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Subject: Geophysical Instrument Verification Strip Report Updated June 2018  
Fort Wingate Depot Activity  
Gallup, New Mexico  
Contract No. W912BV-16-C-0033

The purpose of this report is to summarize the geophysical instrument verification strip (IVS) results for demonstrations performed at Fort Wingate Depot Activity (FWDA), on December 12, 2017. This IVS was conducted in support of production digital geophysical mapping (DGM) at the Site, and conforms to guidance specified in Engineering Manual (EM) 200-1-15 (USACE, 2015).

## **INTRODUCTION**

Upon arriving at FWDA, the Quality Control (QC) Geophysicist started by mapping and installing Industry Standard Objects (ISOs) at the previously established IVS location (ISO items were removed at the completion of the last project). All geophysical and positioning instrumentation was inspected and tested to ensure that it was functioning within the parameters specified in the work plan. This report contains the results of those tests using a Geonics EM61-MK2A (EM61) time domain electromagnetic metal detector mounted on the standard 42 cm wheels paired with a real-time kinematic global positioning system (RTK GPS) for location.

## **OBJECTIVES**

The primary objectives of the IVS are the following:

- Demonstrate that the DGM instrument and positioning systems are functioning properly, and
- Verify conformance with specifications in the work plan (WP).

Secondary objectives of the IVS include:

- Determination of the root mean square (RMS) background noise at the site, and
- Quantification of expected errors in recorded response due to variations such as, seed item location, depth and orientation, and along-track offset.

## INSTRUMENT VERIFICATION STRIP DESCRIPTION

The IVS location was selected during a previous field effort on Monday, May 20, 2013 by the Unexploded Ordinance Quality Control Specialist (UXOQCS). The location was selected based on its accessibility, proximity to the main area of DGM collection, and similarity in terrain and geology to the production environment. The IVS items were removed upon completion of the previously contract, so new items were emplaced on December 11, 2017. Three small ISOs were placed in a line running east-west with nominal 15 foot spacing at a depth of six inches each. Flags were used to mark the locations of the items and ends of the line at least 10 feet from the nearest item.

**Table 1** shows the types, depths, orientations, and the locations of the ISO items used at the IVS location. The area was previously mapped in real-time with the EM61 prior to emplacing the ISO items. Given that this location was used previously, the area was free of metal with no anomalies greater than 4 mV on Channel 1 present.

<b>ID</b>	<b>X (ft)</b>	<b>Y (ft)</b>	<b>Depth (ft)</b>	<b>Orientation</b>	<b>Description</b>
IVS1-1	2489810.022	1623330.079	0.50	Vertical	Small ISO
IVS1-2	2489824.881	1623330.094	0.50	Inline (E-W)	Small ISO
IVS1-3	2489839.960	1623330.081	0.50	Crossline (N-S)	Small ISO

A background lane was also marked 20 feet north of the IVS location. Both lines were marked with lathe, and the end points were recorded with RTK GPS in NAD 83, New Mexico State Plane Zone West, US Survey Feet.

Cable shake, personnel, static, IVS, and IVS background tests were run at the beginning and end of each day when geophysical mapping was performed. Additionally, a six-line test and offset tests were also conducted prior to collecting any production data.

## GEOPHYSICAL SURVEY EQUIPMENT

### EM61-MK2

The EM61-MK2A was configured using the standard wheels; bottom coil nominally 42 centimeters (cm) above the ground surface. The survey was performed with the 1.0-meter (m) edge perpendicular to the direction of travel. Data were logged at a rate of 10 Hertz (Hz) and recorded from the four time gates of the lower coil. The top coil was only used to affix the GPS tripod.

### Global Positioning System Equipment

A Trimble R10 RTK GPS was used to position the data during the IVS survey. Positional data and other GPS data were recorded in the National Marine Electronics Association (NMEA) time, position, and fix related data (GGA) and dilution of precision (DOP) and active satellites (GSA) formats at 1-second intervals (1 Hz) using a serial cable. The GPS antenna was placed on a tripod directly above the center of the coil for accurate location of data.

