Appendix B-2e

Geophysical Prove-Out Documentation

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FINAL
Geophysical Prove-Out Work Plan

for

U.S. FWS Land Transfer Area
Fort McClellan, Alabama

Task Order 0020

Contract Number:
DACA87-99-D-0010

Prepared For:
U.S. Army Engineering and Support Center
Huntsville, Alabama

Prepared By:
Foster Wheeler Environmental Corporation

November 2003

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LIST OF ACRONYMS

CEHNC	United States Army Engineering and Support Center, Huntsville
EM	Electromagnetic
ft	Feet
DGPS	Differential Global Positioning System
DID	Data Item Description
EM	Electro-Magnetic
FWENC	Foster Wheeler Environmental Corporation
GPO	Geophysical Prove-Out
GPS	Global Positioning System
mV	Millivolts
OE	Ordnance and Explosives
PCMCIA	Personal Computer Memory Card International Association
QA	Quality Assurance
QC	Quality Control
RLS	Registered Land Surveyor
RTS	Robotic Total Station
TDEM	Time Domain Electromagnetic
UXO	Unexploded Ordnance

1.0 INTRODUCTION

The The United States Army Engineering and Support Center Huntsville (CEHNC) has contracted Foster Wheeler Environmental Corporation (FWENC), under Contract DACA87-99-D-0010, to perform a Geophysical Prove-Out (GPO) at Fort McClellan located in Anniston, Alabama. The task will be performed in the winter of 2003 in support of the land transfer of roads and high use areas to the U.S. Fish and Wildlife Service (FWS).

1.0.1 In addition to performing the GPO in the existing test grid area, changes in equipment, significant field personnel and/or operational procedures will warrant evaluation by acquiring data in the test grid. A senior geophysicist will evaluate this data. Any actions performed in the test grid area following the GPO will be documented.

2.0 OBJECTIVE

The objective of the GPO is to demonstrate and document the performance of the data acquisition methodology and spatial sampling protocols, sensor(s) and positioning equipment, data analysis and management systems, data transfer procedures, and the geophysical Quality Control (QC) system. The following components of the geophysical system will be evaluated during the GPO field program to ensure the program objectives will be met:

- Spatial sample density (i.e., line and station spacing)
- Navigation and positioning methodologies
- Sensor and positioning system platform (stability, noise characteristics and ergonomics)
- Data processing, analysis and interpretation, management and transfer system
- Quality Assurance (QA) Control, documentation protocol for data acquisition, processing and analysis and data management and transfer

2.0.1 In addition to evaluating our present methodology, the GPO test grid has been designed and placed in a location where it can be maintained for ongoing usage. It is the intention of Foster Wheeler Environmental Corporation (FWENC) to validate our geophysical systems throughout the duration of the present contract as well as any subsequent removal actions. These validations will occur based on any change in significant personnel and/or equipment. Similar to other technology driven industries, geophysical sensor technology improves over time. FWENC has and will continue to utilize advancements in technology where applicable. Should technology dictate redesigning the layout of the test grid (i.e., placement of deeper items), CEHNC will be notified.

3.0 TEST GRID LOCATION AND DESIGN

3.1 LOCATION

The GPO area is located near the scrap yard off Bains Gap Road (Figure B-1). It is an excellent representation of the environment to be encountered during geophysical operations on Fort McClellan. A number of the areas to be investigated consist of wooded areas, cultural features such as power lines and fences, as well as some open areas.

3.1.1 The trees, some with continuous foliage, are similar to those found throughout Fort McClellan. A smaller grid (test grid #2 in Figure B-1) is positioned in a heavily wooded area. This grid is designed for internal testing of new technology. It will not be used for this GPO, however CEHNC is welcome to utilize this grid at any time.

3.1.2 A fence is located approximately 30 feet from the northern side of the GPO test plot, as seen in the picture to the left. This will allow our geophysicist to determine if signal interference from the cultural features may present a problem.

3.1.3 A background geophysical survey of the test plot was performed prior to seeding the existing items. Qualified UXO technicians removed the detected anomalies from the subsurface.

3.1.4 The road adjacent to the prove-out test grid is a very good representation of the roads that will be mapped in the FWS area. Markers will be placed at 200ft increments down the center of the road. Surface items will be placed between the stakes. These surface items will represent anomalies. The Vehicle Towed Array (VTA) will be operating in Global Positioning System (GPS) mode, however FWENC programmers have created an accurate fiducial marking system that will be utilized in areas where GPS coverage is not available. The fiducial method will be utilized and evaluated during the survey of this road. Reacquisition of the anomalies will be performed in detail. Reacquiring anomalies from data that has been acquired using the fiducial method is a very important part of the process. For this reason, considerable effort will be taken to ensure that the process works. The reacquisition of the anomalies will be based on the distance of the anomaly location from the stakes located in the center of the road. A senior geophysicist from the Denver office will assist in the evaluation. The results of the GPO, including established operational procedures, will be documented in the GPO letter report.

3.2 DESIGN

Foster Wheeler Environmental began construction of a 165ft x 70ft test grid at the site in August of 2002 to meet the requirements of Data Item Description (DID) OE-005-05A.01. Grid corners were predetermined and surveyed using a high resolution Leica Total Station. The control points were calculated from pre-existing monuments established with a Differential Global Positioning System (DGPS) by a registered land surveyor (RLS). For the GPO to be performed in support of the FWS Area, a RLS will calculate the position of all corner points and seeded items. Measurements of the seeded items will be performed in accordance with DID OE-005-05A.01. These points will be calculated to an accuracy of no less then 3cm in the horizontal plane and 5cm in the vertical plane. Coordinates of the test grid corners are presented in Table A-2 (Values may change based on the results of the RLS determination).

3.2.1 Anomaly avoidance techniques were used prior to placing wooden stakes at each corner and mid point of the grid. A metallic nail was driven into the ground at the grid corners and mid points to facilitate relocation of the corner points for future use. Anomaly avoidance techniques will be used, when applicable, where any objects are placed in the ground.

3.2.2 The items presently located in the grid are specified in Table A-1. These items were provided by CEHNC and were buried by FWENC. An additional 27 items were added later and are also included in Table A-1. The exact location of the additional items can be found on Figure B-4. The following procedures were used in seeding the items for the test grid:

1. Inert seeded items were labeled and photographed before burial.

2. Holes were excavated with a shovel and/or backhoe.

3. The seeded item was placed in the hole and the depth measured to the top of the item using a bar placed across the hole at ground level for reference. For larger items (e.g. 2.36 inch rocket), the center point and both ends of the item were measured.

4. The items were buried with one end of a bar on the item. The dirt was then replaced in the hole and the bar was replaced with the pin flag noting the item number.

5. The location of the item was then determined using a high-resolution positioning system (Constellation) based on the center of mass of each item while it resided in the excavation. The location and depth of each item was recorded in an Excel Table. The additional 27 items which were added after initial construction were located by a RLS in accordance with the applicable DID.

4.0 EQUIPMENT

Based on our previous experience at numerous UXO sites including Fort McClellan, the EM61 TDEM instrument exhibits the greatest potential to meet the program objectives. FWENC will evaluate the following equipment in the GPO test grid.

4.1 EM61 MK2

The EM61 MK2 utilizes two coaxial receiver coils to measure the residual magnetic field generated by conductive and/or magnetic materials. The EM61 MK2's employed by FWENC are designed to measure the residual magnetic field at a time when the response from conductive and/or magnetic objects is maximized, compared to the response from most earth materials. The use of two receiver coils also makes it possible to differentiate, in a simplistic fashion, shallow versus deep objects. An additional benefit of the specific design of the EM61 MK2 system is that it permits a more focused observation of the subsurface in areas of cultural interference as well as areas characterized by a high spatial density of subsurface objects. This is due to the mechanical design and operational parameters of the instrument, as well as the inherent nature of active electro-magnetic (EM) fields, which diminish in magnitude at a much higher rate than other sensor technologies such as magnetometry.

4.1.1 A modified version of the standard EM61 the EM61 MK2, utilizes multiple time-gates centered at 216, 366, 660, and 1,266 μs. The signal intensity for a given ferrous target recorded by the earlier time-gates is generally a factor of 2 to 4 times that recorded by the standard (660μs) EM61 MK2 time-gate for the top and bottom coil. This feature facilitates a more efficient and repeatable interpretation of smaller targets such as 37mm projectiles.

4.2 VALLON VMX2

The VMX2 is a handheld mine and UXO detector. This unit will be used for target reacquisition, and may be used in small areas where the EM61 MK2 system is unable to acquire data due to terrain or vegetation. The VMX2 utilizes a 60cm search coil and has a search depth of up to two (2) meters.

4.3 CONSTELLATION POSITIONING SYSTEM

This system consists of four (4) transmitters, each with a unique signature of light pulses, optical sensors and signal processing. The positioning is based on line-of-sight triangulation. The Constellation system remotely transmits data from a handheld computer to a stationary laptop. The picture at right shows a typical Constellation positioning system being used in the field.

4.4 ROBOTIC TOTAL STATION (RTS) POSITIONING SYSTEM

The Leica TCM1105plus motorized Robotic Total Station (RTS) allows the geophysical team to continuously collect the positional data of the team members carrying an EM61 one-meter coil. The RTS continuously records the position of the center of the coil by tracking the location of the 360° prism centered over the top of the coil. Positional data is recorded several times per second to give an accurate position to correlate with the geophysical data collected by the EM61. The positional data from the RTS and the geophysical data from the EM61 will both be collected on Personal Computer Memory Card International Association (PCMCIA) cards and submitted to the on-site geophysicist for merging and initial processing.

4.5 VEHICLE TOWED ARRAY (VTA)

The VTA will acquire data over the existing prove-out area utilizing RTK corrected GPS navigation. This test will simulate locations in the Fish and Wildlife area that are open and relatively flat. Data will be collected by the individuals who will be operating the vehicle during the actual removal action. All data will be processed and interpreted by the site geophysicist. The location of the anomalies on the resulting geophysical maps will be compared to the actual location of the seeded items. In addition to the existing test grid, the VTA will be tested on the road adjacent to the prove-out area. The road adjacent to the test grid is a very good representation of the roads that will be mapped in the FWS area. The road is lined by trees and has approximately the same width as the ones that will be mapped. Stakes will be placed at 200ft increments down the center of the road. Surface items will be placed between the stakes. These surface items will represent anomalies. The VTA will be operating in GPS mode however FWENC programmers have created an accurate fiducial marking system that will be utilized in areas where GPS coverage is not available. The fiducial method will be utilized and evaluated during the survey of this test road. Reacquisition of the anomalies will be performed in detail. Reacquiring anomalies from data that has been acquired using the fiducial method is a very important part of the process. For this reason, considerable effort will be taken to ensure that the process works. The reacquisition of the anomalies will be based on the distance of the anomaly location from the stakes located in the center of the road. FWENC has brought in a senior geophysicist from the Denver office to assist in the evaluation. The results of the GPO, including established operational procedures, will be documented in the GPO letter report.

5.0 PROCEDURES

5.1 INSTRUMENT CONFIGURATIONS

Two (2) instrument configurations will be tested at the GPO to determine which combination of instruments and positioning would be most appropriate for the pending removal action that uses the man carried version of the EM61. The VTA will use the GPS and fiducial method only.

5.1.1 The specific system configurations and surveys to be performed at the GPO grid are documented in the following table.

GPO Instrument Configurations

Instrument	Coils	Time Gates	Positioning	Line Spacing (ft.)
EM61 MK2	1m by 1m	216 μs, 366 μs, 660 μs	Constellation	~2.5
EM61 MK2	1m by 1m	216 μs, 366 μs, 660 μs	RTS	~2.5

5.1.2 For each of the above instrument configurations, the geophysical data will be collected over 100% of the test area with the EM61 MK2 logging at 12-15 times per second and a line spacing of ~ 2.5 feet. The EM61 MK2 instrument height will be set at 16 inches above the ground. The instrument height will be measured prior to each data acquisition session.

