys

4.1.1 Test Plot 1

4.1.1.1 EM61-MK2

The background EM61-MK2 survey was collected on March 10, 2008 to establish a background for characterization and for anomaly avoidance prior to seeding Test Plot 1. A color plot of the stacked channel is shown on Figure 4. The figure shows seven individual point source “background” anomalies were selected at a threshold of 4.0 mV based on a background analysis. As confirmation to the navigational accuracy of the survey, the center of the anomalies associated with the four corner spikes were selected within 0.6 foot of their actual locations.

4.1.1.2 G-858

The magnetometer background survey was collected on March 10, 2008 to establish a background for characterization and for anomaly avoidance prior to seeding Test Plot 1. A color plot of the analytic signal grid is shown on Figure 5. The figure shows 14 individual point source “background” anomalies were selected at a threshold of 5.0 nanoTeslas per foot (nT/ft) based on a background analysis. As confirmation to the navigational accuracy of the survey, the center of the anomalies associated with the four corner spikes were selected within 1.5 feet of their actual locations.

4.1.2 Test Plot 2

4.1.2.1 EM61-MK2

The background EM61-MK2 survey was collected on March 11, 2008 to establish a background for characterization and for anomaly avoidance prior to seeding Test Plot 2. A color plot of the filtered stacked channel is shown on Figure 6. Because cultural noise from the overhead power line was evident in the data, a basic nonlinear filter was applied to remove some of the high-frequency, low-amplitude external noise. Additionally, a manual review of the anomalies was conducted to confirm the coherency of the response on adjacent lines. To account for these interferences in the vicinity of overhead power lines, the survey team will perform a static test for 3 to 5 minutes. The figure shows eight individual point source “background” anomalies were selected at a threshold of 9.0 mV based on a background analysis. The background of Test Plot 1 (1.31 mV) was lower than the Test Plot 2 value (5.53 mV). The difference in the two is most likely due to the external noise introduced from the overhead power line. The background on the filtered Stack data was 2.86 mV, which removed a majority of the external noise. The four corner spikes were selected within 0.9 foot of their actual locations.

4.1.2.2 G-858

The magnetometer background survey was collected on March 11, 2008 to establish background geophysical characteristics and for anomaly avoidance prior to seeding Test Plot 2. A color plot of the analytic signal grid is shown on Figure 7. The figure shows 49 individual point source “background” anomalies were selected at a threshold of 5.0 nT/ft based on a background analysis. The background of Test Plot 1 was 3.0 nT/ft and Test Plot 2 was 4.2 nT/ft. The amount of small amplitude targets is most likely due to the influence of the power line or the conservative threshold. The four corner spikes were selected within 1.1 feet of their actual locations.

4.2 Probability of Detection Analysis

This section represents an analysis of the Pd and the False Alarm Rate (FAR) for both geophysical test plots and all instruments, which was performed independently by the QC Geophysicists. The information presented in this section represents an analysis of the test plot geophysical data performed in the blind mode (the surveyed locations of seed items are not disclosed to the geophysicist processing the data) on a draft version of the processed geophysical data.

The test plots included both inert MEC and MEC-like simulants made of metallic pipe. The minimum size MEC DQO for the test plot was a 37 mm projectile. Three grenade fuze assemblies were included in each test plot even though their mass was below the equivalent of a 37 mm projectile. The grenade fuze assemblies were included in both test plots because they have been found at the Seaside MRA and they aid in understanding the detection limits of the equipment for this type of object. Therefore, the number of seeds included in the Pd analysis was 15 (Seeds 1 through 15) out of the 21 seed items. A separate analysis of grenade fuze assembly (Seeds 16 through 18) selection is included for each piece of equipment in the test plots; however, they do not count in calculating the official Pd, as they are below the mass of the 37 mm, as were the three pieces of steel scrap (Seeds 19 through 21). Targets associated with these items were therefore counted against the FAR. If a target was located within 3 feet of a seed it was reported in the delta column; however, only seeds located within 2 feet (the project DQO) are considered selected targets. Blanks in the delta column indicate a clear non-detect.

4.2.1 Test Plot 1

4.2.1.1 EM61-MK2 Towed Array

Table 4 shows that Seeds 1 through 15 were all selected (15 of 15 items) within the 2-foot investigation DQO of the seeded location for a Pd of 100%. A total of 38 targets were identified for a FAR of 60%. The average error in location (Delta) was 0.88 foot. All three grenade fuze assemblies were selected.

4.2.1.2 EM61-MK2 Single Unit

Table 5 shows the seeded items with the selection results. Seeds 1 through 15 (15 of 15 items) were selected within 2 feet of the seeded location for a Pd of 100%. A total of 23 targets were identified for a FAR of 34%. The average error in location (Delta) was 0.9 foot. One of the three grenade fuze assemblies was selected.

