APPENDIX A

GEOPHYSICAL SURVEY REPORTS

ATTACHMENT A

GEOPHYSICAL SURVEY REPORT FOR SINKHOLE AT TRAINING AREA 8C

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List of Acronyms

EM	electromagnetic induction
EM31	Geonics Limited EM31 Terrain Conductivity Meter
EM61	Geonics Limited EM61 High-Resolution Metal Detector
G-856AX	Geometrics, Inc. G-856AX magnetometer
G-858G	Geometrics, Inc. G-858G magnetic gradiometer
GPS	global positioning system
IT	IT Corporation
MOA	Memorandum of Agreement
mS/m	millisiemens per meter
mV	millivolts
NAD-83	North American Datum 1983
N-S	north to south
nT	nanoTeslas
nT/m	nanoTeslas per meter
ppt	parts per thousand
TERC	Total Environmental Restoration Contract
USACE	U.S. Army Corps of Engineers
USCHPPM	U.S. Army Center for Health Promotion and Preventative Medicine

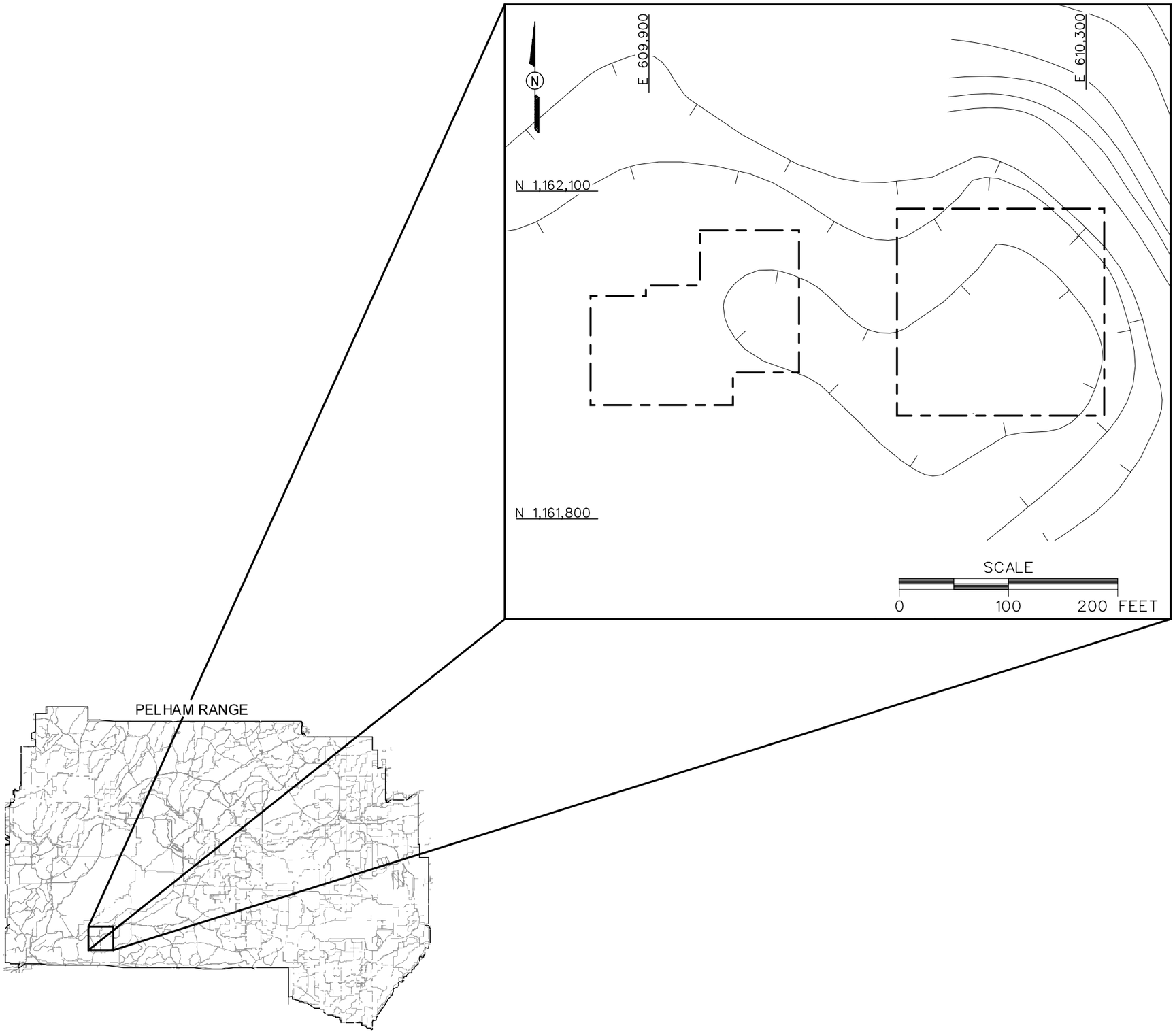
A.1.0 Introduction

IT Corporation (IT) conducted a surface geophysical survey at the sinkhole location in Training Area 8C, at Pelham Range, Fort McClellan Army National Guard Training Center, in Calhoun County, Alabama, from November 1 through 3, 2000 and from January 3 through 5, 2001. This survey was conducted for the U.S. Army Corps of Engineers (USACE) Mobile District, under Total Environmental Restoration Contract (TERC) No. DACA21-96-D-0018, Delivery Order CK005. The geophysical activities were designed to fulfill requirements of the Memorandum of Agreement (MOA) between the National Guard and the U.S. Army with regard to the transfer of Pelham Range to the Alabama National Guard. The geophysical survey objectives were to screen the two sinkholes located in the western survey area and the depression in the eastern survey area for the presence of hazardous debris such as smoke pots and oil drums suggested in historical reports. The total area surveyed was approximately 59,200 square feet (1.36 acres). The Vicinity Map (Figure A-1) shows the approximate locations of the survey areas.

To accomplish the objectives of the investigation, the magnetic method was initially used. Following review of the magnetic data contour maps, a decision was made to acquire electromagnetic (EM) profile data over select anomalies to refine interpretations. All geophysical data were processed and color-enhanced to aid in interpreting subtle anomalies. Following geophysics fieldwork, a sub-meter global positioning system (GPS) was used to document the location of the site.

The survey areas are generally flat topographically with a southwest sloping hill along the northern boundaries. There are two sinkholes in the western survey area and a depression in the eastern survey area as shown on the site map with geophysical interpretation (Figure A-2). The site is primarily tree covered with small areas of brush.

Field procedures used during the investigation are described in Chapter A.2.0. The data processing methods used during the investigation are presented in Chapter A.3.0. Data interpretation and criteria used to interpret geophysical anomalies are presented in Chapter A.4.0. Conclusions and recommendations derived from the geophysical surveys are presented in Chapter A.5.0. A description of the equipment and a theoretical discussion of the geophysical methods are presented in Attachment D.



LEGEND

- UNIMPROVED ROAD
- GEOPHYSICAL SURVEY AREA
- DEPRESSION

FIGURE A-1
VICINITY MAP
TRAINING AREA 8C
PELHAM RANGE

U. S. ARMY CORPS OF ENGINEERS
MOBILE DISTRICT
FORT McCLELLAN
CALHOUN COUNTY, ALABAMA
Contract No. DACA21-96-D-0018

Shaw™ Shaw Environmental, Inc.

DWG. NO.: ...\774645es.691 | PROJ. NO.: 774645
INITIATOR: C. SCHMALZ | PROJ. MGR.: J. YACOUB
DRAFT. CHCK. BY: | ENGR. CHCK. BY: C. SCHMALZ
DATE LAST REV.: | DRAWN BY:
STARTING DATE: 01/19/01 | DRAWN BY: D. BOMAR
5/18/2004 9:16:31 AM
dbomar
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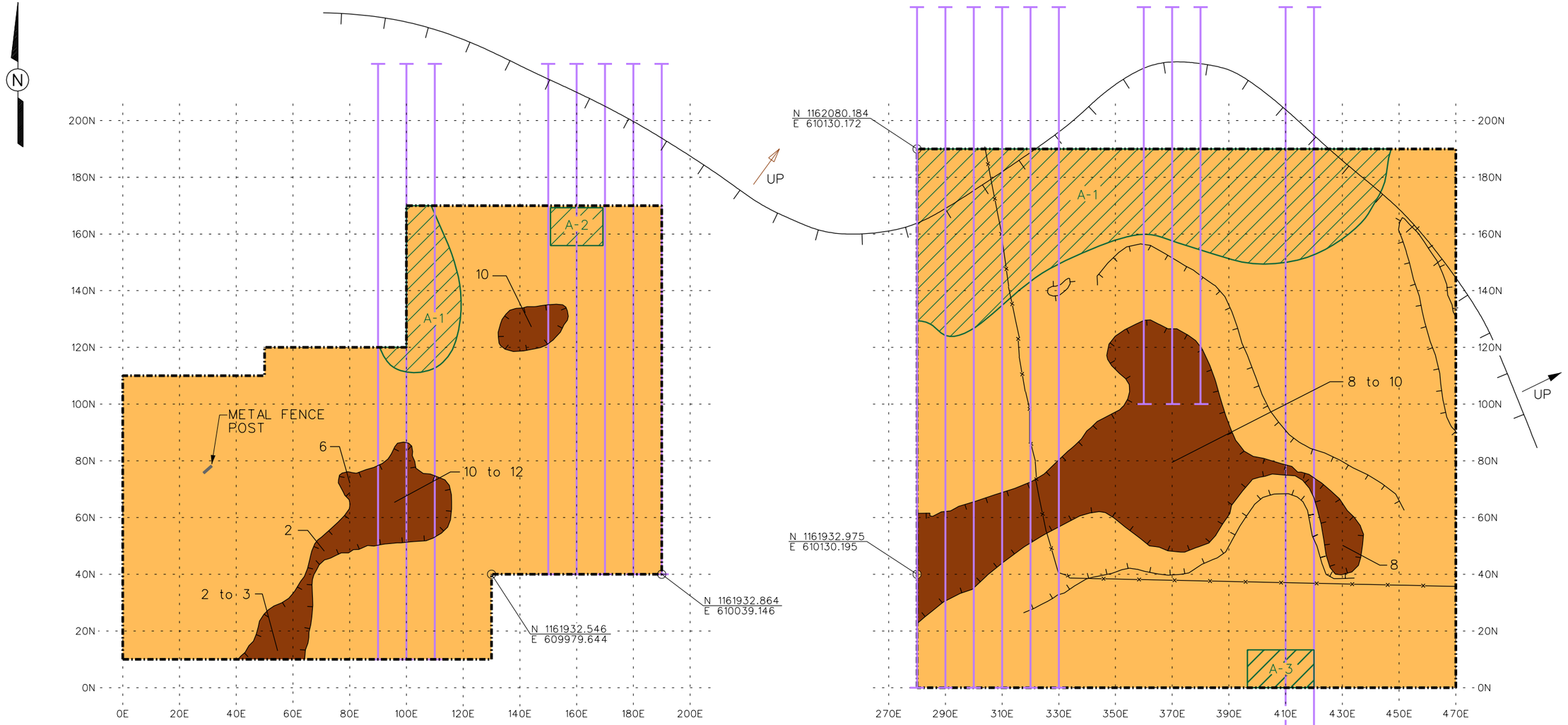

LEGEND:

- GEOPHYSICAL SURVEY BOUNDARY
- A-1 — ANOMALY CAUSED BY GEOLOGIC VARIATIONS (DISCUSSED IN TEXT)
- GEOPHYSICAL SURVEY LINES (EM31 & EM61)
- N 1161932.546 / E 609979.644 — ALABAMA EAST ZONE COORDINATE SYSTEM NORTH AMERICAN DATUM [NAD] 1983
- 2 to 3 — APPROXIMATE DEPTH TO BOTTOM OF DEPRESSION IN FEET
- DEPRESSION
- MOUND
- UP — SLOPE
- WIRE FENCE

NOTES:

1. LOCATION OF FEATURES OUTSIDE SURVEY AREA ARE APPROXIMATE.
2. SURVEY COORDINATES ARE APPROXIMATE SUB-METER GPS SYSTEM USED.

SCALE

0 40 80 FEET

FIGURE A-2
SITE MAP WITH GEOPHYSICAL INTERPRETATION
TRAINING AREA 8C
PELHAM RANGE

U. S. ARMY CORPS OF ENGINEERS
MOBILE DISTRICT
FORT McCLELLAN
CALHOUN COUNTY, ALABAMA
Contract No. DACA21-96-D-0018

Shaw™ Shaw Environmental, Inc.

DRAFT. CHCK. BY:
ENGR. CHCK. BY: C. SCHMALZ
INITIATOR: C. SCHMALZ
PROJ. MGR.: J. YACOUB
DWG. NO.: ...\774645es.718
PROJ. NO.: 774645
DATE LAST REV.:
DRAWN BY:
STARTING DATE: 01/29/01
DRAWN BY: D. BOMAR
5/18/2004 9:34:18 AM
dbomar
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A.2.0 Field Procedures

Field procedures are presented in this chapter, including discussions of the survey control and site map, field equipment, data acquisition parameters, and field verification of geophysical anomalies.