5.2 SURVEY METHODS

5.2.1 The man-portable acquisition method will be applied during the GPO. In the man-portable configuration, two (2) operators will be used to collect the data. One (1) person transports the EM61 MK2 coils and positioning system detector while the other person walks approximately seven to eight feet behind carrying the EM61 MK2 electronics and the positioning system logging device. The positioning system detector will be centered above the EM61 MK2 coils for both instrument configurations.

5.2.2 The VTA will be composed of five (5) EM61, 1 meter by 1/2 meter coils. The coils are arranged on a trailer configured to carry them and will be towed by a diesel powered all terrain vehicle. This process has been used by FWENC on other projects. In addition to being reliable, it also allows for the collection of large amounts of geophysical data.

5.3 DATA PROCESSING AND MANAGEMENT

Data will be stored on Personal Computer Memory Card International Association (PCMCIA) cards during data acquisition. After acquisition over the test grid is complete, data will be transferred from the PCMCIA cards to the site database for processing. A Foster Wheeler Environmental geophysicist will perform preliminary geophysical and navigation data processing as well as QC checks. The final analysis and interpretation of the data will be performed at a centralized processing center located at the Foster Wheeler Environmental Huntsville, Alabama or Lakewood, Colorado office or at the on-site Foster Wheeler field office. Processing, QC, analysis and interpretation of the data will be performed with internally developed software that has been specifically produced to integrate and interpret digital geophysical data acquired with the above-mentioned positioning systems. Geosoft Oasis Montaj Mapping software will also be used to graphically display data.

5.3.1 Several steps will be performed to process the geophysical data prior to analysis. All data will be processed and transformed into the requested coordinate system (State plane zone Alabama North, NAD83). If data is acquired using a relative coordinate system, the x-y

locations will also be included in the file output. EM61 MK2 instrument bias will be removed, signal drift corrected and minor instrument positioning (lag) corrections applied.

5.3.2 The data will be interpreted using one of two independent modes of target prediction (profile data and color-coded image data) to provide x, y and z location information for each target. Data transfer will be tested during the GPO, including the transfer of raw EM and positioning data.

6.0 RESULTS

The results of the GPO will be submitted in the GPO letter report in tabular and graphical form. The FWENC seeded targets will be labeled "**a**" and will be indicated with a cross (+). The interpreted target locations will be labeled with a red circle (●).

6.0.1 Target selection criteria will include anomaly size, shape, amplitude and background noise. In general, anomalies that extended across at least two adjacent acquisition lines with amplitudes of at least 2 millivolts (mV) above background will be selected as potential targets. In some cases, if background noise levels are sufficiently low, anomalies with lower amplitudes will be selected if size and shape characteristics indicated potential buried metal.

6.1 TARGET REACQUISITION

Target reacquisition accuracy will be evaluated using the FWENC seed items. A UXO Technician will be given a dig-sheet and will reacquire the anomalies listed on the dig-sheet using the previously mentioned positioning systems. The technician will then use a Vallon VMX2 to pinpoint the target location. The position of the actual item will be compared to the position determined by the technician. We will meet the requirement as per DID OE-005-005A.01, which states that 95% of the reacquired items shall fall within 1 meter of the target location.

6.2 QUALITY CONTROL

Instrument and functional checks will be performed at the beginning and end of every data acquisition session. Independent QC tests to be performed include static tests, line tests and positioning (cloverleaf) tests. As mentioned in the introduction, the GPO test grid will be used to validate operation procedures based on any changes in equipment, personnel, or objectives. These tests will be documented and delivered to CEHNC.

6.2.1 Equipment Warm-up

The geophysical equipment will be turned on and allowed to run for a period of time sufficient to allow the system to reach operating temperature.

6.2.2 Distance Between Sensors

The distance between the top and bottom sensors as well as the height above ground will be measured and recorded.

6.2.3 Personnel Test

All personnel involved in data collection during the removal action will be involved with data collection during the GPO.

6.2.4 Shake Test

All cables and connections will be shook in a manner simulating walking in rough terrain. Any noise induced from this test will be recorded and the appropriate corrective action will be implemented.

6.2.5 Static Tests

The static test involves locating the instrument over a magnetically quiet area and recording data for a minimum of three (3) minutes, then placing a steel ball under the instrument and recording an additional three (3) minutes of data. The photograph at the right depicts the testing scenario.

6.2.6 Six Line Tests

The line test involves collecting data along an 80-foot line six times. The purpose of the line test is to determine noise due to system movement/motion as well as location error caused by temporal time lag or spatial correction due to waypoint placement. For the first two (2) line tests, data will be collected along the line in each direction at a normal pace with no object on the ground (Lines 1 and 2). A steel ball will then be placed near the middle of the line and data will be collected along the line in each direction at a slow pace and a fast pace. (Lines 3 and 4). For lines five and six the fast and slow pace directions will be reversed.

6.2.7 Positioning Tests

6.2.7.1 To test the positioning, the navigation unit will record data in a clover-leaf pattern around three (3) known points, with the operator crossing over the known points from three (3) different directions. The line path will then be plotted over the known points.

6.2.7.2 The VTA positioning test will be done on the road which runs next to the current test grid. Figure B-5 shows a rough drawing of the road to be used for this test, the location of the fiducial markers and the location of the placed anomalies. A listing of the anomalies is provided

in Appendix A, Table A-3. The test will consist of traversing the road with the VTA. A geophysicist will interpret the data and generate reacquire sheets. The sheets will contain information that consist of the straight line vector distance from the fiducial marker number and the distance left or right of the vector line to the anomaly. For consistency vector lines will run from the smaller number to the larger number fiducial marker, and left and right will be based on the same direction.

6.2.8 Repeat Lines

A minimum of 2% of the lines collected during the GPO will be recollected and analyzed for repeatability determination.

APPENDIX A

TABLES

TABLE A-1: GEOPHYSICAL PROVE-OUT ANOMALIES

X	Y	Target ID	Item	Depth(in)	Orientation
677699.94	1167164.58	a1	37mm	4.00	Horizontal
677708.37	1167173.14	a2	37mm	4.00	Vertical
677719.73	1167188.12	a3	81mm	34.00	Horizontal
677721.10	1167175.99	a4	2.36" rocket	26.00	Horizontal
677730.10	1167179.32	a5	rocket motor	12.00	Horizontal
677723.37	1167167.69	a6	37mm	16.00	Horizontal
677735.00	1167169.03	a7	60mm	12.00	Vertical
677735.62	1167156.66	a8	MKII HG	8.00	Vertical
677745.30	1167155.03	a9	2.36" rocket	6.00	Vertical
677743.41	1167136.92	a10	Anti Tank Mine	6.00	Horizontal
677726.67	1167132.67	a11	60mm	6.00	Vertical
677718.25	1167118.37	a12	MKII HG	4.00	Horizontal
677719.58	1167146.36	a13	37mm	0.00	Horizontal
677688.23	1167097.99	a14	3 "stokes	20.00	Horizontal
677704.27	1167108.58	a15	3 "stokes	32.00	Horizontal
677694.61	1167113.24	a16	75mm	30.00	Horizontal
677709.18	1167133.61	a17	60mm	25.00	45 degrees
677691.87	1167128.25	a18	75mm	12.00	Vertical
677681.35	1167118.85	a19	MKII HG	14.00	Horizontal
677673.49	1167132.86	a20	75mm	18.00	45 degrees
677666.45	1167141.88	a21	37mm	4.00	45 degrees
677680.90	1167152.03	a22	slap flare	4.00	45 degrees
677706.20	1167151.98	a23	105mm	45.00	45 degrees
677753.84	1167216.57	a24	37mm	4.00	Horizontal
677765.13	1167208.06	a25	37mm	4.00	Vertical
677771.70	1167196.19	a26	81mm	17.00	Horizontal
677771.95	1167190.79	a27	2.36" rocket	26.00	Horizontal
677781.41	1167187.60	a28	rocket motor	12.00	Horizontal
677794.28	1167178.14	a29	37mm	16.00	Horizontal
677775.16	1167162.11	a30	60mm	12.00	Vertical
677767.82	1167173.71	a31	MKII HG	8.00	Vertical
677763.33	1167167.94	a32	2.36" rocket	6.00	Vertical
677750.42	1167179.97	a33	60mm	6.00	Horizontal
677756.51	1167195.77	a34	60mm	6.00	Vertical
677740.94	1167197.48	a35	MKII HG	4.00	Horizontal
677741.04	1167180.67	a36	37mm	0.00	Horizontal
677728.58	1167178.52	a37	3 "stokes	20.00	Horizontal
677733.40	1167171.79	a38	3 "stokes	32.00	Horizontal
677743.27	1167161.79	a39	75mm	30.00	Horizontal
677758.76	1167148.27	a40	81mm	25.00	45 degrees
677697.46	1167163.21	a41	75mm	12.00	Vertical
677699.23	1167155.70	a42	MKII HG	0.00	Horizontal
677700.11	1167144.91	a43	75mm	18.00	45 degrees
677715.77	1167137.08	a44	37mm	4.00	45 degrees
677715.85	1167112.69	a45	slap flare	4.00	Vertical

Table A-1: Geophysical Prove-Out Anomalies (Continued)

X	Y	Target ID	Item	Depth (in)	Orientation
677706.94	1167104.36	a46	105mm	10.00	Vertical
677693.62	1167134.69	a47	81mm	34.00	Vertical
677683.47	1167133.54	a48	rocket motor	12.00	Vertical
677680.56	1167145.54	a49	3 "stokes	20.00	Vertical
677674.37	1167119.69	a50	37mm	2.00	Horizontal
677753.19	1167226.71	NE	corner point		
677651.45	1167138.05	NW	corner point		
677762.26	1167147.30	M1	mid point		
677728.18	1167117.92	M2	mid point		
677685.25	1167167.49	M3	mid point		
677719.52	1167196.53	M4	mid point		

TABLE A-2: CORNER POINTS

Corner Point	X	Y
SW	677693.96	1167088.76
SE	677796.54	1167176.86
NE	677753.19	1167226.71
NW	677651.45	1167138.05
M1	677762.26	1167147.30
M2	677728.18	1167117.92
M3	677685.25	1167167.49
M4	677719.52	1167196.53

Table A-3: Anomalies for VTA Position Test

Anomaly Number	Item	Vector Straight Line Distance(in Feet)/From Fiducial Marker Number	Offset Distance (in Feet) and Direction
1	Practice Hand Grenade	28.45/716	0
2	Practice Hand Grenade	51.2/716	4.5 Left
3	Practice Hand Grenade	75.5/716	9.3 Right
4	75mm Shrap Round (75% Whole)	96/716	7.35 Left
5	Practice Hand Grenade	87.8/5965	5.7 Right
6	60mm Mortar, Training	7.8/5965	6.5 Left
7	37mm, Projectile AP	10.05/5965	3.55 Left
8	81mm Mortar, Training	27.6/715	8.55 Left
9	37mm, Projectile, AP (75% Whole)	61.7/715	6.3 Left
10	75mm Fragment (2in long)	49.3/714	5.35 Left
11	37mm, Projectile, AP (75% Whole)	2.2/714	7.9 Left
12	60mm Mortar, Training	27.5/714	7.85 Right
13	75mm Fragment (2in long)	80.7/714	6.1 Left
14	Small sample of Misc. Fragmentation	31.5/714	5.25 Right
15	Metal Sign and Sign Post	92.3/713	14.7 Left