## **GEOPHYSICAL SURVEY PROCEDURES**

### **DATA ACQUISITION**

The EM61 data were collected by pulling the cart back and forth across the IVS. Data were collected for the Six-Line Test by walking up and down the IVS at a normal rate of speed, low rate of speed, and high rate of speed (respectively) to illustrate the effects of speed on peak response and assist in determining a maximum acceptable velocity. A second Six-Line Test was also performed in the Background Lane to determine noise levels. Additionally, data were collected offset by 1 foot and 2 feet to each side of the IVS to ascertain the horizontal extent of detection.

Prior to the IVS demonstration, several tests were conducted to verify that the instruments were operating properly. Data were recorded from the EM61 while it was stationary and subjected to a cable shake, personnel, and static test.

### **DATA PROCESSING**

The equipment operator monitored the quality of the data in real-time. Upon completion of the IVS survey, the raw data were downloaded from the Juniper data recorder. The geophysical and positional data collected over the IVS survey area were processed using the procedures listed below:

- Raw geophysical data were imported into Trackmaker61 (a position/geophysical data-merging program).
- Correctly positioned data files were exported in \*.xyz format for use in Oasis montaj.
- Combined data were input into Oasis montaj.
- The cable shake/personnel and static test were evaluated for Quality Control (QC) compliance.
- The latency correction was estimated and applied to the IVS data. ISO location and amplitude responses were determined.
- Geophysical sensor data were evaluated in profile format for spikes, gaps, and sensor failure.
- Background and IVS data were leveled to eliminate drift and/or improper nulling (i.e., the effect of inadvertently nulling near subsurface metal is mitigated).

- A latency correction calculated during the latency test was applied to the IVS offset and Six-Line Test datasets.
- The data sets were gridded using a grid cell size of 0.5 feet and a blanking distance of 2.0 feet.
- Both positional and sensor data quality were checked. If required, questionable GPS and EM data were removed and/or edited accordingly. Data were monitored for gaps or incomplete coverage to locate any possible sensor failure.

**RESULTS**

The IVS data are displayed below along with results for a variety of tests as specified in the work plan.

**DYNAMIC PEAK RESPONSE AND LOCATION OFFSETS**

The IVS lane centerline was surveyed in two directions (W-E and E-W). The profile of the magnitude of the channels 1, 2, and 3 is plotted in **Figure 1** (morning test). Depth/Response curves were generated to compare predicted Least Favorable Orientation/Most Favorable Orientation (LFO/MFO) responses to measured responses (**Figure 2**). The peak responses to each ISO are also presented in **Table 2**.

<b>Table 2 IVS Dynamic Peak Response Values (Channel 1)</b>						
<b>Date</b>	<b>Database</b>	<b>Line</b>	<b>Nominal Depth (cm)</b>	<b>IVS1-1 (MFO) (mV)</b>	<b>IVS1-2 (mV)</b>	<b>IVS1-3 (LFO) (mV)</b>
12/12/2017	DailyTest_121217	ivs1212a (forward)	15.24	110.0	24.6	13.3
12/12/2017	DailyTest_121217	ivs1212A (back)	15.24	107.0	30.0	13.5
Mean Response				108.5	27.3	13.4
Expected ISO Response				127.5	NA	14.7
Mean Response vs. Expected Response (%)				85%	NA	91%
Maximum Deviation from Mean Response				3%	20%	1%

**Table 3** contains the measured offsets between the surveyed seed location and the peak response (or midpoint between double peak responses) identified during the IVS surveys.