A.2.1 Survey Control

The geophysical survey area was identified in the site specific work plan based on historical site information compiled by IT and information obtained from Assessment No. 38-EH-1775-99 by the U.S. Army Center for Health and Preventative Medicine (USCHPPM). The geophysics crew established base grids on 100-foot centers throughout the site. Using the base grids as a reference, control points were marked on 10-foot centers with surveyor's paint to provide the resolution required for the investigation. Due to the uncertainty of true field positions inherent when establishing a survey area using 300-foot fiberglass tapes in the presence of wind and surface obstructions (e.g., trees and rough terrain), the lateral precision for the survey areas and anomalies is estimated to be within +/- 5 feet. Following geophysics field work, a GPS survey was conducted at the site referencing the U.S. State Plane Coordinate System (Alabama East Zone, North American Datum 1983 [NAD-83]). The GPS survey provided sub-meter resolution in XY coordinates for the site.

A detailed site map was hand-drawn in the field. The map included any surface cultural features within the survey area, or near the perimeter, that could potentially affect the geophysical data (e.g. topographic slopes, mounds, and surface metal). The map also shows reference features such as depressions that could later aid in reconstructing the site boundaries. All pertinent reference information documented on the hand-drawn site map was placed on the site interpretation map (Figure A-2). GPS coordinates are included on the site map to help relocate the survey areas.

A.2.2 Geophysical Survey

Field Instruments. The magnetic instruments used during the investigation consisted of a Geometrics Inc. G-858G magnetic gradiometer (G-858G) for collecting survey data and a Geometrics G-856AX used as a magnetic base station. Time-domain EM induction equipment consisted of a Geonics EM61 High-Resolution Metal Detector (EM61) coupled to an Omnidata

DL720 digital data logger. Frequency-domain EM induction equipment consisted of a Geonics EM31 Terrain Conductivity Meter (EM31) coupled to an Omnidata DL720 digital data logger.

All geophysical data were collected using the following IT standard operating procedures:

- ITGP-001 Surface Magnetic Surveys
- ITGP-002 Surface Frequency-Domain Electromagnetic Surveys
- ITGP-004 Surface Time-Domain Electromagnetic Surveys
- ITGP-012 Geophysical Data Management.

Field Instrument Base Station. A field instrument base station was established at the Training Area 8C site to provide quality control for the geophysical survey data collected. The base station location was chosen to be free of surface and subsurface cultural features that could affect the geophysical data. Standard field procedures were to occupy the base station and collect readings with the G-858G, EM31, and EM61 before and after each data collection session. These base station files were then reviewed to assess instrument operation. Base station file names and average data values within them were recorded on base station summary forms.

A.2.2.1 Magnetic Survey

Magnetic Base Station. A magnetic base station was established at Fort McClellan to record the background fluctuation (diurnal drift) of the Earth's magnetic field. The magnetic base station was located in a field of small pine trees on the south side of Sixth Avenue (near Parcel 151), a location which was determined to be free of surface and subsurface cultural features that could affect the data. The G-856AX base station magnetometer was time-synchronized with the G-858G field survey instrument and programmed to record the Earth's background magnetic field at 10-second intervals during the magnetic survey. These base station data were later used during data processing to "drift-correct" the G-858G survey data for variations in the Earth's magnetic field.

G-858G Data Collection. Magnetic field measurements were made with the two sensors of the G-858G spaced 2.5 feet (0.76 meters) apart vertically; the lower sensor was 2.0 feet above the ground surface and the upper sensor was 4.5 feet above the ground surface. At the start and end of each data collection session, approximately 60 readings were recorded with the G-858G at the field instrument base station to verify that the instrument was operating properly and to provide a quantitative record of instrument variation during the survey period. A review of these base

station files indicated the instrument was operating properly and the instrument drift was within acceptable limits. Magnetic survey data were collected at 0.5-second intervals (approximately 2.0- to 2.5-foot intervals) along north-south (N-S) oriented survey lines spaced 10 feet apart, for a total of approximately 6,270 linear feet of survey coverage.

The magnetic data were stored in the internal memory of the G-858G, along with corresponding line and station numbers and time of acquisition. Magnetic survey data were screened in the field to assess data quality prior to completing the investigation. All magnetic survey and base station data were downloaded to a personal computer, backed up on IOMEGA® compatible zip disks, and are retained in project files.

A.2.2.2 Time-Domain EM Survey

EM61 Data Collection. EM61 profile data were acquired to refine interpretations of magnetic data anomalies. Prior to conducting the EM61 survey, the instrument was calibrated to read zero at the field instrument base station. The EM61 was operated in the wheel mode with manual triggering, and measurements of the potential difference in the top and bottom coils were collected. At the start and end of each data collection session approximately 20 readings were recorded at the field instrument base to verify that the instrument was operating properly and to provide a quantitative record of instrument variation, or drift, during the survey period. A review of these base station files indicated the instrument was operating properly and instrument drift was within acceptable limits. Survey data were collected at 2.5-foot intervals along N-S oriented survey lines at select locations as noted on Figure A-2, for a total of approximately 3,970 linear feet of survey coverage.

The EM61 data were stored in the digital data logger programmed with corresponding line and station numbers. EM61 line profiles were reviewed in the field using the DAT61® program to verify data quality prior to completing the survey. All EM61 survey and base station data were downloaded to a personal computer, backed up on IOMEGA® compatible zip disks, and are retained in project files.

A.2.2.3 Frequency-Domain EM Survey

EM31 Data Collection. EM31 profile data were acquired to refine interpretations of magnetic data anomalies. Prior to conducting the EM31 survey, the instrument was calibrated and the in-phase component zeroed at the field instrument base station. The instrument was operated in the vertical dipole mode measuring the in-phase and out-of-phase components of the secondary EM field. At the start and end of each data collection session approximately 20 readings were recorded at the field instrument base station to verify that the instrument was operating properly and to provide a quantitative record of instrument variation, or drift, during the survey period. A review of these base station files indicated the instrument was operating properly and instrument drift was within acceptable limits. Survey data were collected at 5-foot intervals along N-S oriented survey lines at select locations as noted on Figure A-2, for a total of approximately 3,970 linear feet of survey coverage.

The EM31 data were stored in the digital data logger programmed with corresponding line and station numbers. EM31 line profiles were reviewed in the field using the DAT31® program to verify data quality prior to completing the survey. All EM31 survey and base station data were downloaded to a personal computer, backed up on IOMEGA® compatible zip disks, and are retained in project files.

A.2.2.4 Anomaly Verification

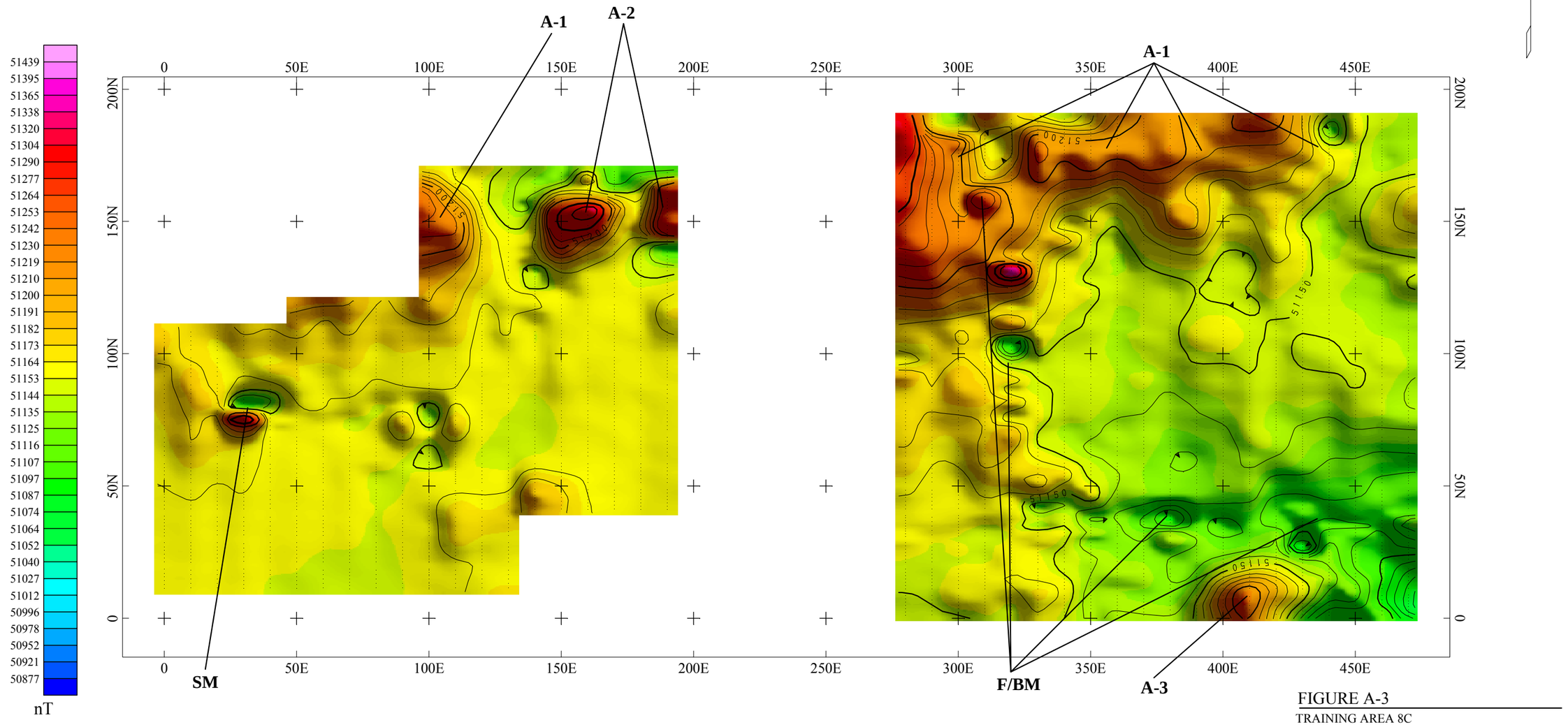
Preliminary color-contour maps of the magnetic data were generated and field-checked to differentiate between anomalies caused by surface and subsurface sources. Geophysical anomalies verified as being caused by surface features were labeled as such on the field data maps. Anomalies potentially caused by buried metallic objects were carefully located in the field and marked on the site map.

A.3.0 Data Processing

Color contour maps of the magnetic data were generated using the OASIS Montaj® geophysical mapping system from Geosoft, Inc. The maps were color-enhanced to aid with interpreting subtle anomalies. The magnetic data contour maps from this site are presented as Figures A-3 through A-5 and EM data profiles are presented as Figures A-6 through A-9.

A series of data processing steps were required to generate the contour maps. Magnetic gradiometer data were downloaded from the field instrument and converted to an ASCII file using the Geometrics, Inc. MAGMAP2000® program. EM61 and EM31 data were downloaded from the data logger and converted to ASCII files using DAT61® and DAT31® software from Geonics, Inc. The ASCII data files were then reviewed to assess line numbers, station ranges, and overall data quality. Field data file names and corresponding base station data files were recorded on the data file tracking form. Data screening results were then recorded on the base station summary form. Following data quality assessment, geometry corrections to field data files were made, if necessary, using a text editor and recorded on the geophysical data editing form.

Final, corrected magnetic, EM61, and EM31 data files containing local geophysical station coordinates (X,Y) and the geophysical measurement (Z) were converted to OASIS Montaj® format and imported into the geophysical mapping software. The magnetic data were then gridded using bi-directional gridding with an Akima spline. The grid cell size for the magnetic data was chosen to be 1.25 feet. Color contouring was used to enhance data anomalies. The EM61 and EM31 data are presented as profile maps. The names of files generated and processing parameters used were recorded on data processing forms. Final processed map names are shown in the data processing box found in the lower left corner of each map presented. All completed forms of magnetic data collected during the investigation are retained in project files.