APPENDIX B

FIGURES

FIGURE B-1: TEST GRID LOCATION

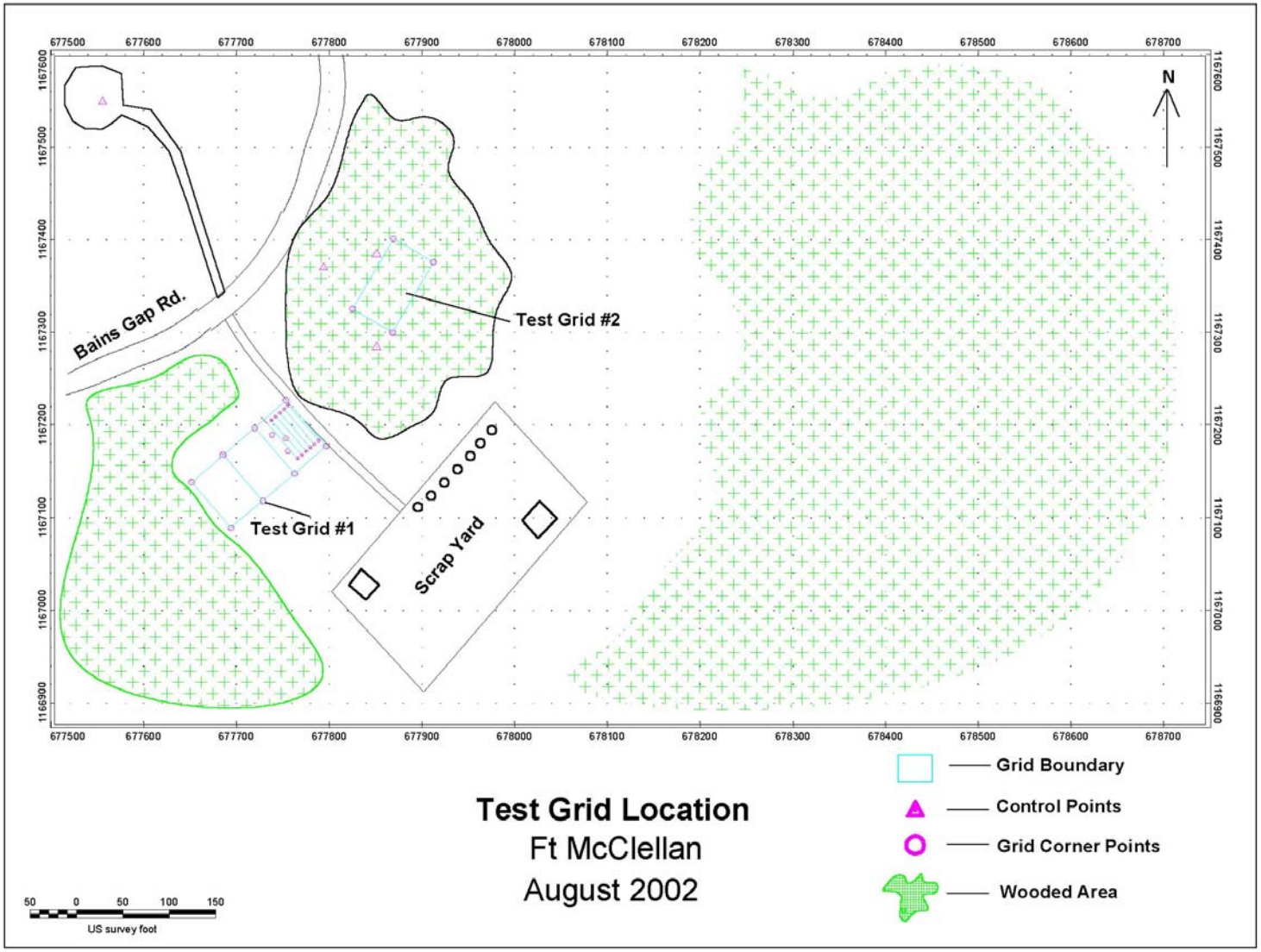


FIGURE B-2: BACKGROUND TEST

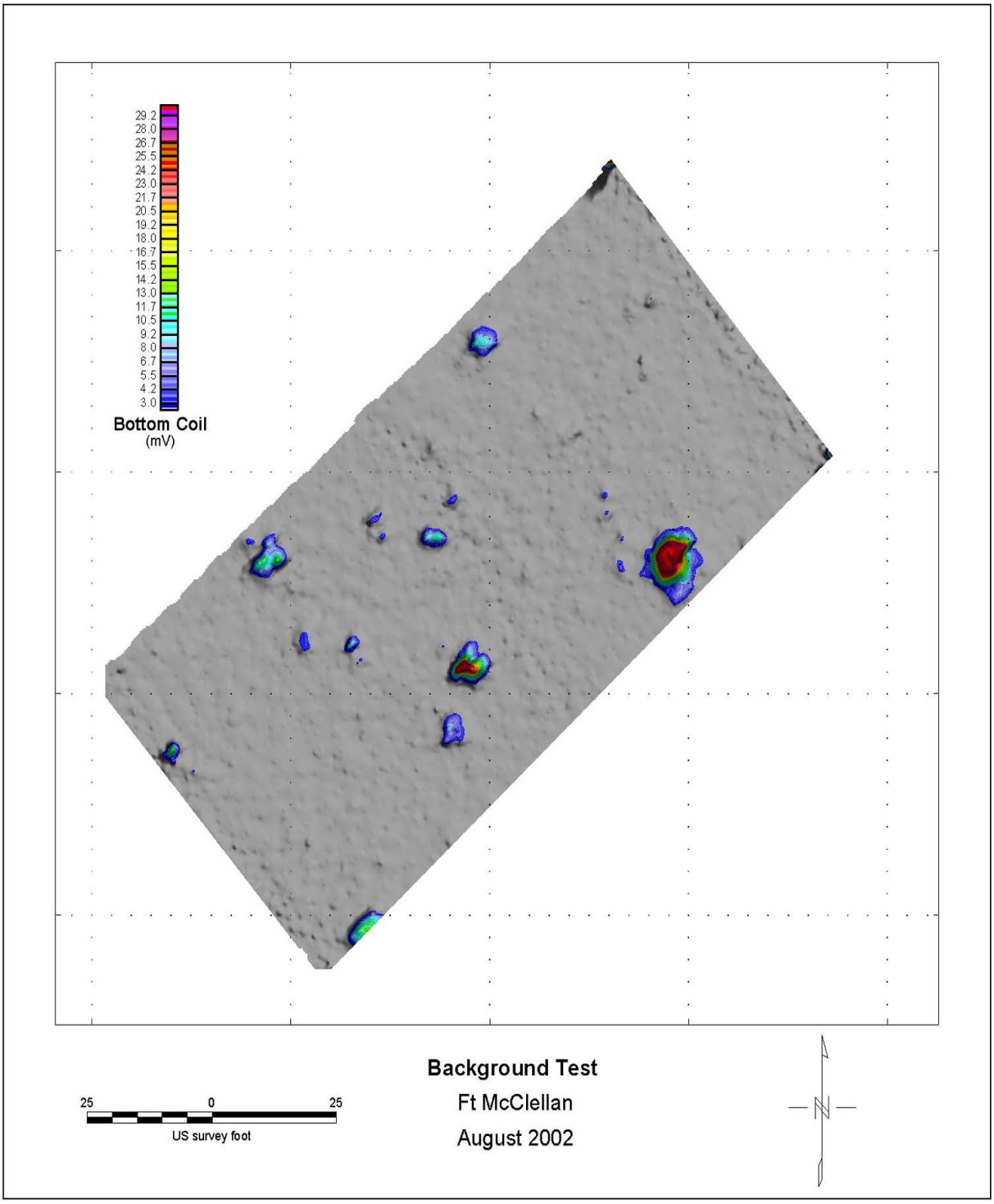


FIGURE B-3: CONSTELLATION TEST

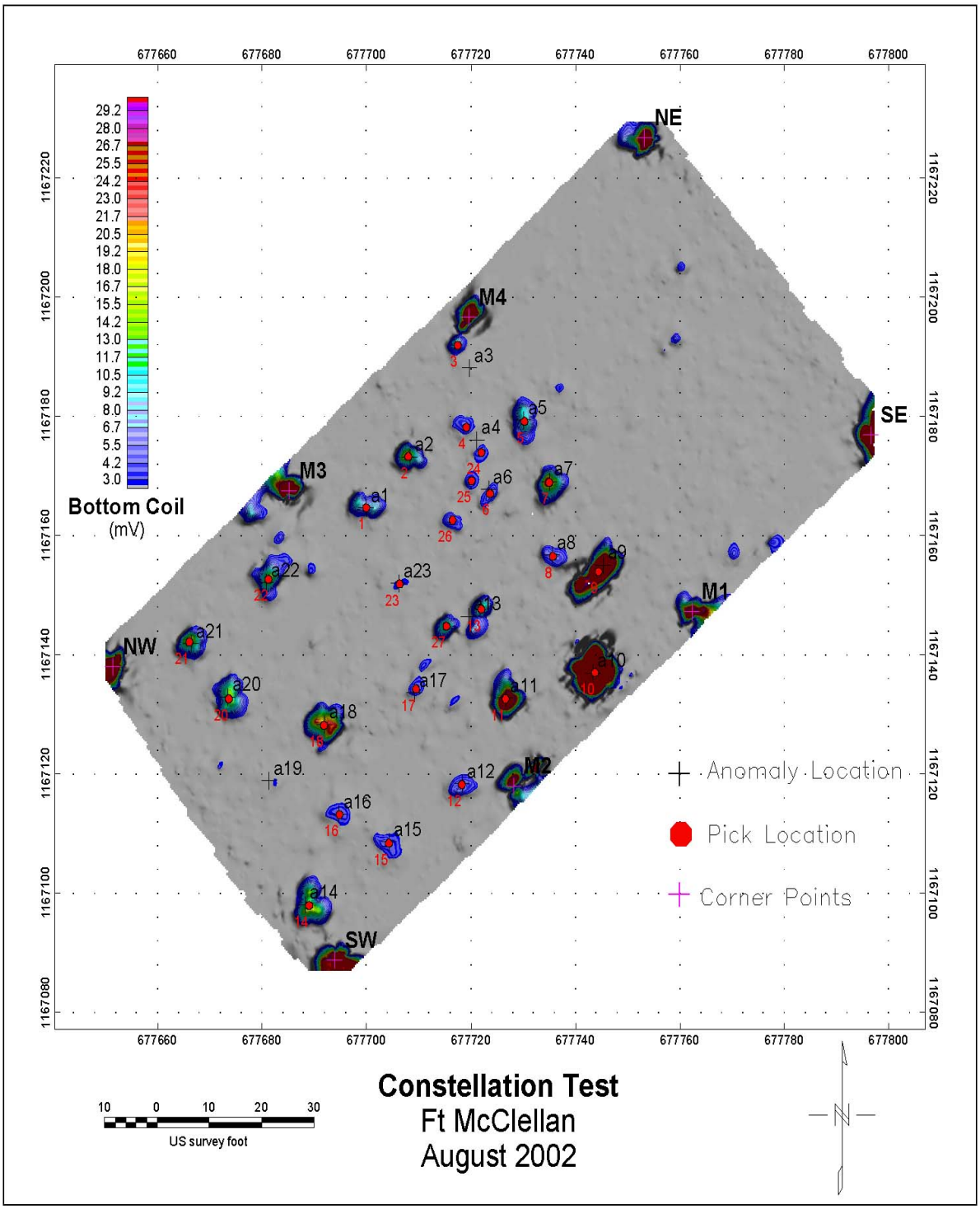


FIGURE B-4: TEST GRID LAYOUT

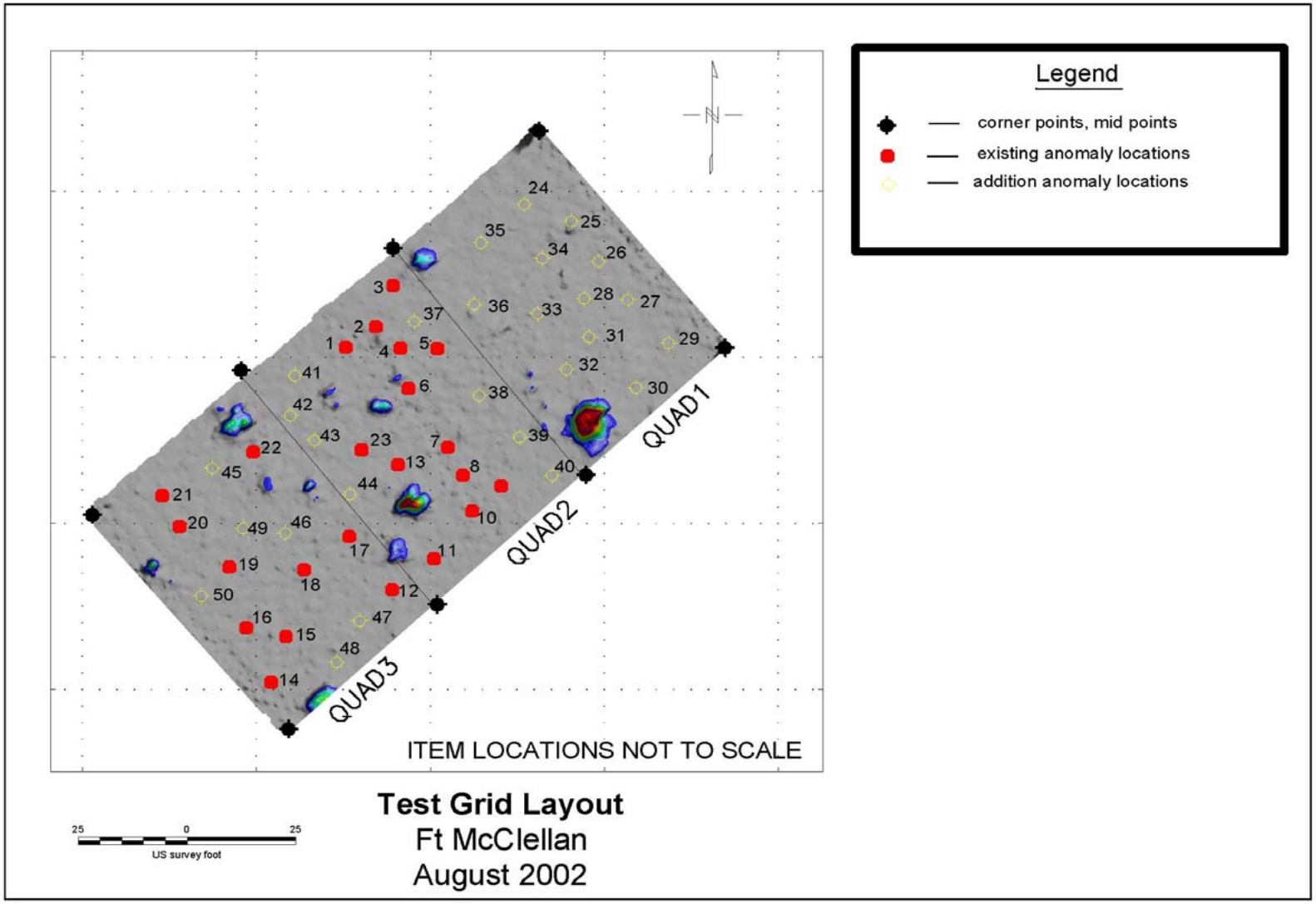
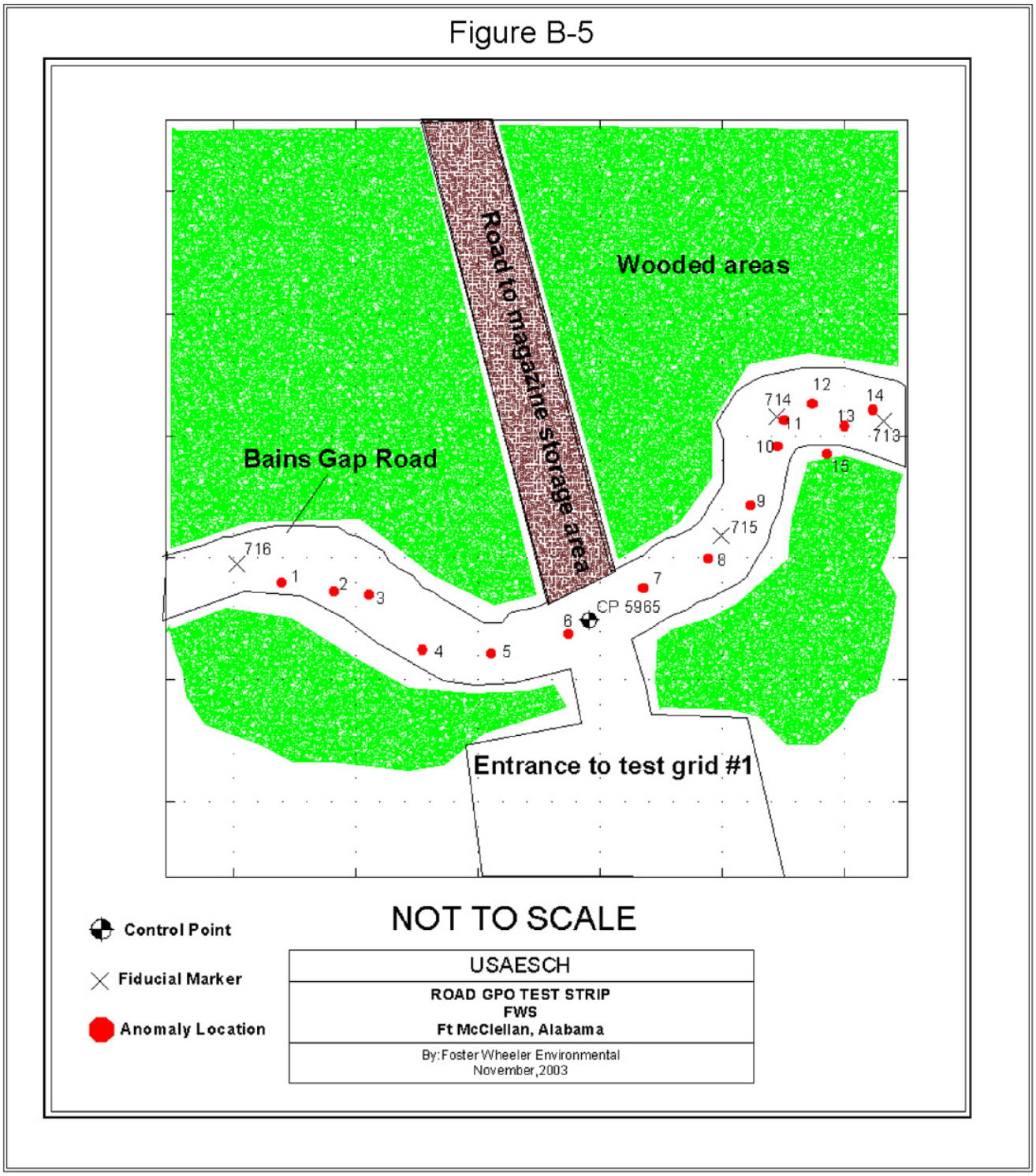


FIGURE B-5 ROAD TEST STRIP



Geophysical Prove-Out Letter Report

for the

Choccolocco Area

U.S. Fish and Wildlife Land Transfer

of

Fort McClellan, Alabama

Task Order 0020

Contract Number DACA87-99-D-0010

U.S. Army Corps of Engineers

Engineering and Support Center

Huntsville, Alabama

Prepared by

Foster Wheeler Environmental Corporation

Huntsville, Alabama

December 2003

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1.0 INTRODUCTION

The United States Army Engineering and Support Center, Huntsville (USAESCH) has contracted Foster Wheeler Environmental Corporation under Contract DACA87-99-D-0010, to perform a Geophysical Prove-Out (GPO) at Fort McClellan located in Anniston, Alabama. The GPO was performed during the week of November 24th, 2003. Foster Wheeler Environmental Corporation (FWENC) utilized one (1) three (3) man team to acquire geophysical data in the Fish and Wildlife Service (FWS) Area. Essential aspects of the GPO will be discussed in the following report with additional information, to include all digital data, provided on the CD-ROM submitted as a supplement to this report.

2.0 OBJECTIVE

FWENC has extensive experience in mapping wooded road areas. From these experiences a number of "lessons learned" have been tabulated which will be applied to this project. An in depth discussion of the lessons learned can be found in section 6.2, Recommendations.

The GPO was implemented to validate and document the performance of the data acquisition methodology and spatial sampling protocols, sensor(s) and positioning equipment, data analysis and management systems, data transfer procedures, and the geophysical Quality Control (QC) system. In addition, the GPO test was used to validate each team member's ability to perform his or her required task. The following components of the geophysical system were evaluated during the GPO field program to ensure the program objectives were met:

- Spatial sample density (i.e., line and station spacing)
- Navigation and positioning methodologies
- Sensor and positioning system platform (stability, noise characteristics, and ergonomics)
- Data processing, analysis and interpretation, management, and transfer system
- Quality Assurance (QA) Control, documentation protocol for data acquisition, processing and analysis, and data management and transfer

The GPO test grid was designed and placed in a location were it can be maintained for ongoing usage. It is the intention of FWENC to validate the geophysical systems throughout the duration of the present contract as well as any subsequent removal actions. These validations will occur based on modifications to the geophysical sensors, positioning equipment, or acquisition/reacquisition procedures that affect the accuracy and/or repeatability of the data and cannot be assessed in real-time during normal field operations.