<b>Table 3 IVS Dynamic Peak Response Positional Offset Values</b>					
<b>Date</b>	<b>Database</b>	<b>Line</b>	<b>IVS1-1 Offset (cm)</b>	<b>IVS1-2 Offset (cm)</b>	<b>IVS1-3 Offset (cm)</b>
12/12/2017	DailyTests_121217	ivs1212a (forward)	4.69	9.94	10.94
12/12/2017	DailyTests_121217	ivs1212a (back)	6.22	18.61	4.05

The results of the positional offsets are presented in **Figure 3**.

**BACKGROUND NOISE LEVELS**

In addition to the seeded portion of each IVS, a background noise lane was surveyed (bck1212a). **Table 4** shows the Background Noise Lane statistics, including the sum channel Sum1\_3 (Channel 1 plus Channel 2 plus Channel 3).

<b>Table 4 IVS Background Noise Lane Statistics</b>					
<b>Channel Name</b>	<b>Minimum (mV)</b>	<b>Maximum (mV)</b>	<b>Mean (mV)</b>	<b>Standard Deviation (mV)</b>	<b>Signal to Noise (LFO)</b>
lev1	-1.83	1.48	-0.05	0.58	23.10
lev2	-1.36	1.54	-0.03	0.38	21.71
lev3	-1.09	1.18	0.00	0.32	13.03
Sum1_3	-3.80	4.20	-0.08	1.15	22.39

**DETERMINATION OF OPTIMUM VELOCITY**

A six-line test consisting of two passes each over the seeded IVS at slow, medium, and fast pace was conducted to evaluate the influence of velocity on overall signal to noise levels (six1212a with lines labeled fast, slow, and normal). **Table 5** shows the six-line test including a signal to noise composed of the peak response over IVS1-1 (vertical seed) on Channel 1.

<b>Table 5 Six-Line Test Results</b>			
<b>Average Velocity (mph)</b>	<b>Average IVS1-1 Peak Channel 1 (mV)</b>	<b>Standard Deviation (mV)</b>	<b>Signal to Noise</b>
1.78	105.74	0.65	162.68
3.31	80.77	0.81	99.72
6.24	47.66	1.24	38.44

In order to access the effect of velocity with respect to background line data, a six-line test was also conducted at the background line (six1212bck with lines labeled fast, slow, and normal). The test results shown in **Table 6** (Channel 1, turns removed) indicate that excessive velocity was not significantly contributing to noise along the background test line.

<b>Table 6</b>		
<b>Background Six-Line Test Results</b>		
<b>Line</b>	<b>Average Velocity (mph)</b>	<b>Ch1 Standard Deviation (mV)</b>
Slow 1	1.77	0.58
Slow 2	2.02	0.72
Normal 1	2.83	0.76
Normal 2	3.22	0.86
Fast 1	5.98	1.09
Fast 2	5.25	1.38

#### QUALITY CONTROL

Quality control for the Fort Wingate IVS data was maintained by performing the tests described below and reviewing the tests for compliance.

#### EQUIPMENT WARMUP

The geophysical equipment was warmed up fifteen minutes prior to collecting data.

#### VIBRATION TEST (CABLE SHAKE) AND PERSONNEL TEST

Prior to completing the morning static test the cables and connectors were shaken to verify that there were no loose connections or bad cables (cab1212a). The personnel involved in the data collection stepped towards and away from the instrument coil in order confirm that they do not have any metallic items that will influence the data results (per1212a). No data spikes were observed in the field or when the test results were reviewed during data processing.

#### RECORD SENSOR POSITIONS

The positioning accuracy of the data acquisition system was tested in conjunction with the IVS tests comparing peak responses to the known ISO item locations as presented in **Table 1**.

#### STATIC BACKGROUND TEST

The static background test was performed by collecting data for 3 minutes in an area free of metallic items before and after data collection (sta1212a with separate lines for the initial static, spike item, and recovery). All datasets exhibited levels of instrument noise within the expected range.