LEGEND:

..... GEOPHYSICAL SURVEY LINES
A-1 GEOPHYSICAL ANOMALY DISCUSSED IN TEXT
F/BM ANOMALY CAUSED BY BURIED METAL
SM ANOMALY CAUSED BY SURFACE METAL

Scale 1:480

25 0 25 50 75
feet

Minimum Contour Interval: 10 nanoTeslas

NAME: James Cox	DATE: January 12, 2001
PROJECT NUMBER: 774645	LOCATION: D:\Projects\FT.McCLELLAN\MAG\8C.map

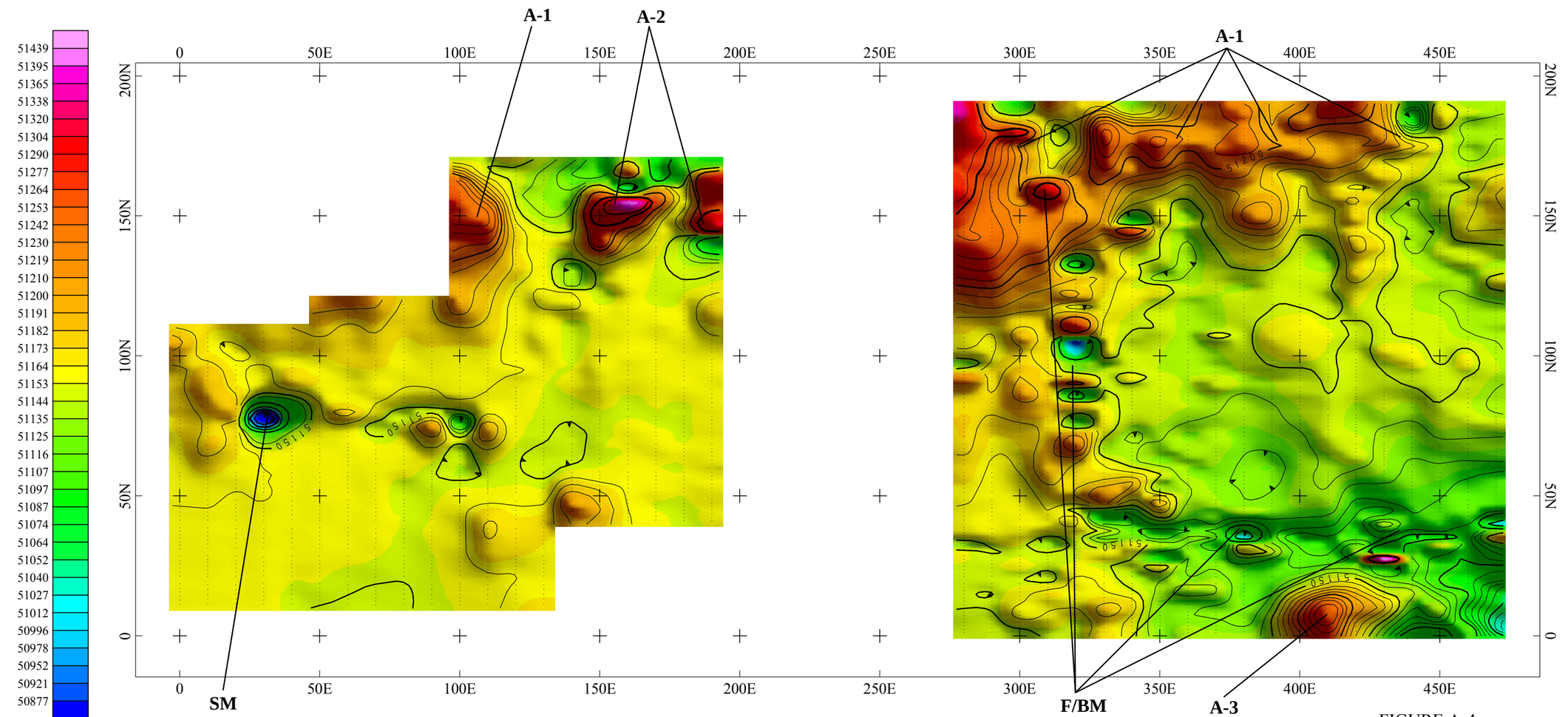
FIGURE A-3

TRAINING AREA 8C
FORT McCLELLAN-PELHAM RANGE

G-858G TOTAL MAGNETIC FIELD
UPPER SENSOR (4.5 FT ABOVE GROUND SURFACE)
NORTH-SOUTH SURVEY LINES

U.S. ARMY CORPS OF ENGINEERS
MOBILE DISTRICT
FORT McCLELLAN
CALHOUN COUNTY, ALABAMA
Contract No. DACA21-96-D-0018

Shaw Shaw Environmental, Inc.



LEGEND:

.....	GEOPHYSICAL SURVEY LINES
A-1	GEOPHYSICAL ANOMALY DISCUSSED IN TEXT
F/BM	ANOMALY CAUSED BY BURIED METAL
SM	ANOMALY CAUSED BY SURFACE METAL

Scale 1:480

25 0 25 50 75

feet

Minimum Contour Interval: 10 nanoTeslas

NAME: James Cox	DATE: January 12, 2001
PROJECT NUMBER: 774645	LOCATION: D:\Projects\FT.McCLELLAN\MAG\8CBOT.map

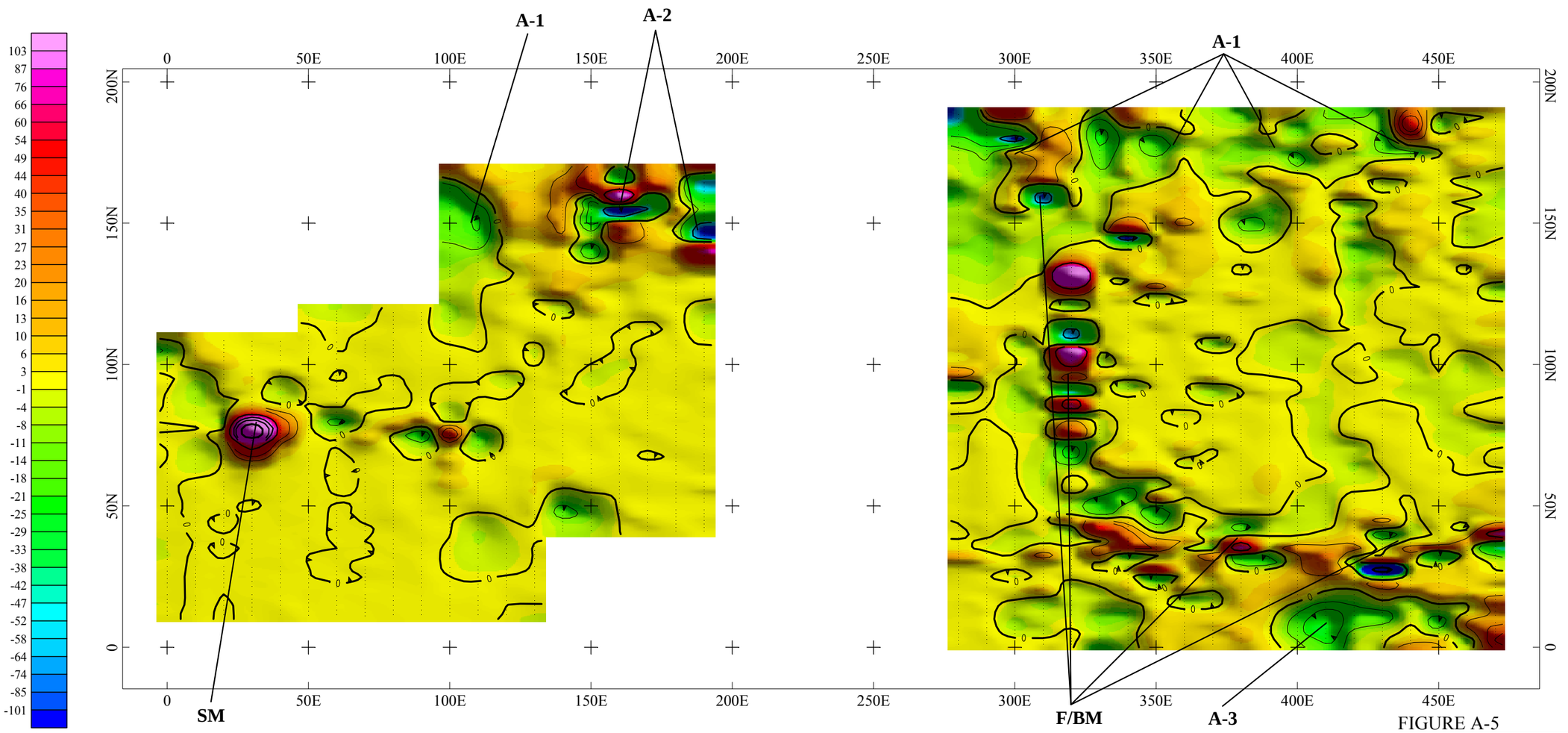
FIGURE A-4

TRAINING AREA 8C
FORT McCLELLAN-PELHAM RANGE

G-858G TOTAL MAGNETIC FIELD
LOWER SENSOR (2.0 FT ABOVE GROUND SURFACE)
NORTH-SOUTH SURVEY LINES

U.S. ARMY CORPS OF ENGINEERS
MOBILE DISTRICT
FORT McCLELLAN
CALHOUN COUNTY, ALABAMA
Contract No. DACA21-96-D-0018

Shaw Shaw Environmental, Inc.



LEGEND:

..... GEOPHYSICAL SURVEY LINES
A-1 GEOPHYSICAL ANOMALY DISCUSSED IN TEXT
F/BM ANOMALY CAUSED BY BURIED METAL
SM ANOMALY CAUSED BY SURFACE METAL

Scale 1:480

25 0 25 50 75
feet

Minimum Contour Interval: 10 nanoTeslas per meter

NAME: James Cox	DATE: January 12, 2001
PROJECT NUMBER: 774645	LOCATION: D:\Projects\FT.McCLELLAN\MAG\8CBOT.map

FIGURE A-5

TRAINING AREA 8C
FORT McCLELLAN-PELHAM RANGE

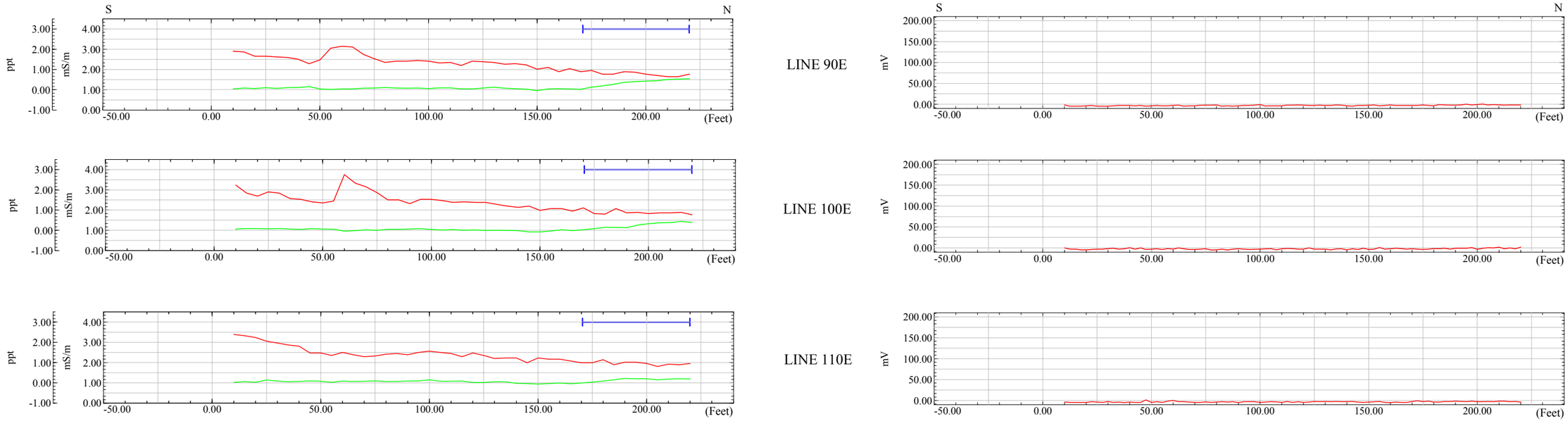
G-858G TOTAL MAGNETIC FIELD
VERTICAL GRADIENT
NORTH-SOUTH SURVEY LINES

U.S. ARMY CORPS OF ENGINEERS
MOBILE DISTRICT
FORT McCLELLAN
CALHOUN COUNTY, ALABAMA
Contract No. DACA21-96-D-0018

Shaw Shaw Environmental, Inc.