3.0 LOCATION

The GPO area is located near the scrap yard off of Bains Gap Road (see Appendix A). The GPO area is representative of the environment encountered during geophysical operations at Fort

McClellan. Three test grids were constructed in this area. Test grid #3 was recently constructed in the road to validate operations associated with the mapping of the FWS roads. Test grid #1 and #3 were used for this GPO.

4.0 EQUIPMENT

Based on FWENC's previous experience at numerous UXO sites, the EM61 MK2 instrument was selected because it has exhibited the best potential to meet the similar program objectives. The EM61 MK2 will be housed in an array resulting in a 13 ft fan of coverage. A diesel Mule will tow the array. The system is known as the Vehicle Towed Array (VTA). Foster Wheeler Environmental has evaluated the following equipment in the GPO test grid.

4.1 VTA

The VTA utilized five (5) EM61 MK2, which are composed of multiple time-gates centered at 216, 366, 660 (bottom coil) and 660 (top coil) μs. The signal intensity for a given ferrous target recorded by the earlier time-gates is generally a factor of 2 to 4 times that recorded by the standard (660μs) EM61 MK2 time-gate. This feature facilitates a more efficient and repeatable interpretation of smaller targets such as 37mm projectiles. The VTA is equipped with two Differential Global Positioning Systems (DGPS) mounted at the front and rear on the array assembly. In addition to the GPS system, the VTA demonstrated a new fiducial marking system, which allows the operator to post fiducial marks in the data stream at known locations. The data can then be force-fit to these known locations.

4.2 CONSTELLATION POSITIONING SYSTEM

The Constellation Positioning System was selected for the system's ability to acquire data in heavily wooded areas. This system consists of four (4) laser transmitters, each with a unique signature of light pulses, optical sensors, and signal processing. The positioning is based on line-of-sight triangulation. The Constellation system remotely transmits data from a handheld computer to a stationary laptop computer. The resulting positioning file is then merged with the sensor data to produce an .xyz file. The Constellation system may be used in areas of difficult terrain. If the constellation system is used at any time during the FWS mapping, the system will be validated in the GPO test grid #1. The results of the validation will be submitted to the government as a revision to this document.

4.3 SEEDED ITEMS

All seeded items were buried or set in place by qualified UXO personnel following a background survey of test grid #1 and #3 (see Appendix B). All items detected during the background survey were removed from the ground. Photographs of the seeded items can be found in the attached CD-ROM. Locations of the items can be found in Appendix C.