## CONCLUSIONS AND RECOMMENDATIONS

All of the ISO seed items buried in the IVS at Fort Wingate were detected and located accurately (<25cm) (**Figure 3**). Responses for IVS-1, IVS-2 and IVS-3 fell within the WP metrics for repeatability, and the amplitude for the responses to MFO and LFO are within expectations.

Overall, the IVS results demonstrate the capability and effectiveness of the equipment, personnel, and procedures to locate buried simulated MEC items under anticipated conditions at the site to the project depth detection requirements.

AECOM has determined that Channel 1, provides the best signal-to-noise ratio, followed by the Channel 2 and Sum1\_3 channel. Previous experience has shown that Channel 1 can be more susceptible to certain noise sources, including wet conditions, which are not typical of Fort Wingate. AECOM proposes to use Channel 1 to identify anomalies. AECOM will continue to calculate the Sum1\_3 channel in case site conditions change and result in increased noise levels for Channel 1, in which case the Sum1\_3 channel is expected to be used to identify anomalies.

Based on the six-line test results shown in **Table 5**, which shows good signal to noise even at relatively fast velocities, AECOM proposes for a maximum velocity tolerance that 98% of measured velocities are less than 3.3 miles per hour.

In order to maintain consistency with previous field efforts at Fort Wingate, AECOM proposes to continue using a 4mV (Ch1) target dig threshold at this time. Anomalies above the target threshold in the leveled gridded data will be targeted for intrusive investigation. This value is equal to 5x the noise present in the background lane of the IVS. AECOM recommends proceeding with data acquisition with the geophysical system detailed in this IVS report.