EM31 CONDUCTIVITY AND IN-PHASE DATA

EM61 BOTTOM COIL DATA



LEGEND:

ANOMALY CAUSED BY GEOLOGY

EM31 PROFILES

In-phase Component - parts per thousand (ppt)

Conductivity - milliSiemens per meter (mS/m)

EM61 PROFILES

milliVolts (mV)

NAME: Corby Schmalz	DATE: January 19, 2001
PROJECT NUMBER: 774645	LOCATION: C:\ITProjects\Ft.McClellan\8CEM31\Profile_A.map

FIGURE A-6

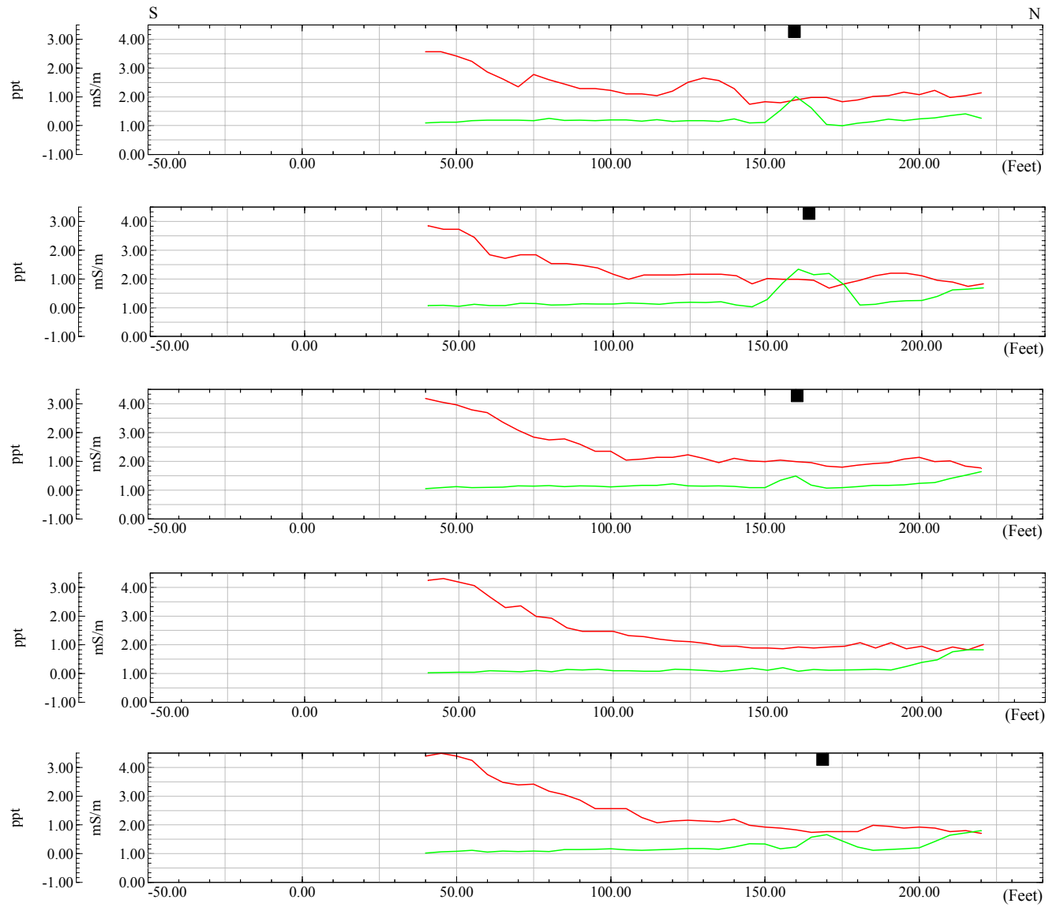
TRAINING AREA 8C
FORT McCLELLAN-PELHAM RANGE

EM31 AND EM61 GEOPHYSICAL PROFILE DATA
COLLECTED ALONG 90E, 100E, 110E
NORTH-SOUTH SURVEY LINES

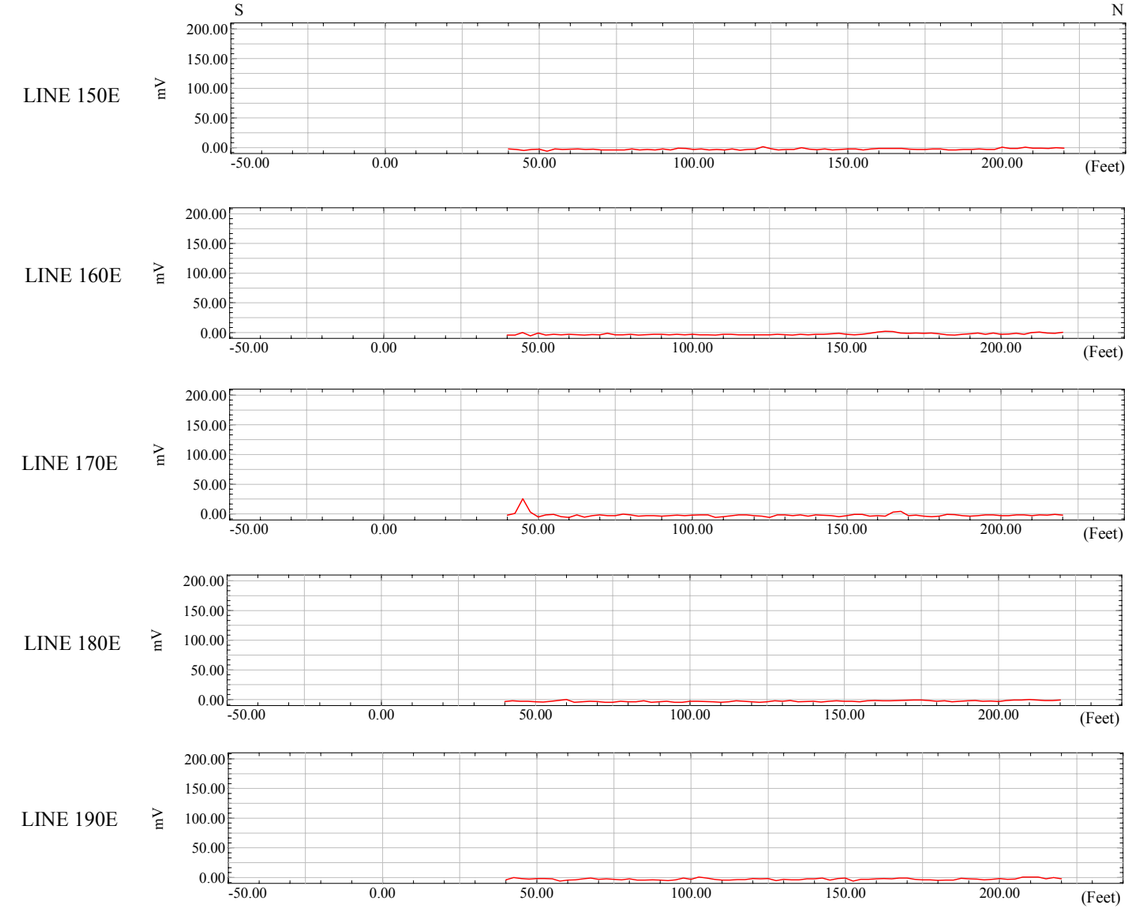
U.S. ARMY CORPS OF ENGINEERS
MOBILE DISTRICT
FORT McCLELLAN
CALHOUN COUNTY, ALABAMA
Contract No. DACA21-96-D-0018

Shaw® Shaw Environmental Inc.

EM31 CONDUCTIVITY AND IN-PHASE DATA



EM61 BOTTOM COIL DATA



LEGEND:

- GEOPHYSICAL ANOMALY
- ANOMALY CAUSED BY GEOLOGY

EM31 PROFILES

- In-phase Component - parts per thousand (ppt)
- Conductivity - milliSiemens per meter (mS/m)

EM61 PROFILES

- milliVolts (mV)

NAME: Corby Schmalz	DATE: January 19, 2001
PROJECT NUMBER: 774645	LOCATION: C:\ITProjects\Ft.McClellan\8CEM31\Profile_B.map

FIGURE A-7

TRAINING AREA 8C
FORT McCLELLAN-PELHAM RANGE

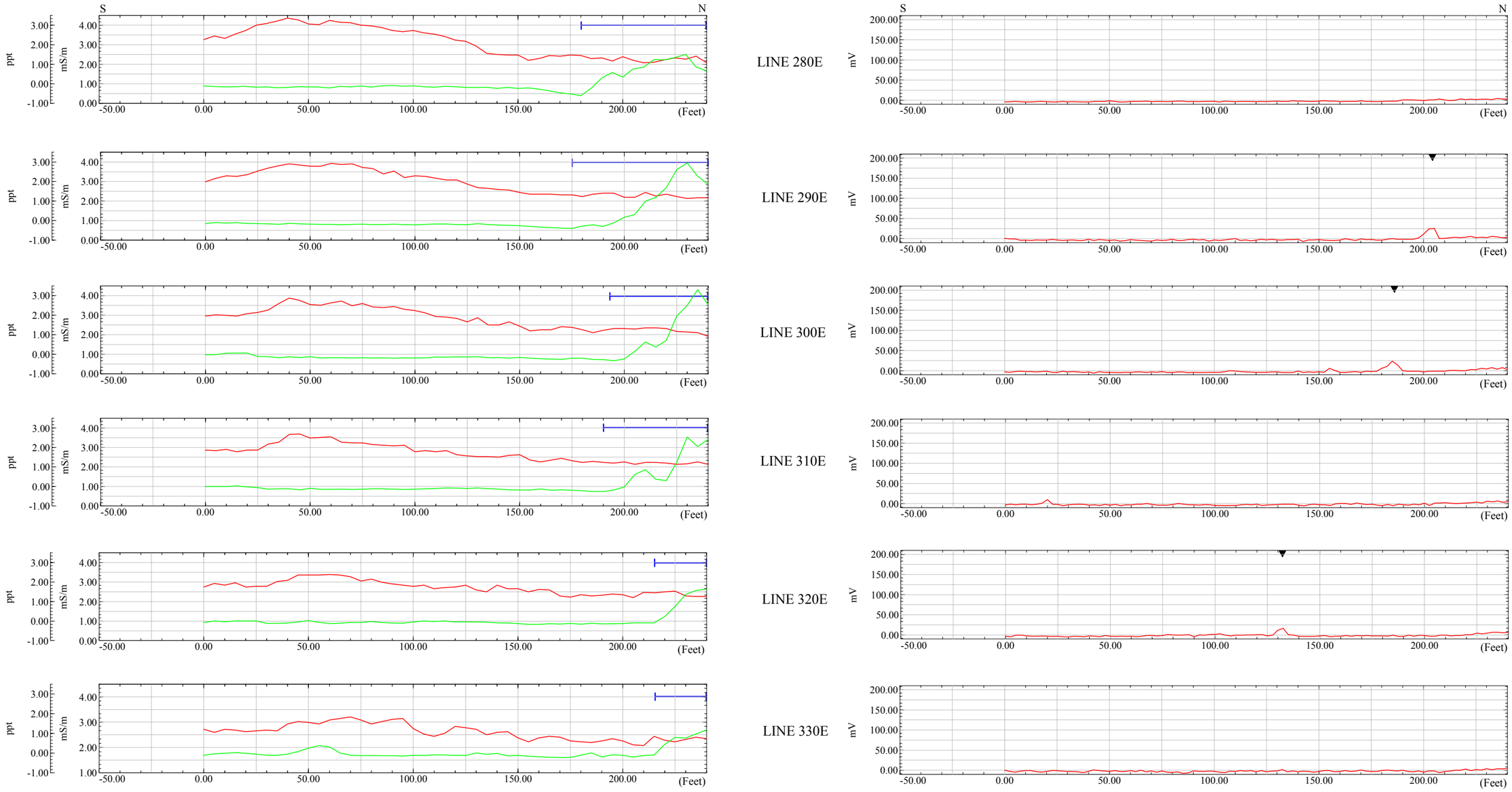
EM31 AND EM61 GEOPHYSICAL PROFILE DATA
COLLECTED ALONG 150E, 160E, 170E, 180E, 190E, 200E
NORTH-SOUTH SURVEY LINES

U.S. ARMY CORPS OF ENGINEERS
MOBILE DISTRICT
FORT McCLELLAN
CALHOUN COUNTY, ALABAMA
Contract No. DACA21-96-D-0018

Shaw® Shaw Environmental Inc.