5.0 PROCEDURES

5.1 DATA ACQUISITION

Data was acquired at a line spacing of approximately 2.0 ft for both test grid #1 (open area) and test grid #3 (road). Prior to starting the acquisition session, the coil height was measured to 16 inches above ground level. Shake tests were performed to verify that all cables were secure in position. All three time-gates were electronically nulled to zero in a magnetically "quiet" area using FWENC internal acquisition software. Following these procedures, static and dynamic data were recorded to facilitate shift and drift corrections. In the open area, the VTA operated in GPS mode. High-quality satellite geometry was maintained throughout the session. The Vehicle traveled in an oval racetrack type pattern to ensure full coverage. The results of this mapping can be found in Appendix D. The road test grid was mapped in fiducial mode. The operator was instructed to travel at a constant speed. Fiducial marks were placed in the data stream by pressing the spacebar on the onboard computer. The fiducial mark was selected each time the VTA traversed one of the fiducial markers which were located every 200ft. A known EM source (chain) was placed at every second fiducial mark for subsequent data shifting.

5.2 DATA PROCESSING

Data were stored on PCMCIA cards following data acquisition. After acquisition on the test grids was completed, data was transferred from the PCMCIA cards to the site laptop computer for processing. A Foster Wheeler Environmental geophysicist performed preliminary geophysical and navigation data processing and Quality Control (QC) checks. The final analysis and interpretation of the data was performed at the Foster Wheeler Environmental processing center at Fort McClellan, Alabama. Processing, QC, analysis, and interpretation of the data was performed with internally developed software that has been specifically produced to integrate and interpret digital geophysical data acquired with the VTA in both GPS and fiducial mode. Geosoft Oasis Montaj Mapping software was also used to graphically display data and select targets. Data transfer was fully tested during the GPO. This included the transfer of raw EM and positioning data. Corrected and leveled processed data were converted to column delimited ASCII format.

5.3 REACQUISITION

The two methods of reacquisition demonstrated during the GPO are fiducial and GPS. The results of fiducial reacquire can be found in the Fiducial Anomaly Table located in Appendix C. The results of the GPS Test are provided in a separate table (GPS VTA Reacquire Results) also located in Appendix C. Accurate target reacquisition is an essential component when using the fiducial method. For this reason, the site geophysicist will be directly involved in this procedure. Based on the results of the mapping of roads in test grid #3, it is expected that there will be offsets in the position of anomalies in the direction of travel due to changes in velocity of the VTA. A search radius of 5ft will be used to reacquire anomalies detected when in fiducial mode. The site geophysicist will review the reacquisition results and will be in constant communication with the reacquire teams. The site geophysicist will also review the subsequent intrusive results to verify that the geophysical signature matches the item recovered. The methodology to be used for reacquiring anomalies detected in the fiducial mode will consist of tape pulls from bounding fiducial points. Each road has a metallic nail placed a maximum of 200ft apart. A nail is also

placed at turns in the road or other locations where there is a loss in line-of-sight. The reacquire teams will be given dig sheets that have distances from bounding markers. In addition to the along line distance from the markers, the teams will also be given the offset from the centerline. An example of the dig sheet can be found in Appendix E. Each anomaly location will be bounded by a 5 ft radius. The maximum audible response produced by a Vallon VMX within the 5 ft radius will be the location at which a flag will be placed. This procedure was confirmed from the results of the GPO reacquisition during which a Vallon VMX was used to pinpoint the location of the seeded items and the response was noted in the operator's logbook. Reacquisition of data acquired using GPS is far more straightforward. The dig sheets will consist of xy locations in local state plane coordinates. A man portable GPS unit was used to reacquire the anomalies from the data acquired in the open test grid #1. Eight anomalies were selected for reacquisition and were reacquired to within 0.5 ft on all eight. The target ID, Easting and Northing will be stored onto the man portable unit and the anomalies will be reacquired in "stakeout" mode within the GPS unit.

5.4 SUMMARY

All members of the geophysical mapping team demonstrated the ability to successfully meet the project objectives. Utilizing the VTA, the team confidently detected the seeded items with zero false positives.

6.0 CONCLUSIONS AND RECOMMENDATIONS

6.1 CONCLUSIONS

The GPO was conducted to validate and document the performance of the proposed data acquisition methodology (including personnel) and spatial sampling protocols, sensor(s) and positioning equipment, data analysis and management systems, data transfer procedures, and the geophysical Quality Control (QC) system.

The VTA in open areas or in areas with a relatively low tree line (as is the case in test grid #1) performed very well. The anomalies were located accurately and the data quality was good. The VTA test along the road was a creditable representation of roads to be mapped in the FWS. Anomalies #7 and #15 were removed from the GPO road test. These two items were placed on the surface of the road, but during the performance of the GPO the items were contacted by the wheels of the VTA and were subsequently displaced off of the road. Of the remaining 13 anomalies, only two were reacquired outside of 1 ft. One item was two feet and the second item was 4.3 feet. This can be attributed to variations in the VTA velocity. Based on these results, the VTA demonstrated the ability to meet the program objectives and should be approved for continual work.

6.2 RECOMMENDATIONS

FWENC has obtained valuable lessons learned from similar projects involving the geophysical mapping of roads in wooded areas. Mapping in fiducial mode over roads is very complex, therefore the FWENC VTA team has developed protocols to ensure that the quality standards, which have always been associated with our company, are maintained. Listed below are some of the key procedures that will be mandated for the mapping of the roads:

- Detailed notations including terrain description

- Communication between mapping team and site geophysicist
- Maintaining constant velocity in VTA
- Geophysical involvement in the reacquire procedures
- Detailed analysis of intrusive results by site geophysicist

Another recommendation was the development of software specially designed for this task. Fortunately FWENC has internal capabilities to develop state-of-the-art software, which was successfully utilized during the GPO. Some of the key features of the internally developed software include:

- Displayed track path on onboard computer
- Sensor profile display on onboard computer
- Notification screens for lost GPS lock
- Spacebar used for fiducial marker
- Position adjustment software (along line and offset from center line)

The GPO test grids at Fort McClellan are a very good indication of the types of areas that will be surveyed during the FWS Area Removal Project. It is anticipated that, trees, cultural features, and open areas will all be encountered on a daily basis. The items seeded in the prove-out are also representative of the items to be encountered during the investigation and have accurate depth and location calculations. Approximately 85% of the anomalies in road test grid #3 were reacquired to within 1ft of the actual location, however, it is recommended that a 5ft search radius be used during data reacquisition.

6.3 DETECTION METHOD

Using the early time-gate on the EM61 MK2 will allow for the detection of smaller, deeper items, however, the late time gates should be used to aid in discrimination

6.4 POSITIONING

As discussed above, the fiducial method requires a systematic approach and attention to detail. The GPO proved successful by operating within these parameters. The fiducial method coupled with available streaming GPS data is the recommended positioning method.

6.5 LINE SPACING

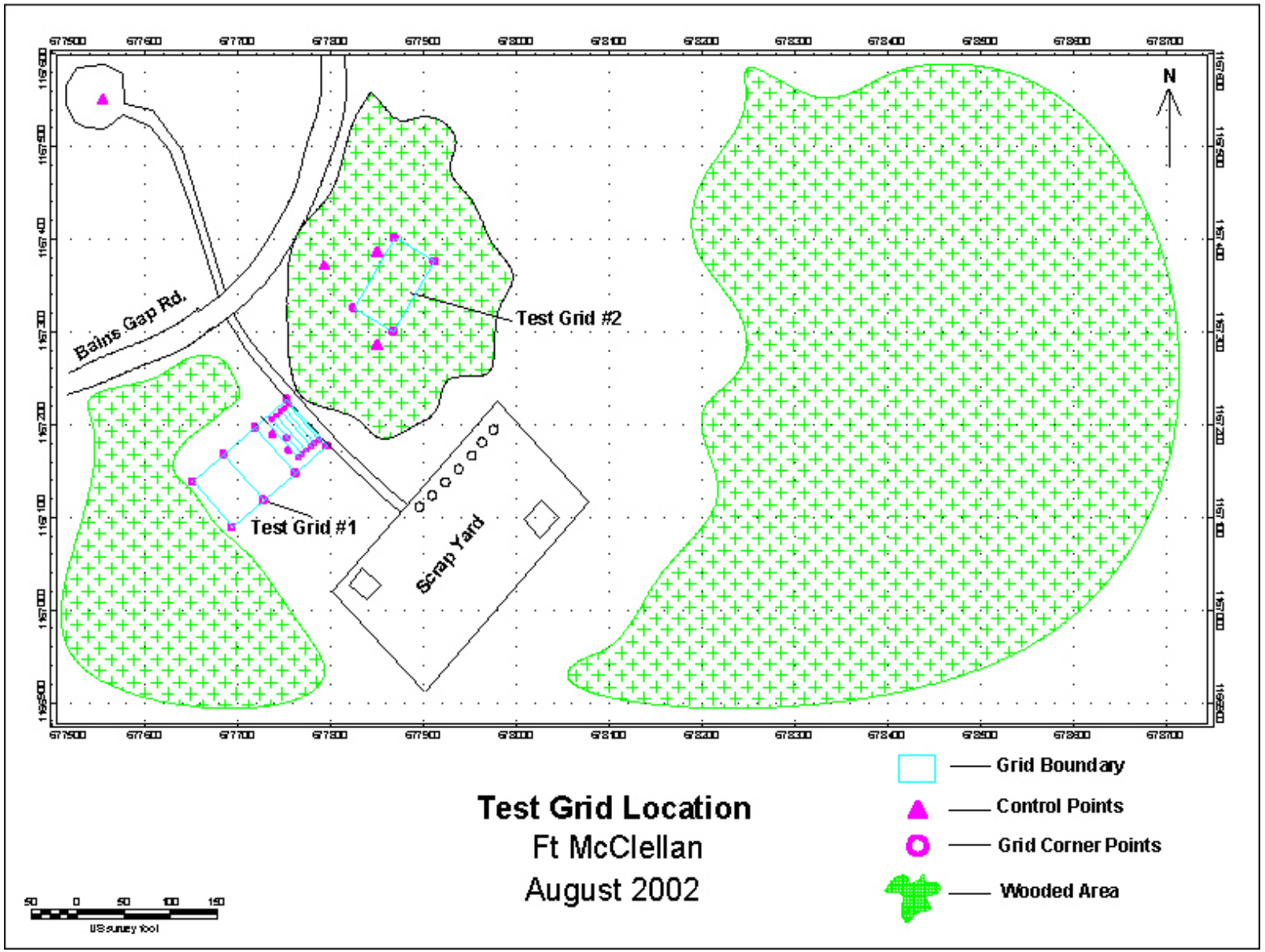
A line spacing of 2.0 to 2.5 ft is recommended. This spacing allows for overlap (1m by 1m coil) while reducing acquisition time.