4.2.1.3 G-858 Magnetometer

Table 6 shows the seeded items with the selection results. Seeds 1 through 15 (15 of 15 items) were selected within 2 feet of the seeded location for a Pd of 100%. A total of 33 targets were identified for a FAR of 54%. The average error in location (Delta) was 0.62 foot. All three grenade fuze assemblies were selected.

4.2.2 Test Plot 2

4.2.2.1 EM61-MK2 Towed Array

Test Plot 2 was designed consistent with Test Plot 1 in terms of target description, depth orientation, and inclination. The only exception is that the items were placed with respect to the northeastern corner of the test plot as the local (0,0) coordinate, which was different than Test Plot 1 where the items were placed using the southwestern corner as the local (0,0) coordinate. The objective of this two plot configuration was to test the affect of the high-tension power line on detection. The results indicate a slight reduction in the Pd and an increase in the Delta due to Radio Frequency (RF) interference with the RTK GPS radio component.

Table 7 shows the seeded items with the selection results. For Seeds 1 through 15, 13 of the 15 items were selected within 2 feet of the seeded location for a Pd of 87%. A total of 26 targets were identified for a FAR of 50%. The average error in location (Delta) was 1.2 feet.

The increase in the Delta is assumed to be RF interference with the RTK receiver. This effect was documented during the Test Plot 2 operations. WESTON is currently working on a solution to minimize the RF interference on the RTK GPS operations. Note that Seed 1 had a delta of 2.1 feet and would likely fall within the DQO upon resolution, bringing the Pd to 93%.

The only seed that was clearly not selected was the vertical grenade at a depth of 24 inches (Seed 14). This seed was missed by all of the equipment in Test Plot 2. It is buried at the extreme limits of selection for grenades. Two of the three grenade fuze assemblies were selected.

4.2.2.2 EM61-MK2 Single Unit

Table 8 shows the seeded items with the selection results. For Seeds 1 through 15, 12 of the 15 items were selected within 2 feet of the seeded location for a Pd of 80%. A total of 21 targets were identified for a FAR of 42%. The average error in location (Delta) was 0.91 foot.

Note that Seeds 1 and 2 were very close to the 2-foot metric established for the offset DQO (at 2.1 and 2.2 feet, respectively), and will likely be recovered in real operations. As stated with the EM61-MK2 towed array (Section 4.2.2.1), WESTON is currently working on a solution to minimize the RF interference on the RTK GPS operations. The Pd with this error corrected would be 93%, with the only missed seed being the grenade at a depth of 24 inches. The three grenade fuze assemblies were not selected. Because of the problems meeting the positioning DQO, this grid did not meet the Pd DQO of 85%. However, the excess positioning error was 0.2 foot or less on the two missed items. Based on these results, excavation teams working near the power lines will be instructed to expand the search radius around pin flags to 3 feet.

4.2.2.3 G-858 Magnetometer

Table 9 shows the seeded items with the selection results. For Seeds 1 through 15, 14 of the 15 items were selected within 2 feet of the seeded location for a Pd of 93%. A total of 45 targets were identified for a FAR of 68%. The average error in location (Delta) was 0.6 foot.

Note that the magnetometer was run in fiducial mode and was therefore not affected by RF interference with the RTK GPS operation. The higher FAR for the magnetometer in Test Plot 2 is either the result of interference from the power line or spurious anomalies created by passing vehicles on the road. This effect was noted during operations. All three of the grenade fuze assemblies were selected.

4.3 Comparison with the ODDS Geophysical Prove-Out

Because the test plot simulants were buried at different depths and/or orientations than their inert counterparts in the Ordnance Detection and Discrimination Study (ODDS) plot (Parsons 2002), no direct comparison can be made. However, the results of the ODDS Geophysical Prove-Out were used as a guideline for target selection outlined in Section 5 of this report.

4.4 Final Geophysical Test Plot Results

The data presented in this section represent the initial processed geophysical databases before the seed items were made known. All final data (after seed items were disclosed) are provided in Appendix D.

5.0 CONCLUSIONS AND RECOMMENDATIONS

Buried inert ordnance seed items were selected using an EM61-MK2 single unit, towed array, and G-858 at Test Plots 1 and 2 at the Seaside MRA.