EM31 CONDUCTIVITY AND IN-PHASE DATA

EM61 BOTTOM COIL DATA



LEGEND:

- ▼ WIRE FENCE
- ANOMALY CAUSED BY GEOLOGY

EM31 PROFILES

- In-phase Component - parts per thousand (pp)
- Conductivity - milliSiemens per meter (mS/m)

EM61 PROFILES

- milliVolts (mV)

NAME: Corby Schmalz	DATE: January 19, 2001
PROJECT NUMBER: 774645	LOCATION: C:\ITProjects\Ft.McClellan\8CEM31\Profile_C.map

FIGURE A-8

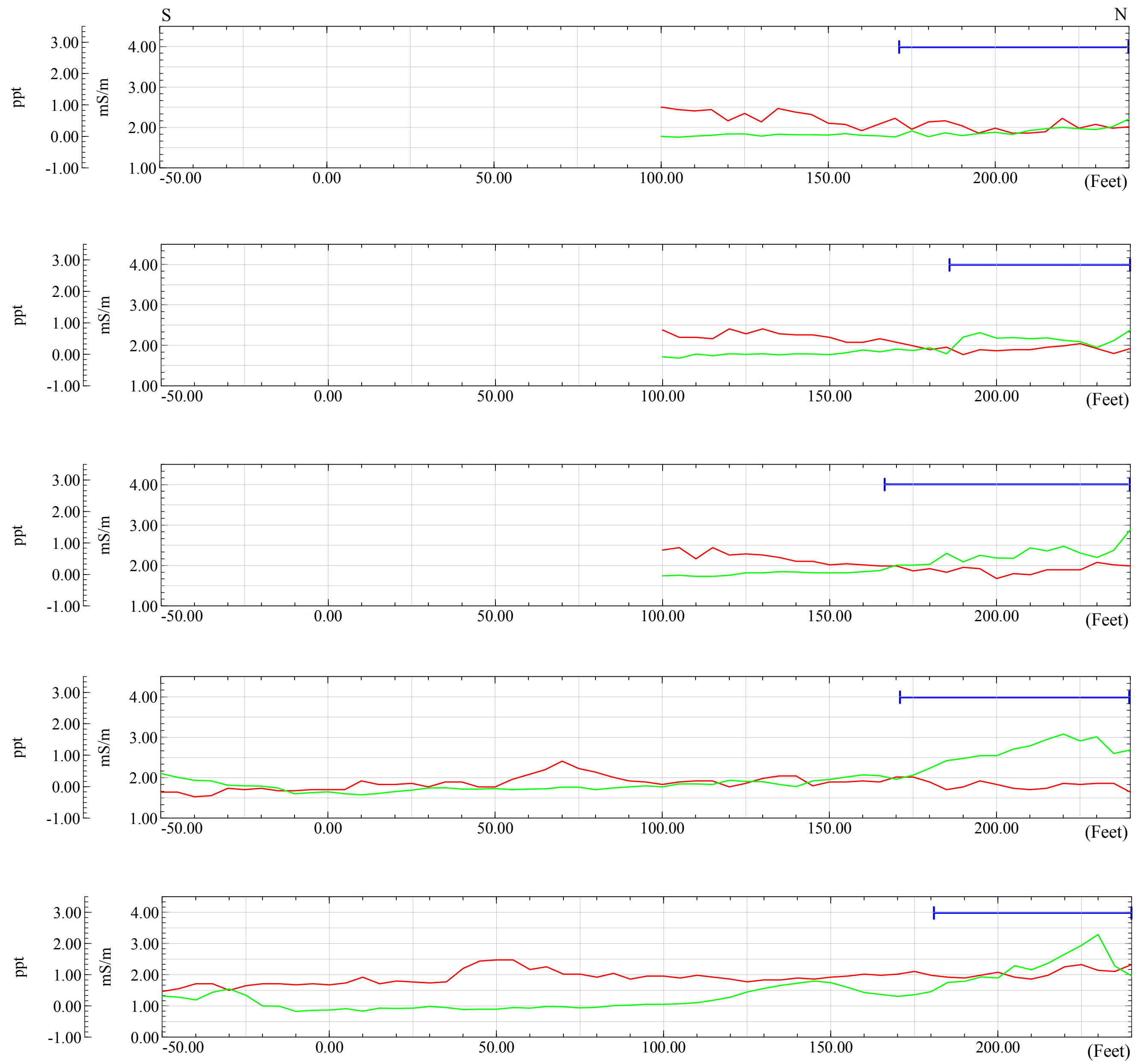
TRAINING AREA 8C
FORT McCLELLAN-PELHAM RANGE

EM31 AND EM61 GEOPHYSICAL PROFILE DATA
COLLECTED ALONG 280E, 290E, 300E, 310E, 320E, 330E
NORTH-SOUTH SURVEY LINES

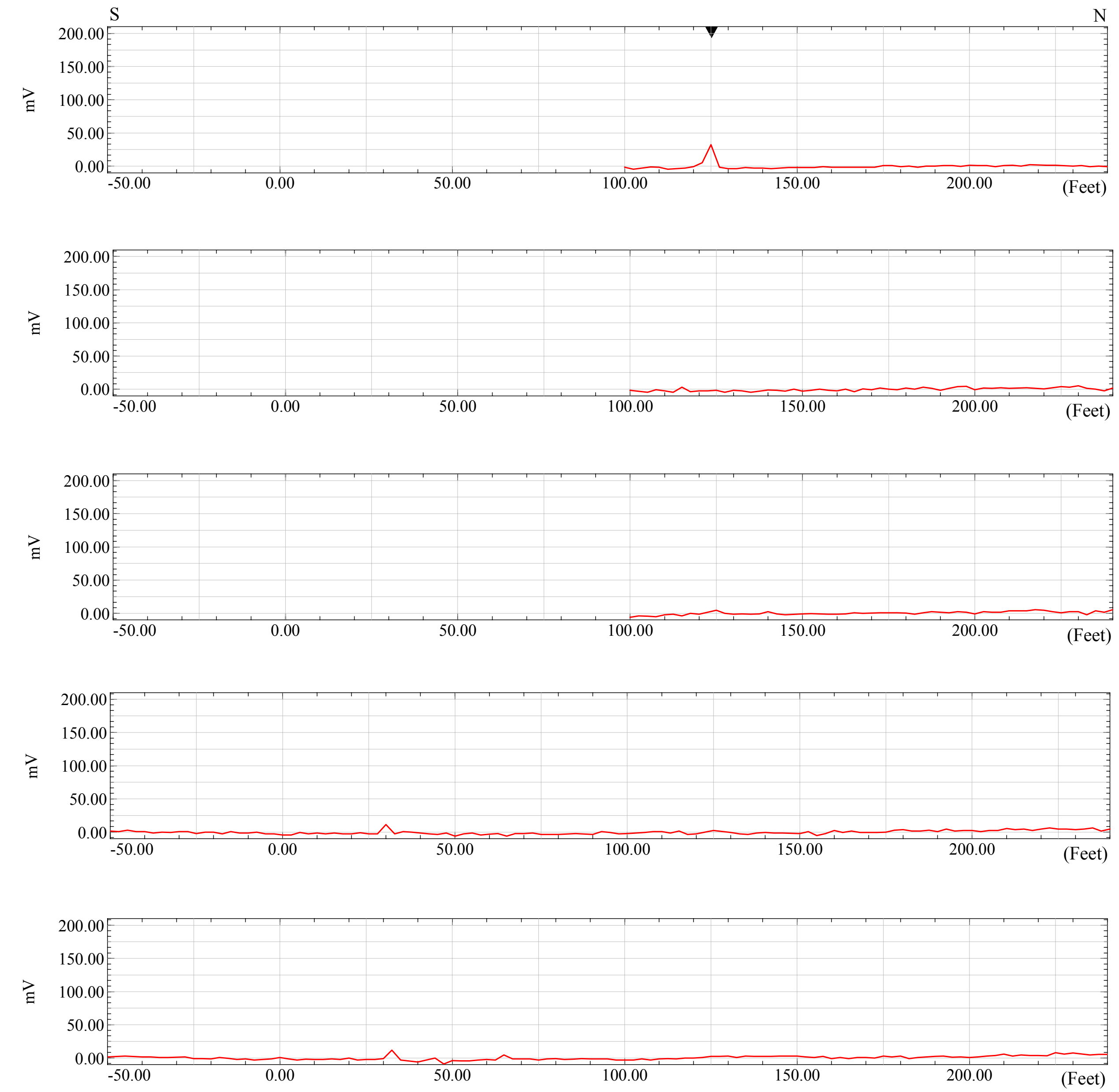
U.S. ARMY CORPS OF ENGINEERS
MOBILE DISTRICT
FORT McCLELLAN
CALHOUN COUNTY, ALABAMA
Contract No. DACA21-96-D-0018

Shaw® Shaw Environmental Inc.

EM31 CONDUCTIVITY AND IN-PHASE DATA



EM61 BOTTOM COIL DATA



LINE 360E

LINE 370E

LINE 380E

LINE 410E

LINE 420E

LEGEND:

▼ WIRE FENCE

ANOMALY CAUSED BY GEOLOGY

EM31 PROFILES

In-phase Component - parts per thousand (ppt)

Conductivity - milliSiemens per meter (mS/m)

EM61 PROFILES

milliVolts (mV)

NAME: Corby Schmalz	DATE: January 19, 2001
PROJECT NUMBER: 774645	LOCATION: C:\ITProjects\Ft.McClellan\8CEM31\Profile_D.map

FIGURE A-9

TRAINING AREA 8C
FORT McCLELLAN-PELHAM RANGE

EM31 AND EM61 GEOPHYSICAL PROFILE DATA
COLLECTED ALONG 360E, 370E, 380E, 410E, 420E
NORTH-SOUTH SURVEY LINES

U.S. ARMY CORPS OF ENGINEERS
MOBILE DISTRICT
FORT McCLELLAN
CALHOUN COUNTY, ALABAMA
Contract No. DACA21-96-D-0018

Shaw® Shaw Environmental Inc.

A.4.0 Interpretation of Geophysical Data

The method by which the geophysical data were interpreted and the results of that interpretation are presented in this chapter.

Figure A-2 presents the site map with geophysical interpretation. Interpreted color-contour maps of total magnetic field for the upper sensor, lower sensor, and vertical gradient, are presented as Figures A-3 through A-5, respectively. EM profiles are presented as Figures A-6 through A-9. A theoretical background is presented as Attachment D. The attachment discusses the factors influencing the observed geophysical response for the various methods and equipment used to conduct the survey at the sinkhole/depression locations in Training Area 8C.

In addition to the geophysical interpretation, the site map (Figure A-2) contains detailed information on reference features (e.g., topographic slopes, mounds, and depressions), so that the survey area and the geophysical anomaly locations can be relocated in the future. Anomalies shown on the site interpretation map correspond to those seen in the magnetic data. Surface reference features shown on the site interpretation map were translated from the hand-drawn site map made in the field. The site interpretation map also references the U.S. Alabama East State Plane, NAD-83 Coordinate System.

A.4.1 Data Interpretation Criteria

Anomalies shown on the magnetic data contour maps range from high to low and from negative to positive values, depending on the type of data displayed. The observed anomalies in the contour map of total magnetic field have values above and below the average magnetic field intensity of 51,150 nanoTeslas (nT) for Anniston, Alabama. The typical magnetic data response to near-surface ferrous metallic debris is an asymmetric south high/north low signature. The upper sensor magnetic data are more useful than the lower sensor data for locating large buried objects because the lower sensor is more sensitive to small near-surface objects. The characteristic EM61 response over a buried metal object shows a positive-amplitude signal, with signal strength dependent upon the size of the object, distance from the transmitter/receiver coils, and the type of material. Upper and lower receiver coil readings are be processed to determine a differential value that can be used to approximate depth of source objects in the data. Although all EM61 data were evaluated during interpretation, only the bottom coil EM61 data are presented in the report since these data are most sensitive to buried metal objects. The characteristic EM31 anomaly over a near-surface metallic conductor consists of a narrow zone having

strong negative amplitude centered over the target and a broader lobe of weaker, positive amplitude on either side of the target. As the depth of the target increases, the characteristic EM31 response changes to a positive amplitude centered over the target.

Anomalies present on the contour maps of magnetic data were field-checked and correlated with known metallic surface objects and other cultural surface features so that anomalies caused by subsurface sources could be determined. Anomalies caused by surface metal are labeled as such on the data contour maps and the locations of these features are indicated on the geophysical interpretation map. In the eastern survey area a partially buried wire fence was traced using a Schonstedt magnetic locator and is labeled as F/BM on the data contour maps. Anomalies interpreted to be caused by buried sources, such as changes in geologic conditions, are also labeled on the data contour maps.

A.4.2 Training Area 8C Data Interpretation.

Anomaly A-1. Anomaly A-1 is located along the northern boundary of both survey areas and occurs as a broad magnetic feature corresponding to low EM31 conductivity values. Anomaly A-1 has a low-amplitude magnetic response of approximately 50 nT above background (Figure A-3 and A-4) with low conductivity values of approximately 2 milliSiemens per meter (mS/m) below background and slightly elevated in-phase values that gradually increase from zero parts per thousand (ppt) to over 3 ppt along some profiles. Anomaly A-1 is interpreted to be caused by localized geologic conditions.

Anomaly A-2. Anomaly A-2 is located at approximately (160E, 160N). It is characterized by a broad magnetic dipole of approximately 230 nT, an approximately 1.5 ppt EM31 in-phase response, and a localized subtle decrease in the EM31 conductivity response. The EM61 profile data response remained at background levels. The source for Anomaly A-2 is interpreted to be caused by localized geologic conditions with an increase in the volume of high magnetic susceptibility rocks at or very near the surface.

Anomaly A-3. Anomaly A-3 is located at approximately (410E, 10N). It is characterized by a magnetic dipole of approximately 110 nT and a localized subtle increase in the EM31 conductivity response. The EM61 profile data response remained at background levels. The source for Anomaly A-3 is interpreted to be caused by localized geologic conditions.

A.5.0 Conclusions and Recommendations

A surface geophysical survey using the magnetic method was conducted from November 1 through 3, 2000. Follow up work to refine subsurface interpretations was conducted on January 3 through 5, 2001 using EM instruments. The geophysical survey objectives were to screen the two sinkholes located in the western survey area and the depression in the eastern survey area for the presence of hazardous debris such as smoke pots and oil drums suggested in historical reports.

No anomalies caused by buried metal objects were identified in the sinkholes or depression. Elevated magnetic readings located primarily along the northern boundary of the areas surveyed are interpreted to be caused by local geologic conditions. The geophysical interpretation map (Figure A-2) indicates the locations of partially buried metal associated with the wire fence and surface metal objects.