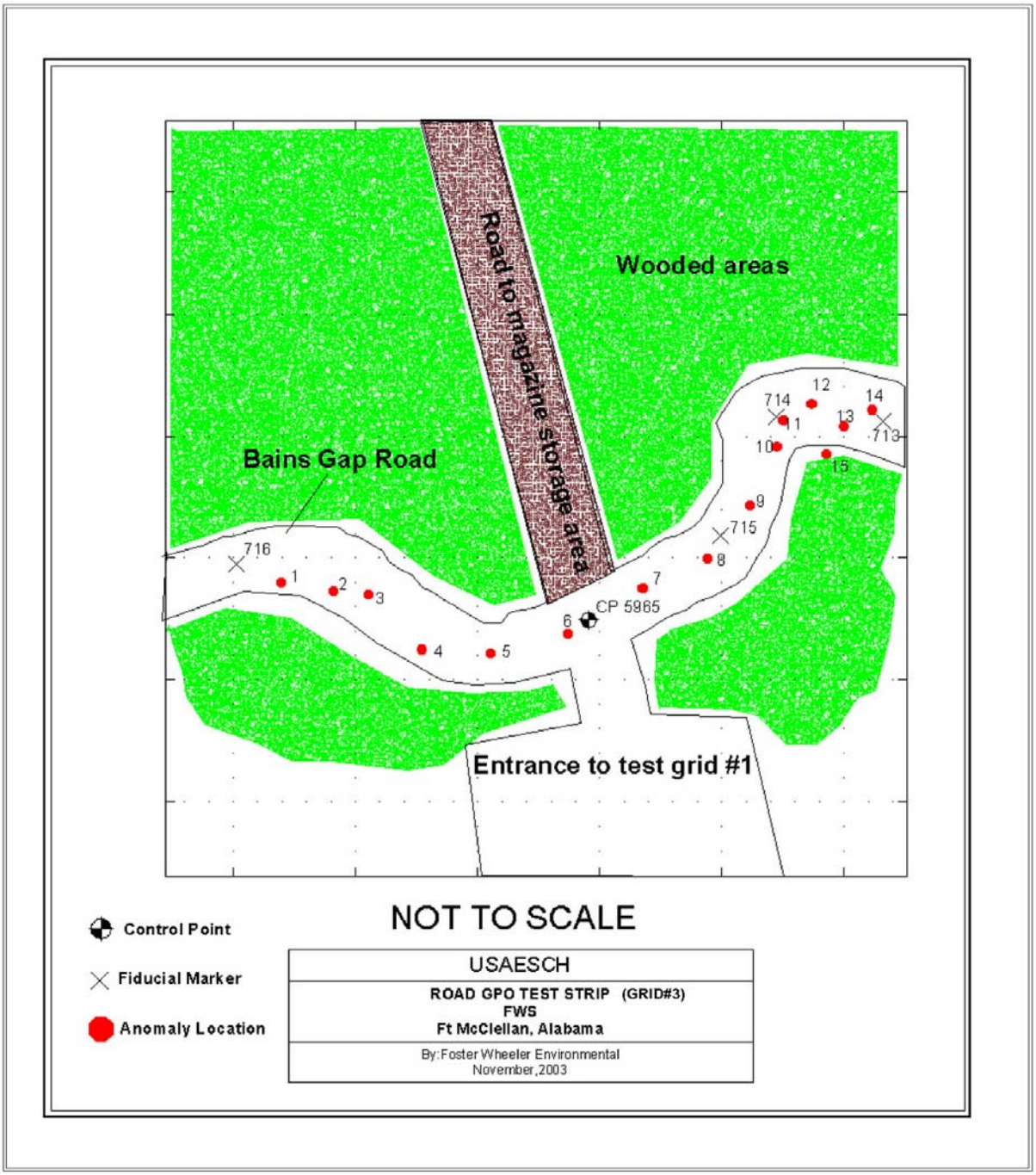
6.6 QUALITY CONTROL

The most essential component to ensure a successful project will be FWENC's internal Quality Control (QC). It is highly recommended that we continue following the procedures established during the preceding projects, which involved direct communication between FWENC QC personnel and the field personnel. The rule of QC will be to ensure that the above-mentioned procedures are implemented.

APPENDIX A

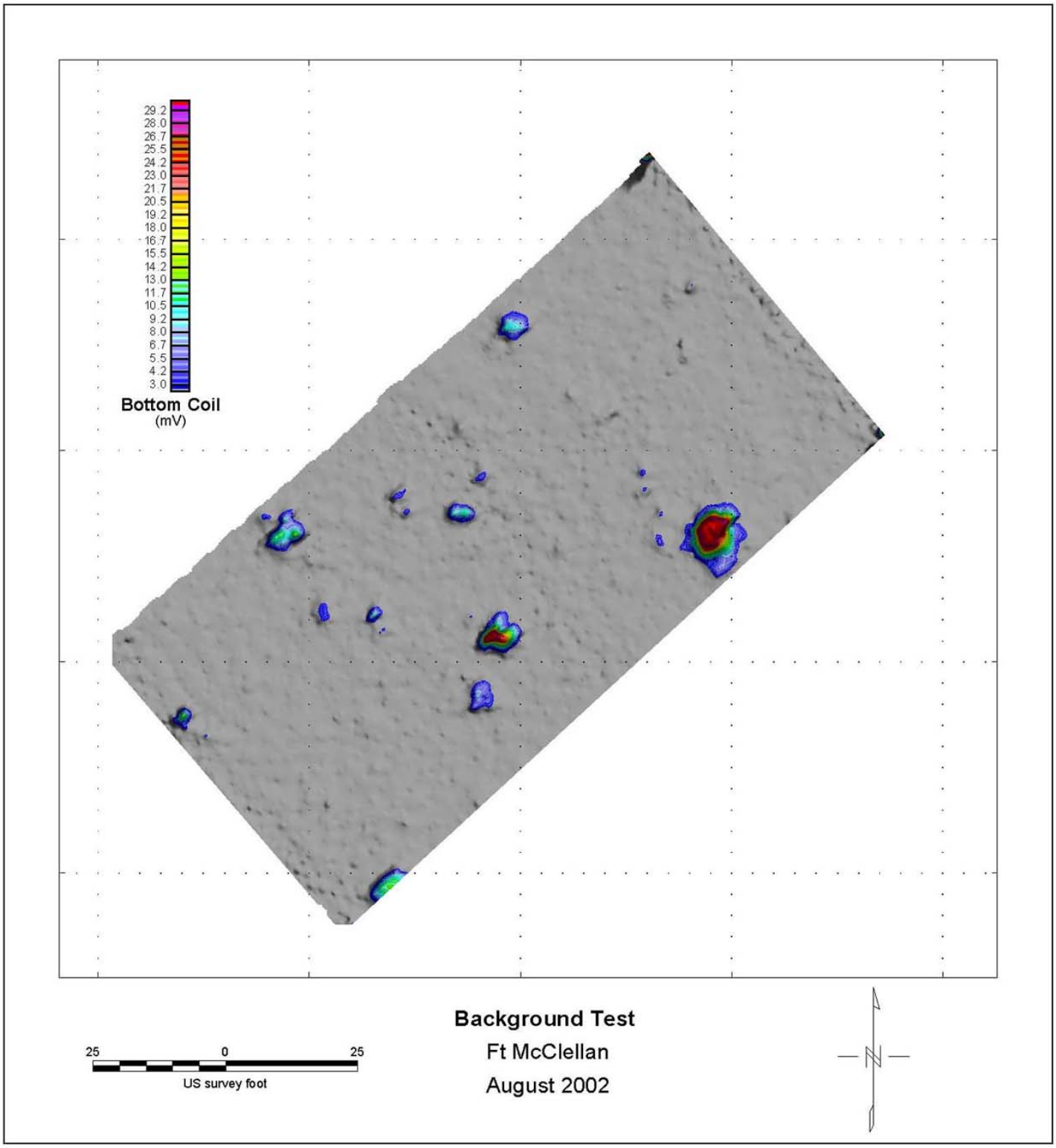
TEST GRID LOCATION


Test Grid Location
Ft McClellan
August 2002
Grid Boundary
Control Points
Grid Corner Points
Wooded Area
Test Grid #1
Test Grid #2
Bains Gap Rd.
Scrap Yard
N


Road to magazine storage area
Wooded areas
Bains Gap Road
716
1
2
3
4
5
6
CP 5965
7
8
715
9
10
714
11
12
13
14
713
15
Entrance to test grid #1
NOT TO SCALE
Control Point
Fiducial Marker
Anomaly Location
USAESCH
ROAD GPO TEST STRIP (GRID#3)
FWS
Ft McClellan, Alabama
By: Foster Wheeler Environmental
November, 2003

APPENDIX B

BACKGROUND TEST GRID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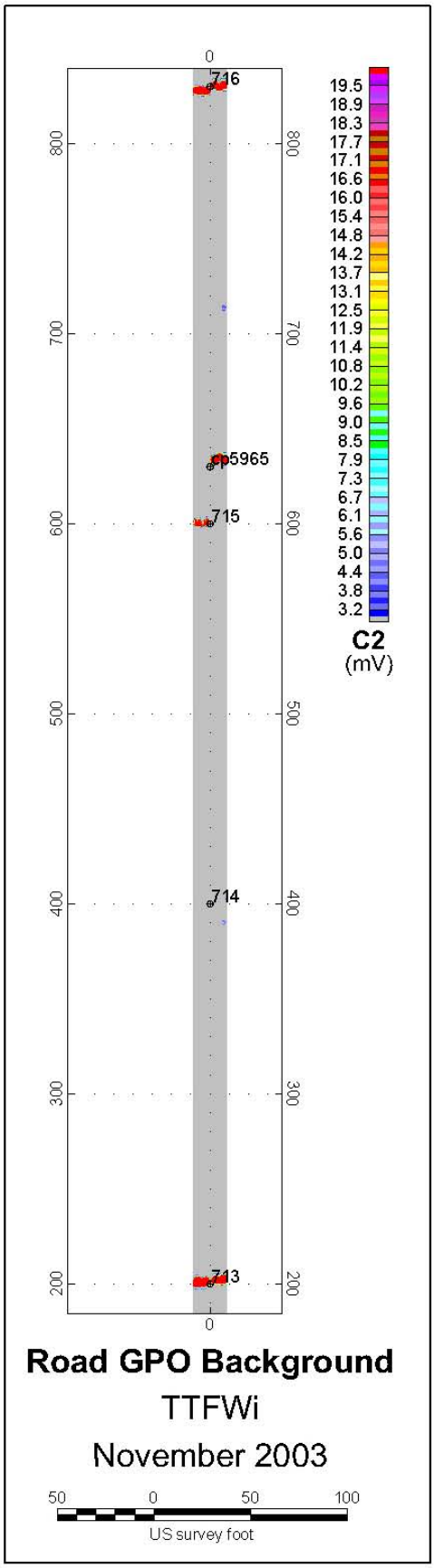
28.0
26.7
25.5
24.2
23.0
21.7
20.5
19.2
18.0
16.7
15.5
14.2
13.0
11.7
10.5
9.2
8.0
6.7
5.5
4.2
3.0
Bottom Coil
(mV)
25
0
25
US survey foot
Background Test
Ft McClellan
August 2002


716
Cp5965
715
714
713
19.5
18.9
18.3
17.7
17.1
16.6
16.0
15.4
14.8
14.2
13.7
13.1
12.5
11.9
11.4
10.8
10.2
9.6
9.0
8.5
7.9
7.3
6.7
6.1
5.6
5.0
4.4
3.8
3.2
C2
(mV)
Road GPO Background
TTFWi
November 2003
50 0 50 100
US survey foot

APPENDIX C

TABLES

TABLE 1

ANOMALY TABLE

X	Y	TARGET ID	ITEM	DEPTH(IN)	ORIENTATION
677699.94	1167164.58	a1	37mm	4.00	Horizontal
677708.37	1167173.14	a2	37mm	4.00	Vertical
677719.73	1167188.12	a3	81mm	34.00	Horizontal
677721.10	1167175.99	a4	2.36" rocket	26.00	Horizontal
677730.10	1167179.32	a5	rocket motor	12.00	Horizontal
677723.37	1167167.69	a6	37mm	16.00	Horizontal
677735.00	1167169.03	a7	60mm	12.00	Vertical
677735.62	1167156.66	a8	MKII HG	8.00	Vertical
677745.30	1167155.03	a9	2.36" rocket	6.00	Vertical
677743.41	1167136.92	a10	Anti Tank Mine	6.00	Horizontal
677726.67	1167132.67	a11	60mm	6.00	Vertical
677718.25	1167118.37	a12	MKII HG	4.00	Horizontal
677719.58	1167146.36	a13	37mm	0.00	Horizontal
677688.23	1167097.99	a14	3 "stokes	20.00	Horizontal
677704.27	1167108.58	a15	3 "stokes	32.00	Horizontal
677694.61	1167113.24	a16	75mm	30.00	Horizontal
677709.18	1167133.61	a17	60mm	25.00	45 degrees
677691.87	1167128.25	a18	75mm	12.00	Vertical
677681.35	1167118.85	a19	MKII HG	14.00	Horizontal
677673.49	1167132.86	a20	75mm	18.00	45 degrees
677666.45	1167141.88	a21	37mm	4.00	45 degrees
677680.90	1167152.03	a22	slap flare	4.00	45 degrees
677706.20	1167151.98	a23	105mm	45.00	45 degrees
677753.84	1167216.57	a24	37mm	4.00	Horizontal
677765.13	1167208.06	a25	37mm	4.00	Vertical
677771.70	1167196.19	a26	81mm	17.00	Horizontal
677771.95	1167190.79	a27	2.36" rocket	26.00	Horizontal
677781.41	1167187.60	a28	rocket motor	12.00	Horizontal
677794.28	1167178.14	a29	37mm	16.00	Horizontal
677775.16	1167162.11	a30	60mm	12.00	Vertical
677767.82	1167173.71	a31	MKII HG	8.00	Vertical
677763.33	1167167.94	a32	2.36" rocket	6.00	Vertical
677750.42	1167179.97	a33	60mm	6.00	Horizontal
677756.51	1167195.77	a34	60mm	6.00	Vertical
677740.94	1167197.48	a35	MKII HG	4.00	Horizontal
677741.04	1167180.67	a36	37mm	0.00	Horizontal
677728.58	1167178.52	a37	3 "stokes	20.00	Horizontal
677733.40	1167171.79	a38	3 "stokes	32.00	Horizontal