## FIGURES

Figure 1 IVS Target Response Profile

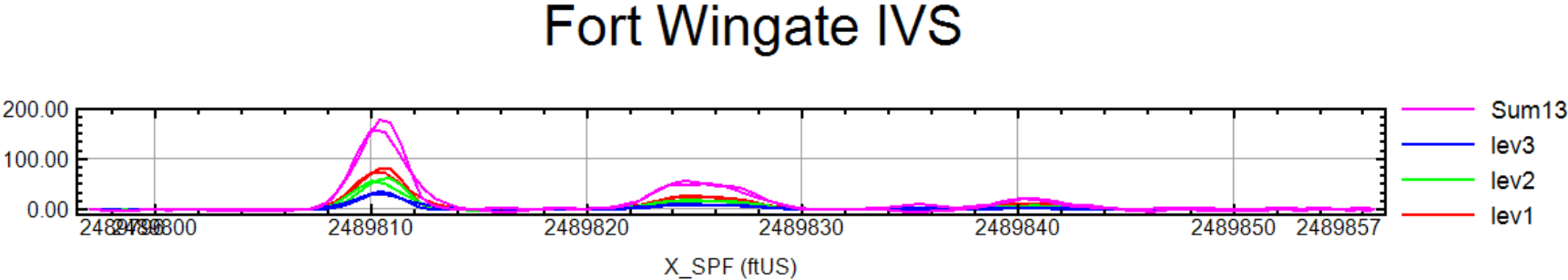


Figure 2 Seed responses relative to LFO/MFO curves

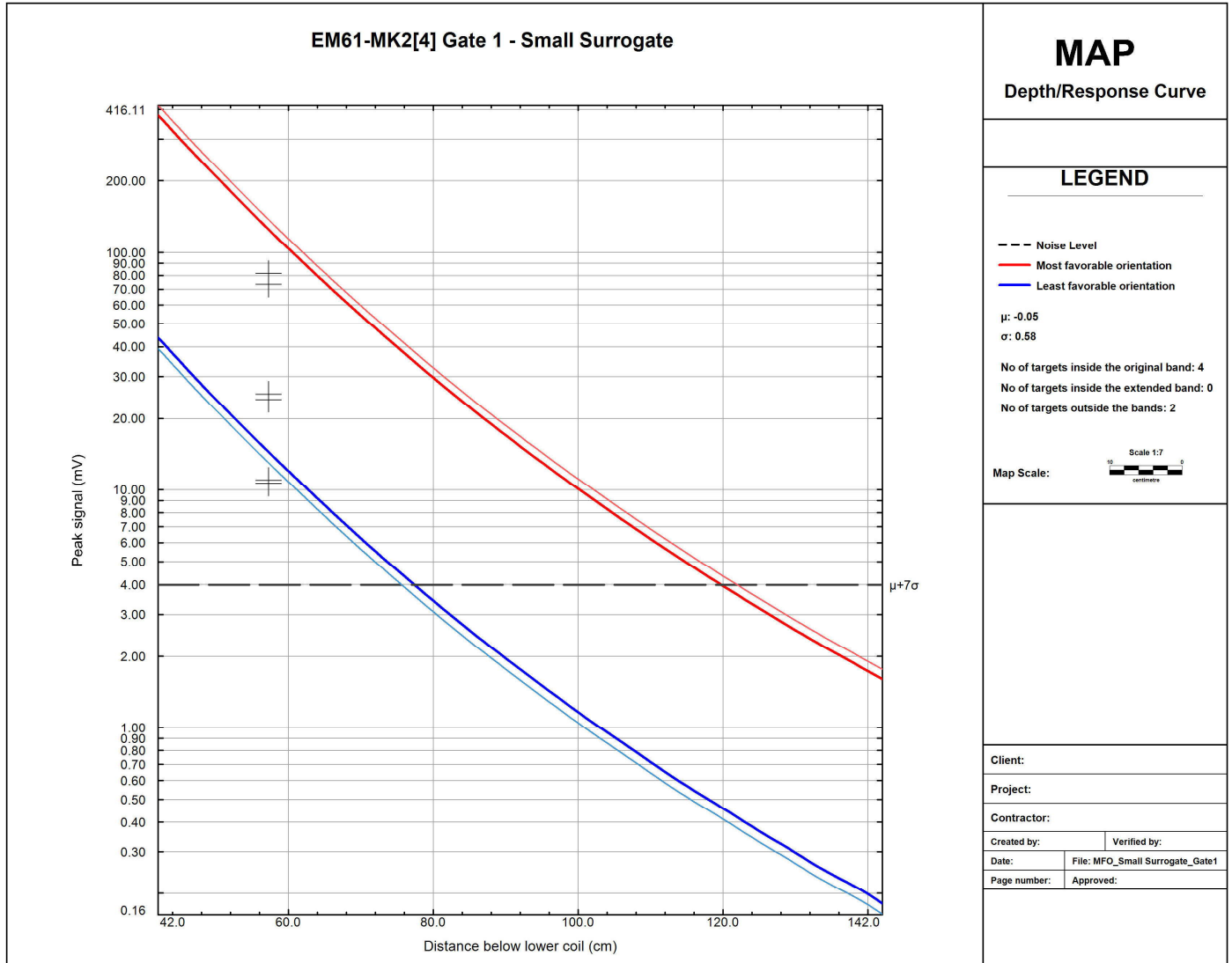