A hand drawn field map and GPS survey of site features provided a permanent record of the survey boundaries and anomaly locations. Features shown on the site interpretation map are conservatively estimated to be accurate to within +/- 5 feet.

Based on the objectives and results of the geophysical survey presented in this report, no further geophysical effort is recommended at the Training Area 8C site.

ATTACHMENT B

GEOPHYSICAL SURVEY REPORT FOR SINKHOLE AT TRAINING AREA 22C

Table of Contents

List of Figures

List of Acronyms

EM	electromagnetic induction
EM31	Geonics Limited EM31 Terrain Conductivity Meter
EM61	Geonics Limited EM61 High-Resolution Metal Detector
G-856AX	Geometrics, Inc. G-856AX magnetometer
G-858G	Geometrics, Inc. G-858G magnetic gradiometer
GPS	global positioning system
IT	IT Corporation
MOA	Memorandum of Agreement
mS/m	millisiemens per meter
mV	millivolts
NAD-83	North American Datum, 1983
N-S	north to south
nT	nanoTeslas
nT/m	nanoTeslas per meter
ppt	parts per thousand
TERC	Total Environmental Restoration Contract
USACE	U.S. Army Corps of Engineers
USCHPPM	U.S. Army Center for Health Promotion and Preventative Medicine

B.1.0 Introduction

IT Corporation (IT) conducted a surface geophysical survey at the sinkhole location in Training Area 22C at Pelham Range, Fort McClellan Army National Guard Training Center, in Calhoun County, Alabama, on November 1 and December 1, 2000 and from January 3 through 5, 2001. This survey was conducted for the U.S. Army Corps of Engineers (USACE) Mobile District, under Total Environmental Restoration Contract (TERC) No. DACA21-96-D-0018, Delivery Order CK005. The geophysical activities were designed to fulfill requirements of the Memorandum of Agreement (MOA) between the National Guard and the U.S. Army with regard to the transfer of Pelham Range to the Alabama National Guard. The geophysical survey objective was to screen the sinkhole for the presence of hazardous debris such as smoke pots and oil drums suggested in historical reports. The total area surveyed was approximately 49,600 square feet (1.14 acres). The Vicinity Map (Figure B-1) shows the approximate location of the survey area.

To accomplish the objective of the investigation, the magnetic method was initially used. Following review of the magnetic data contour maps, a decision was made to acquire electromagnetic (EM) data over select anomalies to refine interpretations. All geophysical data were processed and color-enhanced to aid in interpreting subtle anomalies. Following geophysics fieldwork, a global positioning system (GPS) was used to document the location of the site.

The survey area has generally sloping topography towards the north with a wide depression in the center as shown on the site map with geophysical interpretation (Figure B-2). Two surface drainage channels run into the depression from the northeast and northwest. The site is primarily tree covered with a more open area in the center of the site.

Field procedures used during the investigation are described in Chapter B.2.0. The data processing methods used during the investigation are presented in Chapter B.3.0. Data interpretation and criteria used to interpret geophysical anomalies are presented in Chapter B.4.0. Conclusions and recommendations derived from the geophysical surveys are presented in Chapter B.5.0. A description of the equipment and a theoretical discussion of the geophysical methods are presented in the Attachment D.

LEGEND

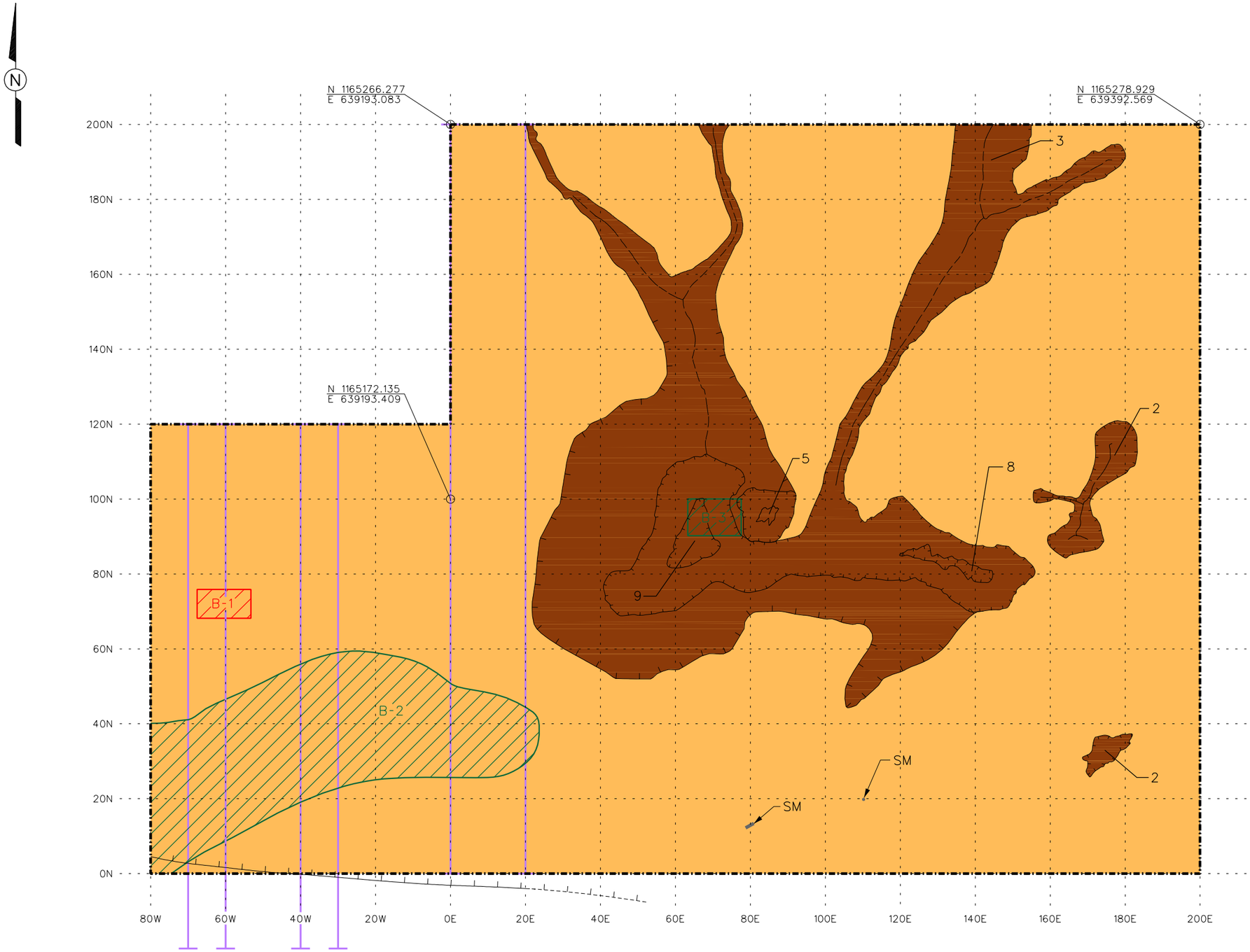
- UNIMPROVED ROAD
- GEOPHYSICAL SURVEY AREA
- DEPRESSION

FIGURE B-1
VICINITY MAP
TRAINING AREA 22C
PELHAM RANGE

U. S. ARMY CORPS OF ENGINEERS
MOBILE DISTRICT
FORT McCLELLAN
CALHOUN COUNTY, ALABAMA
Contract No. DACA21-96-D-0018

Shaw™ Shaw Environmental, Inc.

DWG. NO.: ...\774645es.689	INITIATOR: C. SCHMALZ	DRAFT. CHCK. BY:	DATE LAST REV.:	5/18/2004
PROJ. NO.: 774645	PROJ. MGR.: J. YACOUB	ENGR. CHCK. BY: C. SCHMALZ	DRAWN BY:	9:18:34 AM
	DRAWN BY: D. BOMAR	STARTING DATE: 12/14/00		dbomar
				c:\cadd\design\774645es.689



LEGEND

- GEOPHYSICAL SURVEY BOUNDARY
- B-1 — ANOMALY DISCUSSED IN TEXT
- B-2 — ANOMALY CAUSED BY GEOLOGIC VARIATIONS (DISCUSSED IN TEXT)
- GEOPHYSICAL SURVEY LINES (EM31 & EM61)
- N 1161932.546 / E 609979.644 — ALABAMA EAST ZONE COORDINATE SYSTEM NORTH AMERICAN DATUM [NAD] 1983
- 2 — APPROXIMATE DEPTH TO BOTTOM OF DEPRESSION IN FEET
- DEPRESSION
- SM — SURFACE METAL
- DRAINAGE

NOTES

1. LOCATION OF FEATURES OUTSIDE SURVEY AREA ARE APPROXIMATE.
2. SURVEY COORDINATES ARE APPROXIMATE SUB-METER GPS SYSTEM USED.

SCALE
0 30 60 FEET

FIGURE B-2
SITE MAP WITH GEOPHYSICAL INTERPRETATION
TRAINING AREA 22C
PELHAM RANGE

U. S. ARMY CORPS OF ENGINEERS
MOBILE DISTRICT
FORT McCLELLAN
CALHOUN COUNTY, ALABAMA
Contract No. DACA21-96-D-0018

Shaw™ Shaw Environmental, Inc.

DRAFT. CHCK. BY:
ENGR. CHCK. BY: C. SCHMALZ
INITIATOR: C. SCHMALZ
PROJ. MGR.: J. YACOUB
DWG. NO.: ...\774645es.719
PROJ. NO.: 774645
DATE LAST REV.:
DRAWN BY:
STARTING DATE: 01/30/01
DRAWN BY: D. BOMAR
5/18/2004 10:00:54 AM
dbomar
c:\cadd\design\774645es.719

B.2.0 Field Procedures

Field procedures are presented in this chapter, including discussions of the survey control and site map, field equipment, data acquisition parameters, and field verification of geophysical anomalies.

B.2.1 Survey Control

The geophysical survey area was identified in the site specific work plan based on historical site information compiled by IT and information obtained from Assessment No. 38-EH-1775-99 by the U.S. Army Center for Health and Preventative Medicine (USCHPPM). The geophysics crew established a base grid on 100-foot centers throughout the site. Using the base grid as a reference, control points were marked on 10-foot centers with surveyor's paint to provide the resolution required for the investigation. Due to the uncertainty of true field positions inherent when establishing a survey area using 300-foot fiberglass tapes in the presence of wind and surface obstructions (e.g., trees and rough terrain), the lateral precision for the survey area and anomalies is estimated to be within +/- 5 feet. Following geophysics field work, a GPS survey was conducted at the site referencing the U.S. State Plane Coordinate System (Alabama East Zone, North American Datum 1983 [NAD-83]). The GPS survey provided sub-meter resolution in XY coordinates for the site.

A detailed site map was hand-drawn in the field. The map included any surface cultural features within the survey area, or near the perimeter, that could potentially affect the geophysical data (e.g. topographic slopes, mounds, and surface metal). The map also shows reference features such as depressions that could later aid in reconstructing the site boundaries. All pertinent reference information documented on the hand-drawn site map was placed on the site interpretation map (Figure B-2). GPS coordinates are included on the site map to help relocate the survey area.

B.2.2 Geophysical Survey

Field Instruments. The magnetic instruments used during the investigation consisted of a Geometrics Inc. G-858G magnetic gradiometer (G-858G) for collecting survey data and a Geometrics G-856AX used as a magnetic base station. Time-domain EM induction equipment consisted of a Geonics EM61 High-Resolution Metal Detector (EM61) coupled to an Omnidata DL720 digital data logger. Frequency-domain EM induction equipment consisted of a Geonics EM31 Terrain Conductivity Meter (EM31) coupled to an Omnidata DL720 digital data logger.

All geophysical data were collected using the following IT standard operating procedures:

- ITGP-001 Surface Magnetic Surveys
- ITGP-002 Surface Frequency-Domain Electromagnetic Surveys
- ITGP-004 Surface Time-Domain Electromagnetic Surveys
- ITGP-012 Geophysical Data Management.

Field Instrument Base Station. A field instrument base station was established at the Training Area 22C site to provide quality control for the geophysical survey data collected. The base station location was chosen to be free of surface and subsurface cultural features that could affect the geophysical data. Standard field procedures were to occupy the base station and collect readings with the G-858G, EM31, and EM61 before and after each data collection session. These base station files were then reviewed to assess instrument operation. Base station file names and average data values within them were recorded on base station summary forms.

B.2.2.1 Magnetic Survey

Magnetic Base Station. A magnetic base station was established at Fort McClellan to record the background fluctuation (diurnal drift) of the Earth's magnetic field. The magnetic base station was located in a field of small pine trees on the south side of Sixth Avenue (near Parcel 151), a location which was determined to be free of surface and subsurface cultural features that could affect the data. The G-856AX base station magnetometer was time-synchronized with the G-858G field survey instrument and programmed to record the Earth's background magnetic field at 10-second intervals during the magnetic survey. These base station data were later used during data processing to "drift-correct" the G-858G survey data for variations in the Earth's magnetic field.