TABLE 1

ANOMALY TABLE

X	Y	TARGET ID	ITEM	DEPTH(IN)	ORIENTATION
677743.27	1167161.79	a39	75mm	30.00	Horizontal
677758.76	1167148.27	a40	81mm	25.00	45 degrees
677697.46	1167163.21	a41	75mm	12.00	Vertical
677699.23	1167155.70	a42	MKII HG	0.00	Horizontal
677700.11	1167144.91	a43	75mm	18.00	45 degrees
677715.77	1167137.08	a44	37mm	4.00	45 degrees
677715.85	1167112.69	a45	slap flare	4.00	Vertical
677706.94	1167104.36	a46	105mm	10.00	Vertical
677693.62	1167134.69	a47	81mm	34.00	Vertical
677683.47	1167133.54	a48	rocket motor	12.00	Vertical
677680.56	1167145.54	a49	3 "stokes	20.00	Vertical
677674.37	1167119.69	a50	37mm	2.00	Horizontal
677753.19	1167226.71	NE	corner point		
677651.45	1167138.05	NW	corner point		
677762.26	1167147.30	M1	mid point		
677728.18	1167117.92	M2	mid point		
677685.25	1167167.49	M3	mid point		
677719.52	1167196.53	M4	mid point		

TABLE 2

CORNER POINTS

CORNER POINT	X	Y
SW	677693.96	1167088.76
SE	677796.54	1167176.86
NE	677753.19	1167226.71
NW	677651.45	1167138.05
M1	677762.26	1167147.30
M2	677728.18	1167117.92
M3	677685.25	1167167.49
M4	677719.52	1167196.53

Table 3
Fiducial Anomaly Table

POSITION	OFFSET FROM CENTER LINE	TARGET ID	ITEM	DEPTH	ORIENTATION	REACQUIRED POSITION	REACQUIRED OFFSET	OFFSET
28.45/716	0	1	Practice Hand Grenade	Surface	Horizontal	5965-170.2	L0.59	1.47
51.20/716	4.50 Left	2	Practice Hand Grenade	Surface	Horizontal	5965-149.4	L5.22	0.94
75.50/716	9.30 Right	3	Practice Hand Grenade	Surface	Horizontal	5965-123.8	R8.96	0.78
96.00/716	7.35 Left	4	75mm Shrap Round (75% Whole)	Surface	Horizontal	5965-104	L7.28	0.07
87.80/5965	5.70 Right	5	Practice Hand Grenade	Surface	Horizontal	5965-090.3	R5.2	2.55
7.8/5965	6.5 Left	6	60mm Mortar, Training	Surface	Horizontal	5965-007	L7.08	0.99
10.05/5965	3.55 Left	7	removed	Surface	Horizontal	NA	NA	NA
27.60/715	8.55 Left	8	81mm Mortar, Training	Surface	Horizontal	0714-172.1	R8.4	0.34
61.70/715	6.30 Left	9	37mm, Projectile, AP (75% Whole)	Surface	Horizontal	0714-133.8	L7.7	4.71
49.30/714	5.35 Left	10	75mm Fragment (2in long)	Surface	Horizontal	0714-047	L5.17	2.31
2.20/714	7.90 Left	11	37mm, Projectile, AP (75% Whole)	Surface	Horizontal	0713-199.7	L8.08	1.91
27.50/714	7.85 Right	12	60mm Mortar, Training	Surface	Horizontal	0713-173.3	R7.43	0.90
80.70/714	6.10 Left	13	75mm Fragment (2in long)	Surface	Horizontal	0713-124.5	L7.12	5.30
31.50/714	5.25 Right	14	Small sample of Misc. Fragmentation	Surface	Horizontal	0713-033	R5.83	1.61
92.30/713	14.70 Left	15	removed	Surface	Horizontal	NA	NA	NA

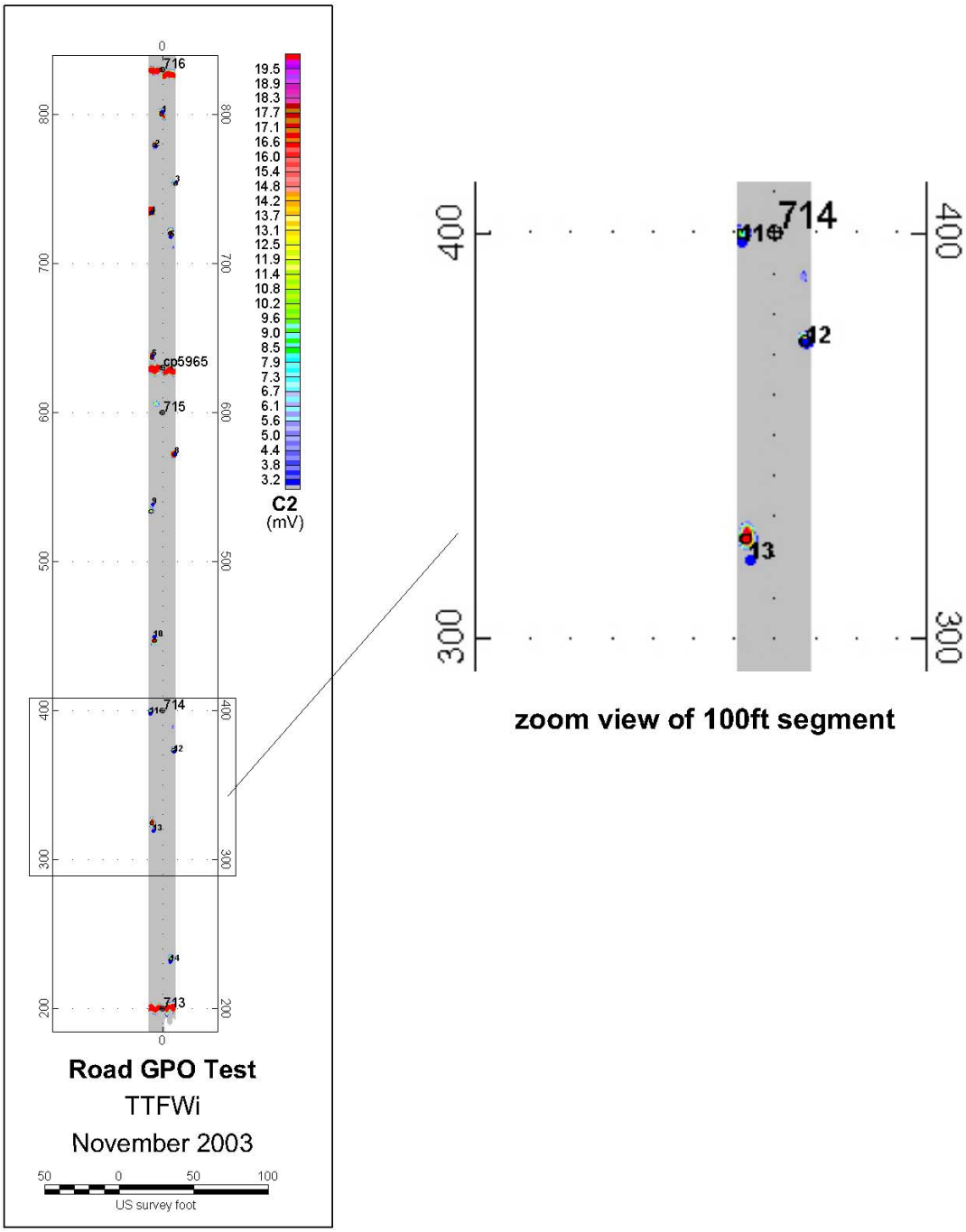
Table 4

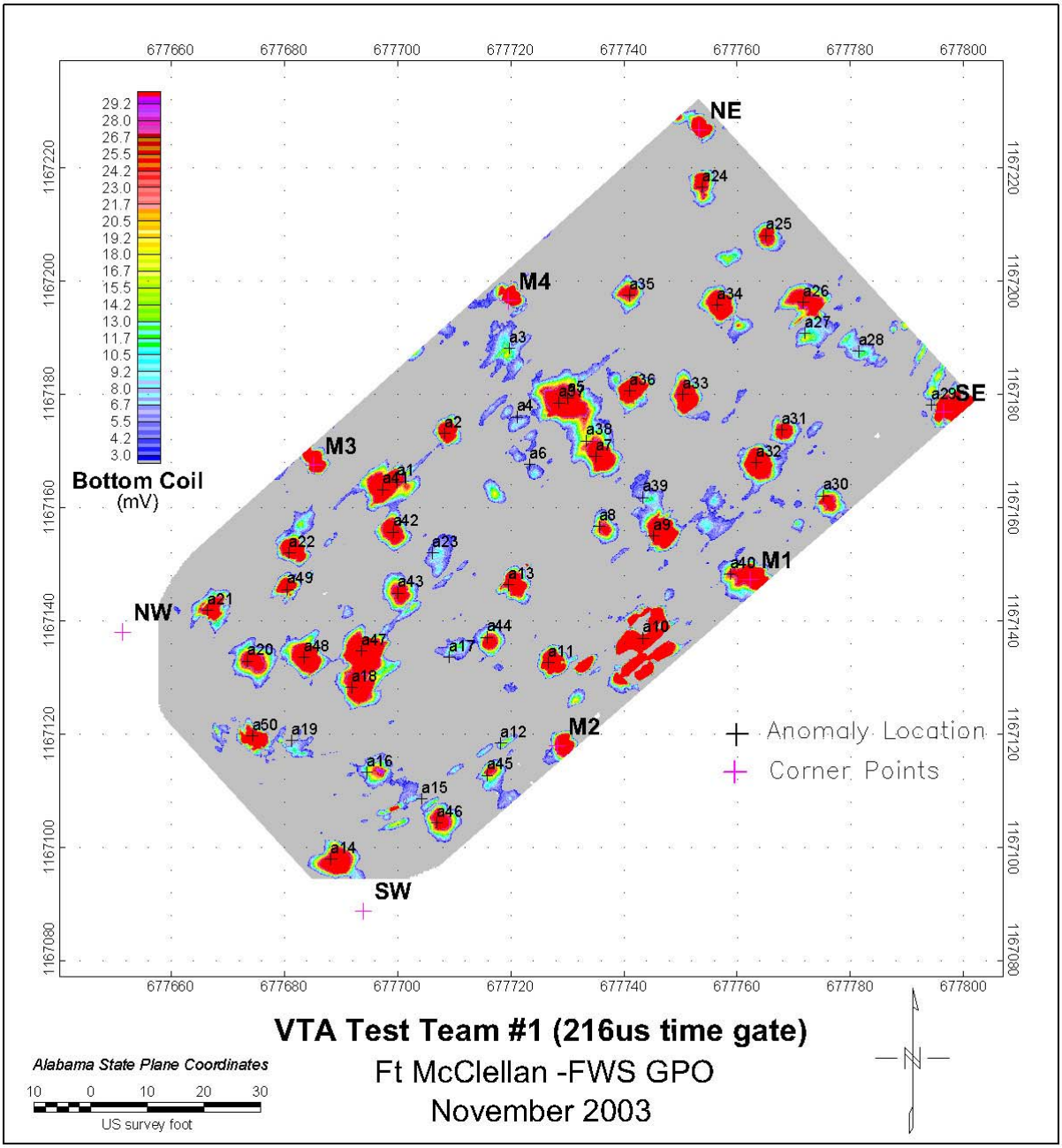
GPS VTA Reacquire Results

X	Y	TargetID	Item	Depth(in)	Orientation	ReaquireX	ReaquireY	OffsetX(in)	OffsetY(in)
677708.37	1167173.14	a2	37mm	4.00	Vertical	677708.64	1167173.53	0.27	0.39
677726.67	1167132.67	a11	60mm	6.00	Vertical	677726.94	1167132.47	0.34	0.20
677719.58	1167146.36	a13	37mm	0.00	Horizontal	677720.27	1167146.67	0.76	0.31
677767.82	1167173.71	a31	MKII HG	8.00	Vertical	677767.83	1167173.70	0.02	0.00
677740.94	1167197.48	a35	MKII HG	4.00	Horizontal	677740.97	1167198.00	0.51	0.51
677741.04	1167180.67	a36	37mm	0.00	Horizontal	677741.14	1167180.72	0.11	0.05
677699.23	1167155.70	a42	MKII HG	0.00	Horizontal	677699.23	1167156.08	0.38	0.38
677700.11	1167144.91	a43	75mm	18.00	45 degrees	677700.08	1167145.13	0.22	0.22
	Note: only select items where selected for reacquire sited in the GPO work plan								