The conclusions of Test Plot 1 show:

- The EM61-MK2 single unit integrated with the RTK GPS navigation was capable of meeting the project scope and DQOs.
    - Low noise was observed at Test Plot 1. Therefore a threshold of 3.0 mV (stacked) was used to select targets and represented a conservative threshold level based on the analysis of three times the standard deviation of the background signal.
- The EM61-MK2 towed array integrated with the RTK GPS navigation was capable of meeting the project scope and DQOs.
    - Low noise was observed at Test Plot 1. Therefore a threshold of 3.0 mV (stacked) was used to select targets and represented a conservative threshold level based on the analysis of three times the standard deviation of the background signal.
    - Similar noise levels were observed with the EM61-MK2 towed array as with the EM61-MK2 single unit despite the towed array being closer to the ground. The towed array is approximately 10 inches off the ground compared to 16 inches for the single unit.
- The G-858 magnetometer operated in line and fiducial mode was capable of meeting the project scope and DQOs.
    - Low noise on the analytic signal and vertical gradient warranted a conservative picking threshold of 3.0 nT/ft (analytic signal) for the magnetometry based on the analysis of three times the standard deviation of the background signal.

The conclusions of Test Plot 2 show:

- The EM61-MK2 single unit was affected by the overhead power line. A basic nonlinear filter was applied to the stacked data to smooth the effect of the high-frequency, low-amplitude noise introduced from the power line.
    - A target selection threshold of 10.0 mV on the filtered Stack channel (Stack filter) based on the analysis of three times the standard deviation of the background signal.
    - Radio lock from the RTK is prone to dropouts in this area, possibly due to the nearby airport broadcasting. This affect will be analyzed and documented to determine optimal survey times in these areas.
- The EM61-MK2 towed array was also affected by the overhead power line. A basic nonlinear filter was applied to the stacked data to smooth the effect of the high-frequency, low-amplitude noise introduced from the power line.
    - A target selection threshold of 11.0 mV on the filtered Stack channel (Stack filter) based on the analysis of three times the standard deviation of the background signal.

- Radio lock from the RTK is prone to dropouts in this area, possibly due to the nearby airport broadcasting. This affect will be analyzed and documented to determine optimal survey times in these areas.

- The G-585 magnetometer operated in line and fiducial mode was capable of meeting the project scope and DQOs.
  - Low noise on the analytic signal and vertical gradient warranted a conservative picking threshold of 3.0 nT/ft (analytic signal) for the magnetometry.
  - Experienced little, if any, effect from the overhead power lines.
  - The G-858 was run in line and fiducial mode and therefore did not exhibit any of the small navigational radio lock issues associated with the RTK.
  - The G-858 will be proved out with the RTK and reported separately before any data collection with this unit takes place in this mode (equipment was not in place to collect GPS data with the G-858 at the time of surveys).

Working under the high-tension power line or the effect of the nearby airport appears to be causing interference with the radio transmission of the RTK GPS unit. The unit tends to lose radio lock and experiences increased dropouts in proximity to the power lines and/or the nearby airport. A technical resolution of the issue is underway and until a satisfactory solution is achieved, excavation crews will expand the search area around each reacquired pin flag to 3.0 feet while working in proximity of the power line. This expansion will ensure meeting the 85% Pd DQO as demonstrated with the Test Plot 2 results.

Based on the results of the geophysical test plot surveys, the following recommendations are proposed for the full-scale activities at the Seaside MRA:

- EM61-MK2 will be the primary instrument for DGM. Data will be collected and processed using conventional processing techniques. The towed array will be used in areas that are wide open and easily accessible. The single unit will be used to collect data at small, discrete locations or where the data from the towed array could be compromised (excessive topography and rough terrain).
- G-858 line and fiducial data will be utilized where RTK signal lock is completely compromised and cannot be achieved. This is expected to be minimal at the Seaside MRA.
  - Further tests with the G-858 and RTK system are necessary before any data collection can commence with the G-858 in conjunction with the RTK.
- Target selection thresholds will initially be based on analysis of a portion of background data in each data set. This background data will be examined to calculate three times the standard deviation of the background signal. This target selection process is conservative and is picking near the noise threshold for the equipment; however, this is necessary to collect a representative sample of these low threshold geophysical targets. After several data sets have been investigated (reacquired and logged), an analysis will be performed of these targets and their resulting dig information, to determine if an increase in the target selection threshold is warranted. If an increase is warranted, a maximum increase in

threshold to 14mV (stacked) will be implemented for EM61-MK2 target picking. This is based on the results presented in this report and the results of the MRS-16 Geophysical Prove-out (Shaw 2007). If a threshold higher than 14mV (stacked) is warranted, a field variance will be submitted for approval.

6.0 REFERENCES

Environmental Services Cooperative Agreement Remediation Program Team (ESCA RP Team). 2008a. Final Addendum to Final OE-15SEA.1-4 Site-Specific Work Plan, Phase II Seaside Munitions Response Area (MRA) Removal Action, Former Fort Ord, Monterey County, California. January 24.

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