G-858G Data Collection. Magnetic field measurements were made with the two sensors of the G-858G spaced 2.5 feet (0.76 meters) apart vertically; the lower sensor was 2.0 feet above the ground surface and the upper sensor was 4.5 feet above the ground surface. At the start and end of each data collection session, approximately 60 readings were recorded with the G-858G at the field instrument base station to verify that the instrument was operating properly and to provide a quantitative record of instrument variation during the survey period. A review of these base station files indicated the instrument was operating properly and the instrument drift was within acceptable limits. Magnetic survey data were collected at 0.5-second intervals (approximately 2.0- to 2.5-foot intervals) along north-south (N-S) oriented survey lines spaced 10 feet apart, for a total of approximately 5,160 linear feet of survey coverage.

The magnetic data were stored in the internal memory of the G-858G, along with corresponding line and station numbers and time of acquisition. Magnetic survey data were screened in the field to assess data quality prior to completing the investigation. All magnetic survey and base station data were downloaded to a personal computer, backed up on IOMEGA® compatible zip disks, and are retained in project files.

B.2.2.2 Time-Domain EM Survey

EM61 Data Collection. EM61 profile data were acquired to refine interpretations of magnetic data anomalies. Prior to conducting the EM61 survey, the instrument was calibrated to read zero at the field instrument base station. The EM61 was operated in the wheel mode with manual triggering and measurements of the potential difference in the top and bottom coils were collected. At the start and end of each data collection session approximately 20 readings were recorded at the field instrument base to verify that the instrument was operating properly and to provide a quantitative record of instrument variation, or drift, during the survey period. A review of these base station files indicated the instrument was operating properly and instrument drift was within acceptable limits. Survey data were collected at 2.5-foot intervals along N-S oriented survey lines at select locations as noted on Figure B-2, for a total of approximately 960 linear feet of survey coverage.

The EM61 data were stored in the digital data logger programmed with corresponding line and station numbers. EM61 line profiles were reviewed in the field using the DAT61® program to verify data quality prior to completing the survey. All EM61 survey and base station data were downloaded to a personal computer, backed up on IOMEGA® compatible zip disks, and are retained in project files.

B.2.2.3 Frequency-Domain EM Survey

EM31 Data Collection. EM31 profile data were acquired to refine interpretations of magnetic data anomalies. Prior to conducting the EM31 survey, the instrument was calibrated and the in-phase component zeroed at the field instrument base station. The instrument was operated in the vertical dipole mode measuring the in-phase and out-of-phase components of the secondary EM field. At the start and end of each data collection session approximately 20 readings were recorded at the field instrument base station to verify that the instrument was operating properly and to provide a quantitative record of instrument variation, or drift, during the survey period. A review of these base station files indicated the instrument was operating properly and instrument drift was within acceptable limits. Survey data were collected at 5-foot intervals along N-S

oriented survey lines at select locations as noted on Figure B-2, for a total of approximately 960 linear feet of survey coverage.

The EM31 data were stored in the digital data logger programmed with corresponding line and station numbers. EM31 line profiles were reviewed in the field using the DAT31® program to verify data quality prior to completing the survey. All EM31 survey and base station data were downloaded to a personal computer, backed up on IOMEGA® compatible zip disks, and are retained in project files.

B.2.2.4 Anomaly Verification

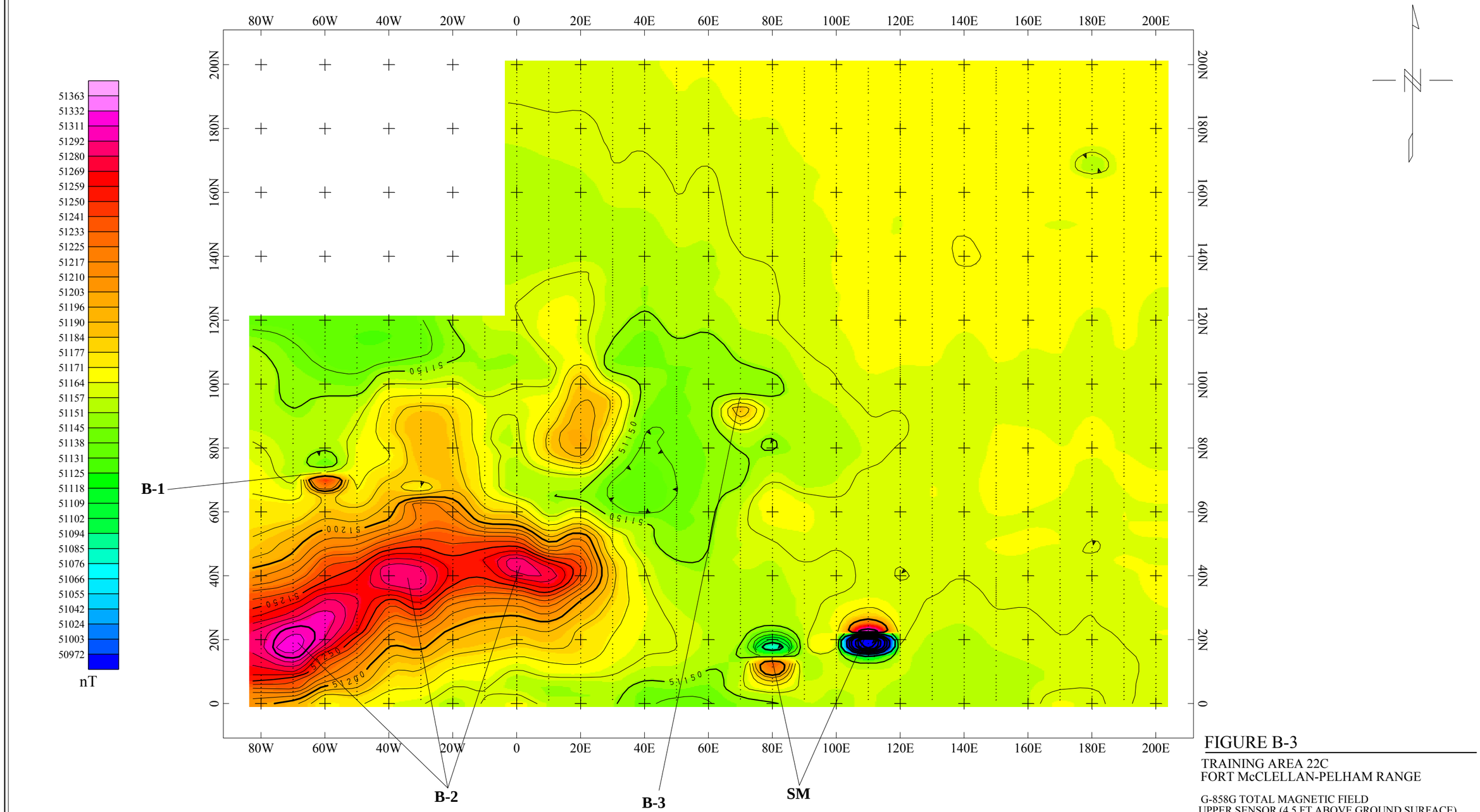
Preliminary color-contour maps of the magnetic data were generated and field-checked to differentiate between anomalies caused by surface and subsurface sources. Geophysical anomalies verified as being caused by surface features were labeled as such on the field data maps. Anomalies potentially caused by buried metallic objects were carefully located in the field and marked on the site map.

B.3.0 Data Processing

Color contour maps of the magnetic data were generated using the OASIS Montaj® geophysical mapping system from Geosoft, Inc. The maps were color-enhanced to aid with interpreting subtle anomalies. The magnetic data contour maps from this site are presented as Figures B-3 through B-5 and EM data profiles are presented as Figure B-6.

A series of data processing steps were required to generate the contour maps. Magnetic gradiometer data were downloaded from the field instrument and converted to an ASCII file using the Geometrics, Inc. MAGMAP2000® program. EM61 and EM31 data were downloaded from the data logger and converted to ASCII files using DAT61® and DAT31® software from Geonics, Inc. The ASCII data files were then reviewed to assess line numbers, station ranges, and overall data quality. Field data file names and corresponding base station data files were recorded on the data file tracking form. Data screening results were then recorded on the base station summary form. Following data quality assessment, geometry corrections to field data files were made, if necessary, using a text editor and recorded on the geophysical data editing form.

Final, corrected magnetic, EM61, and EM31 data files containing local geophysical station coordinates (X,Y) and the geophysical measurement (Z) were converted to OASIS Montaj® format and imported into the geophysical mapping software. The magnetic data were then gridded using bi-directional gridding with an Akima spline. The grid cell size for the magnetic data was chosen to be 1.25 feet. Color contouring was used to enhance data anomalies. The EM61 and EM31 data are presented as profile maps. The names of files generated and processing parameters used were recorded on data processing forms. Final processed map names are shown in the data processing box found in the lower left corner of each map presented. All completed forms of magnetic data collected during the investigation are retained in project files.



LEGEND:

..... GEOPHYSICAL SURVEY LINES
B-1 GEOPHYSICAL ANOMALY DISCUSSED IN TEXT
SM ANOMALY CAUSED BY SURFACE METAL

Scale 1:360

25 0 25 50
feet

MINIMUM CONTOUR INTERVAL: 10 nanoTeslas

NAME: Nicholas Muloshi	DATE: January 12, 2001
PROJECT NUMBER: 774645	LOCATION: C:\IT Projects\FtMcCllelan\22C\MAG\22c.map

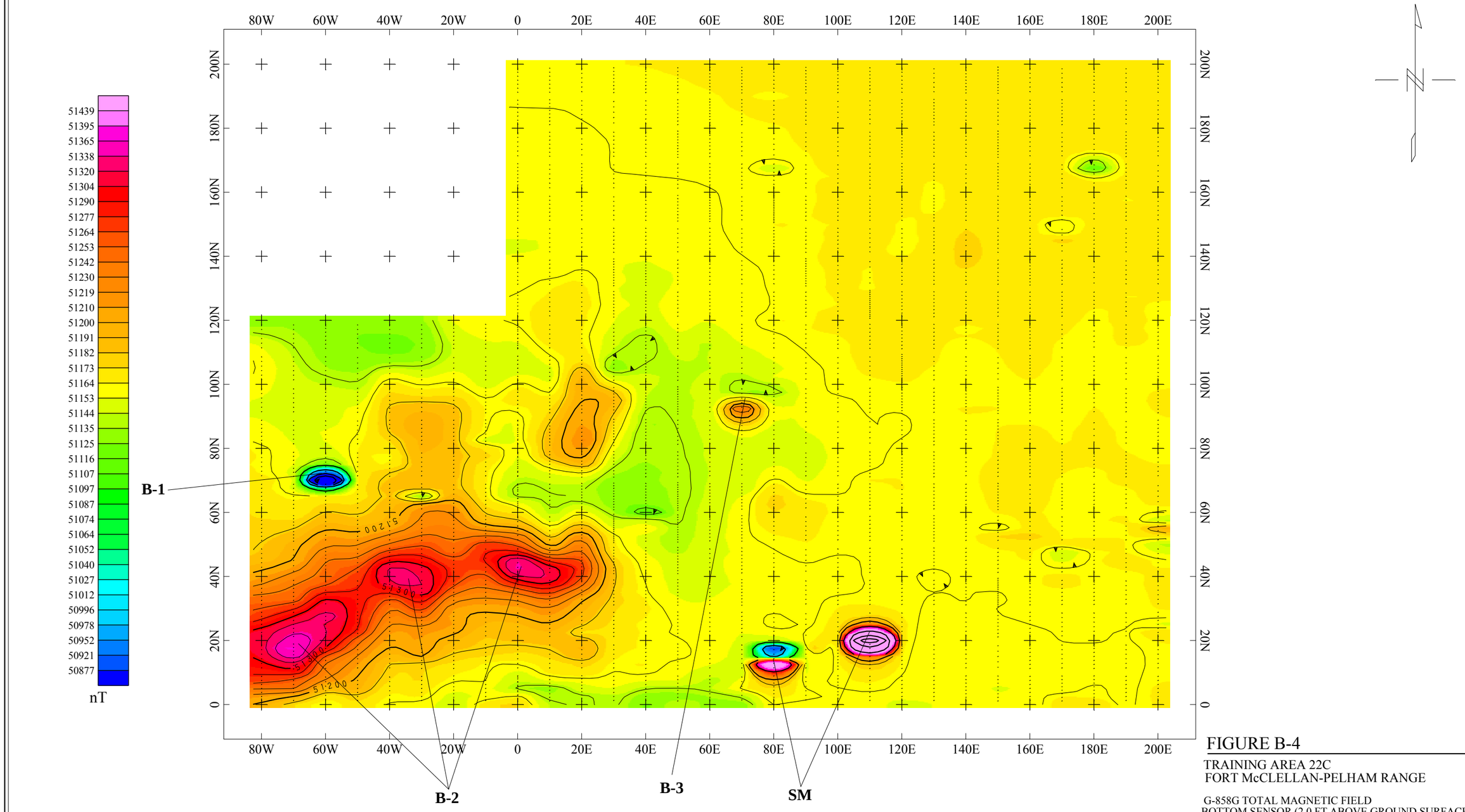
FIGURE B-3

TRAINING AREA 22C
FORT McCLELLAN-PELHAM RANGE

G-858G TOTAL MAGNETIC FIELD
UPPER SENSOR (4.5 FT ABOVE GROUND SURFACE)
NORTH-SOUTH SURVEY LINES

U.S. ARMY CORPS OF ENGINEERS
MOBILE DISTRICT
FORT McCLELLAN
CALHOUN COUNTY, ALABAMA
Contract No. DACA21-96-D-0018

Shaw Shaw Environmental, Inc.