APPENDIX D

TEST RESULTS


716
cp5965
715
714
713
C2
(mV)
Road GPO Test
TTFWi
November 2003
US survey foot
zoom view of 100ft segment


677660
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677700
677720
677740
677760
677780
677800
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1167200
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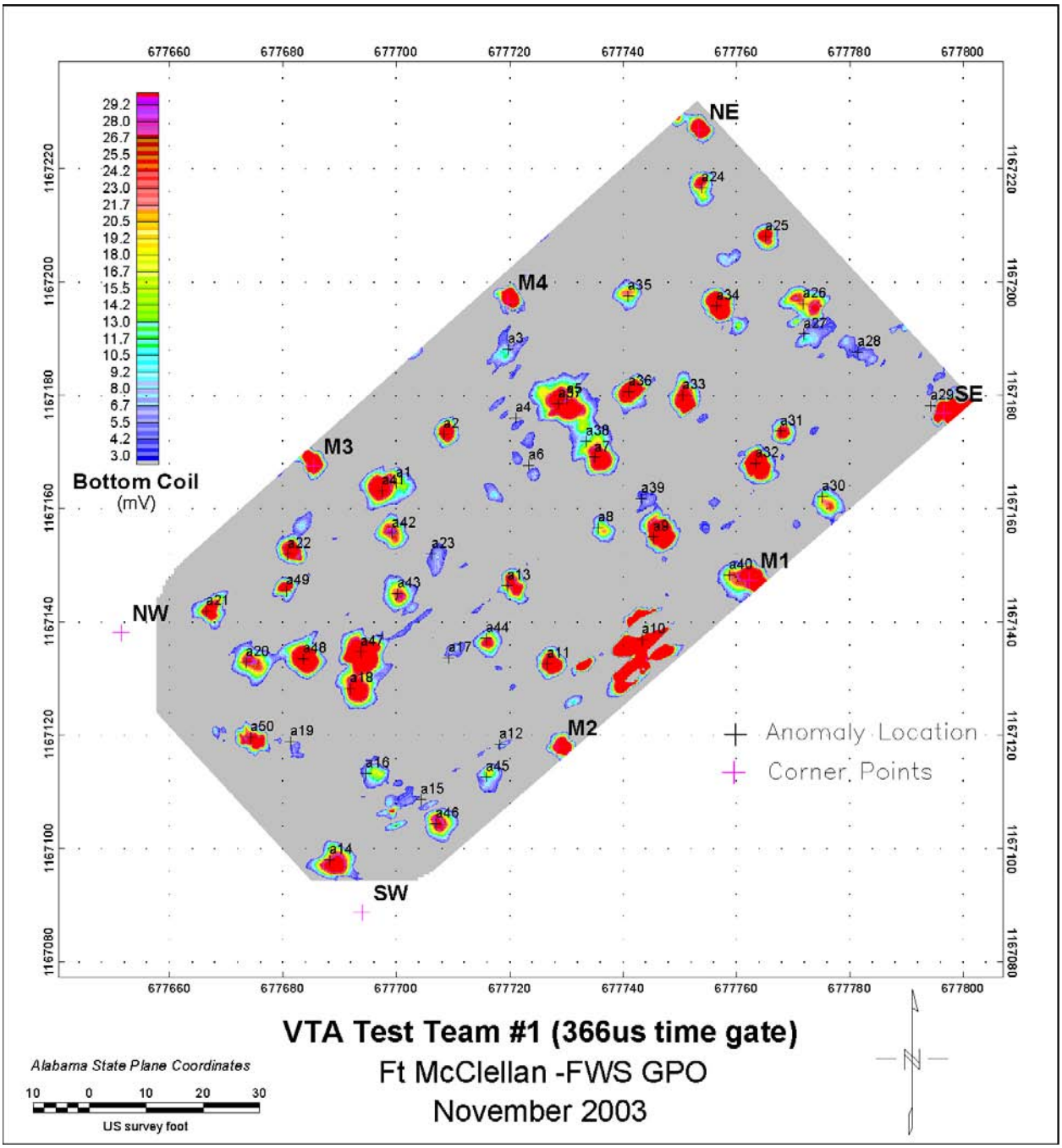
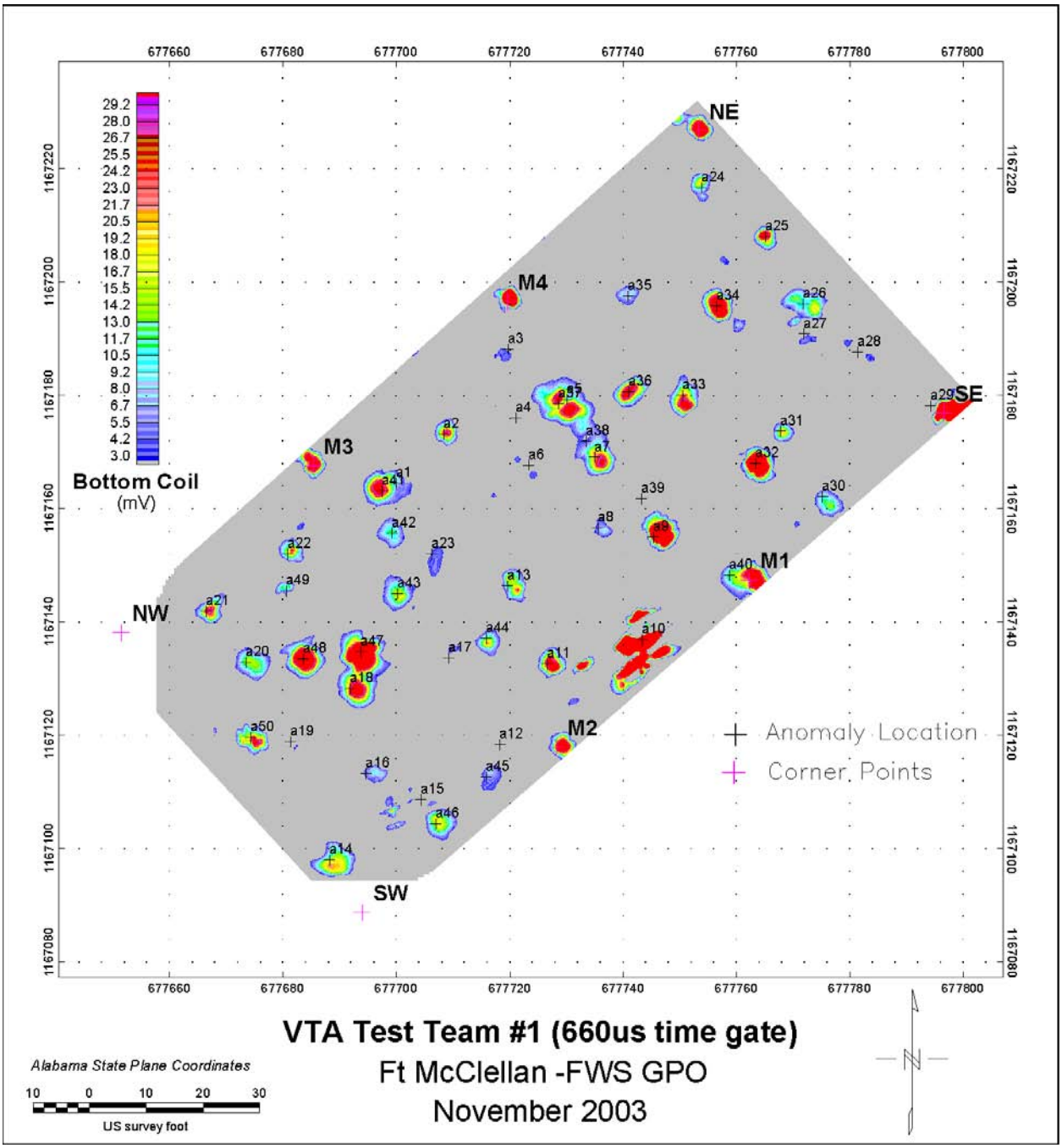
1167160
1167140
1167120
1167100
1167080
29.2
28.0
26.7
25.5
24.2
23.0
21.7
20.5
19.2
18.0
16.7
15.5
14.2
13.0
11.7
10.5
9.2
8.0
6.7
5.5
4.2
3.0
Bottom Coil
(mV)
NE
SE
NW
SW
M1
M2
M3
M4
Anomaly Location
Corner Points
VTA Test Team #1 (216us time gate)
Ft McClellan -FWS GPO
November 2003
Alabama State Plane Coordinates
10 0 10 20 30
US survey foot


Bottom Coil
(mV)
29.2
28.0
26.7
25.5
24.2
23.0
21.7
20.5
19.2
18.0
16.7
15.5
14.2
13.0
11.7
10.5
9.2
8.0
6.7
5.5
4.2
3.0
NE
SE
SW
NW
M1
M2
M3
M4
Anomaly Location
Corner Points
VTA Test Team #1 (366us time gate)
Ft McClellan -FWS GPO
November 2003
Alabama State Plane Coordinates
US survey foot


Bottom Coil
(mV)
29.2
28.0
26.7
25.5
24.2
23.0
21.7
20.5
19.2
18.0
16.7
15.5
14.2
13.0
11.7
10.5
9.2
8.0
6.7
5.5
4.2
3.0
NE
SE
SW
NW
M1
M2
M3
M4
Anomaly Location
Corner Points
VTA Test Team #1 (660us time gate)
Ft McClellan -FWS GPO
November 2003
Alabama State Plane Coordinates
US survey foot

APPENDIX E

DIG SHEET

US Fish and Wildlife

Reacquire Sheet

Anomaly #	From Fiducial __ to __ Feet	From Fiducial __ to __ Feet	Cross Distance
01	0716-029.8	5965-170.2	L0.59
02	0716-050.6	5965-149.4	L5.22
03	0716-076.2	5965-123.8	R8.96
04	0716-096	5965-104	L7.28
05	0716-109.7	5965-090.3	R5.2
06	0716-193	5965-007	L7.08
08	0715-027.9	0714-172.1	R8.4
09	0715-066.2	0714-133.8	L7.7
10	0715-153	0714-047	L5.17
11	0714-000.3	0713-199.7	L8.08
12	0714-026.7	0713-173.3	R7.43
13	0714-075.5	0713-124.5	L7.12
14	0714-167	0713-033	R5.83

Wednesday, December 03, 2003 2: Page 1 of 1

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