Figure 3 Relative offset (cm) of measured versus surveyed position of IVS1-1

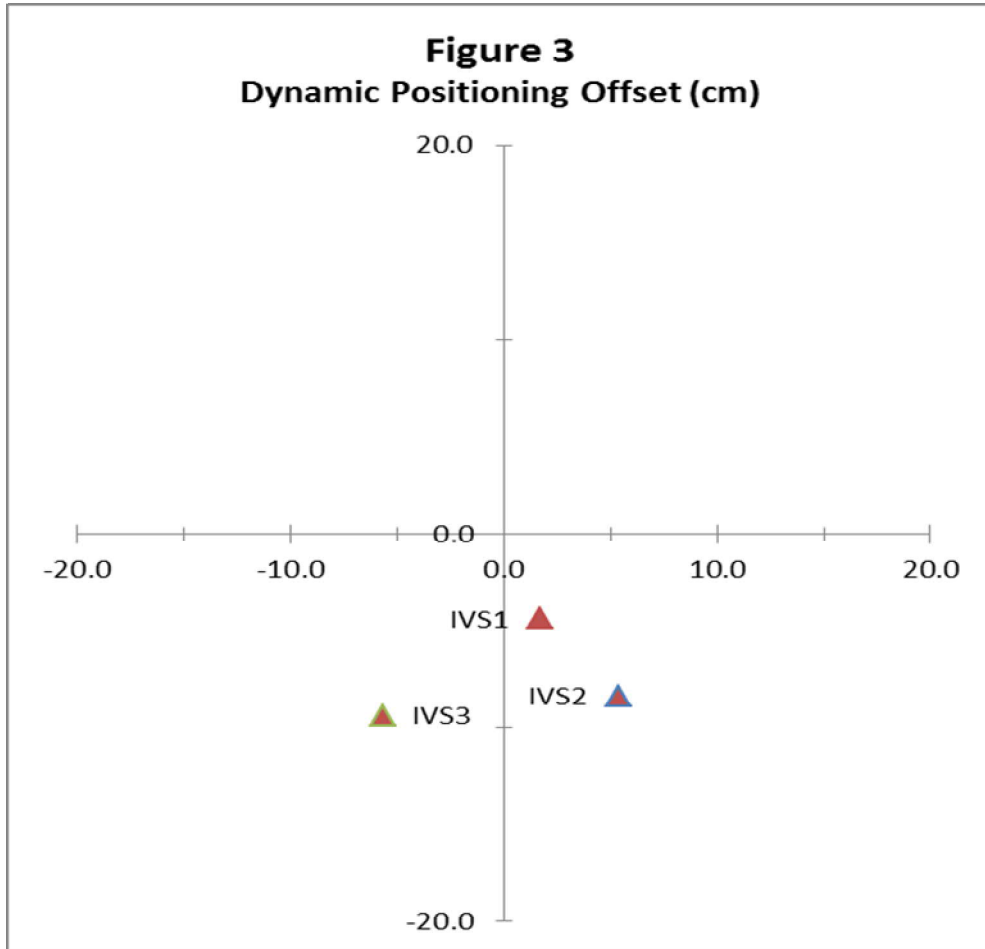


Figure 4 IVS Background Lane Plot

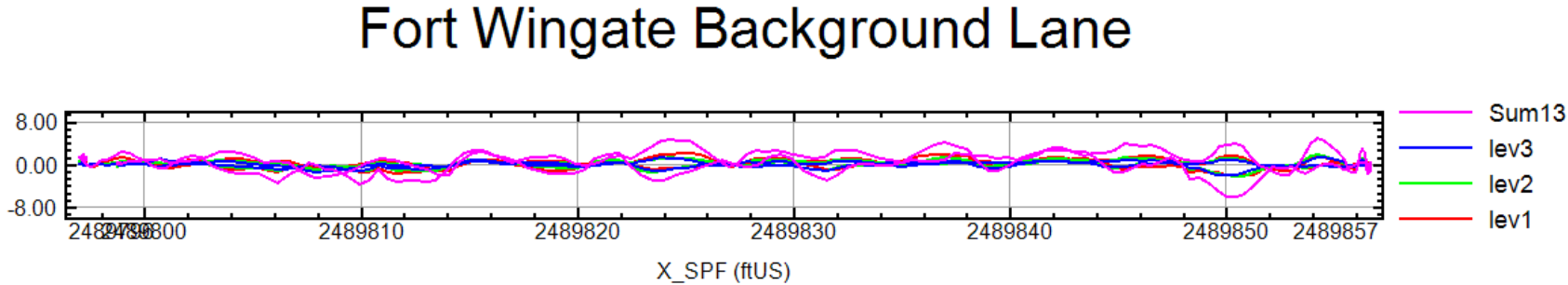


Figure 5 IVS Grid