LEGEND:

..... GEOPHYSICAL SURVEY LINES
B-1 GEOPHYSICAL ANOMALY DISCUSSED IN TEXT
SM ANOMALY CAUSED BY SURFACE METAL

Scale 1:360

25 0 25 50
feet

MINIMUM CONTOUR INTERVAL: 20 nanoTeslas

NAME: Nicholas Muloshi	DATE: January 12, 2001
PROJECT NUMBER: 774645	LOCATION: C:\IT Projects\FtMcC\lelan\22C\MAG\22cBOTa.map

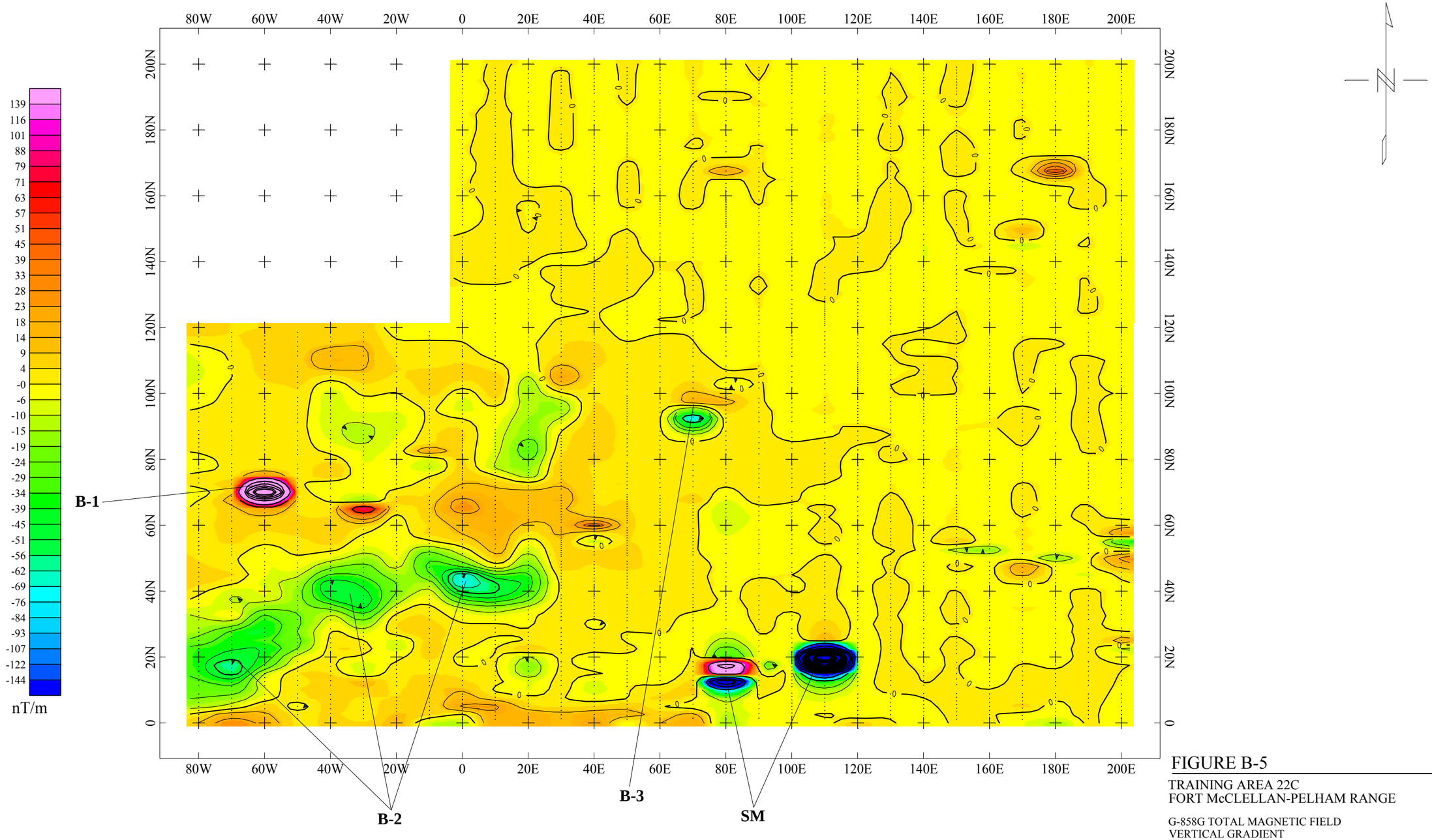
FIGURE B-4

TRAINING AREA 22C
FORT McCLELLAN-PELHAM RANGE

G-858G TOTAL MAGNETIC FIELD
BOTTOM SENSOR (2.0 FT ABOVE GROUND SURFACE)
NORTH-SOUTH SURVEY LINES

U.S. ARMY CORPS OF ENGINEERS
MOBILE DISTRICT
FORT McCLELLAN
CALHOUN COUNTY, ALABAMA
Contract No. DACA21-96-D-0018

Shaw Shaw Environmental, Inc.



LEGEND:

..... GEOPHYSICAL SURVEY LINES
B-1 GEOPHYSICAL ANOMALY DISCUSSED IN TEXT
SM ANOMALY CAUSED BY SURFACE METAL

Scale 1:360

25 0 25 50
feet

MINIMUM CONTOUR INTERVAL: 10 nanoTeslas per meter

NAME: Nicholas Muloshi	DATE: January 12, 2001
PROJECT NUMBER: 774645	LOCATION: C:\IT Projects\FtMcCllelan\22C\MAG\22cVRT.map

FIGURE B-5

TRAINING AREA 22C
FORT McCLELLAN-PELHAM RANGE

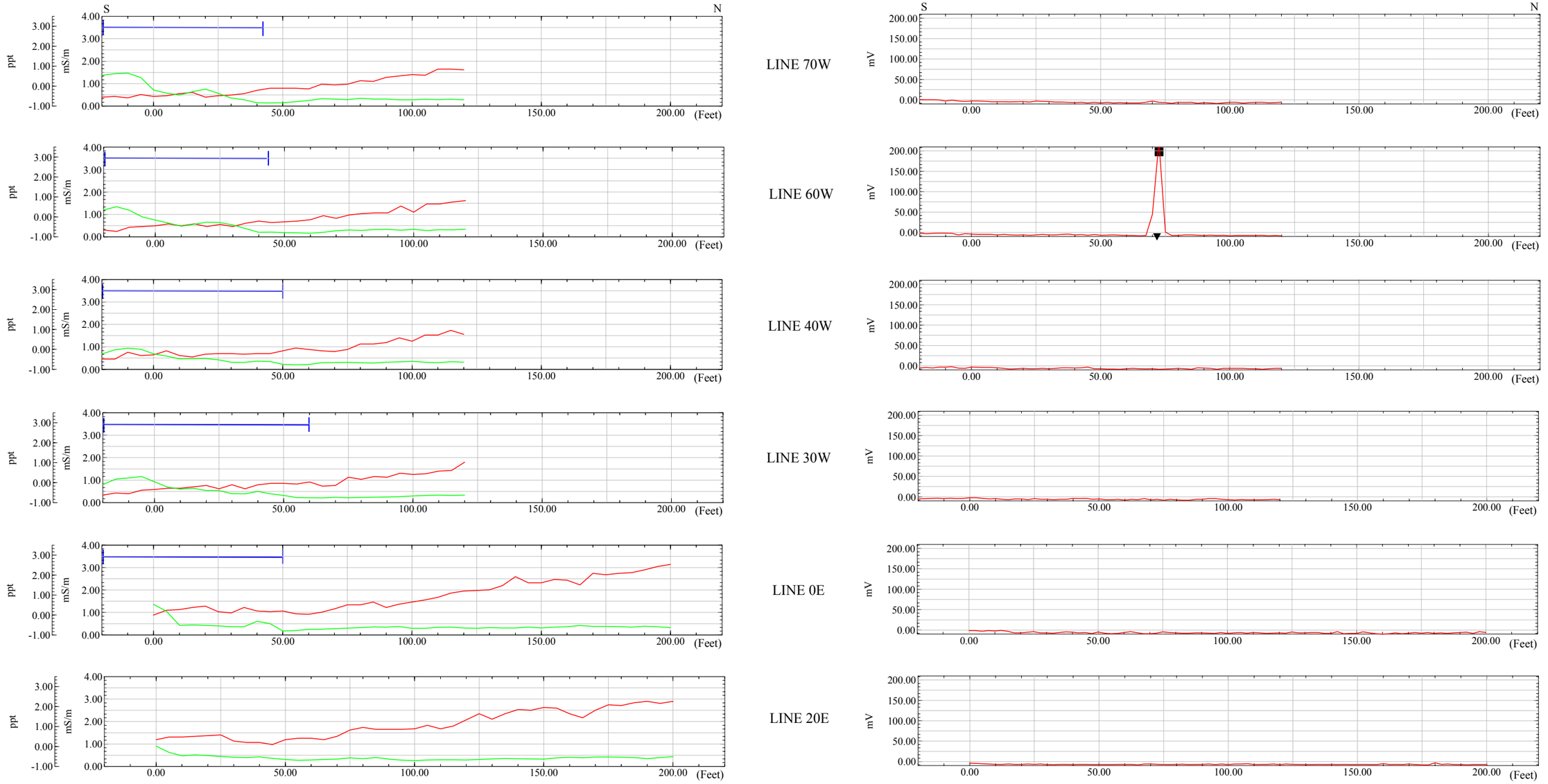
G-858G TOTAL MAGNETIC FIELD
VERTICAL GRADIENT
NORTH-SOUTH SURVEY LINES

U.S. ARMY CORPS OF ENGINEERS
MOBILE DISTRICT
FORT McCLELLAN
CALHOUN COUNTY, ALABAMA
Contract No. DACA21-96-D-0018

Shaw® Shaw Environmental, Inc.

EM 31 CONDUCTIVITY AND IN-PHASE DATA

EM61 BOTTOM COIL DATA



LEGEND:

- ■ GEOPHYSICAL ANOMALY
- ▼ BURIED METAL
- ANOMALY CAUSED BY GEOLOGY

EM31 PROFILES

- In-phase Component - parts per thousand (ppt)
- Conductivity - milliSiemens per meter (mS/m)

EM61 PROFILES

- milliVolts (mV)

NAME: Corby Schmalz	DATE: January 19, 2001
PROJECT NUMBER: 774645	LOCATION: C:\ITProjects\Ft.McClellan\22CEM31\Profile22_a.map

FIGURE B-6

TRAINING AREA 22C
FORT McCLELLAN-PELHAM RANGE

EM31 AND EM61 GEOPHYSICAL PROFILE DATA
COLLECTED ALONG 70W, 60W, 40W, 30W, 0E, 20E
NORTH-SOUTH SURVEY LINES

U.S. ARMY CORPS OF ENGINEERS
MOBILE DISTRICT
FORT McCLELLAN
CALHOUN COUNTY, ALABAMA
Contract No. DACA21-96-D-0018

Shaw Shaw Environmental Inc.

B.4.0 Interpretation of Geophysical Data

The method by which the geophysical data were interpreted and the results of that interpretation are presented in this chapter.

Figure B-2 presents the site map with geophysical interpretation. Interpreted color-contour maps of total magnetic field for the upper sensor, lower sensor, and vertical gradient, are presented as Figures B-3 through B-5, respectively. EM61 and EM31 data profiles are presented as Figure B-6. A theoretical background is presented as Attachment D. The attachment discusses the factors influencing the observed geophysical response for the various methods and equipment used to conduct the survey at the sinkhole location in Training Area 22C.

In addition to the geophysical interpretation the site map (Figure B-2) contains detailed information on reference features (e.g., topographic slopes and the depression), so that the survey area and the geophysical anomaly locations can be relocated in the future. Anomalies shown on the site interpretation map correspond to those seen in the geophysical data. Surface reference features shown on the site interpretation map were translated from the hand-drawn site map made in the field. The site interpretation map also references the U.S. Alabama East State Plane, NAD-83 Coordinate System.

B.4.1 Data Interpretation Criteria

Anomalies shown on the magnetic data contour maps range from high to low and from negative to positive values, depending on the type of data displayed. The observed anomalies in the contour map of total magnetic field have values above and below the average magnetic field intensity of 51,150 nanoTeslas (nT) for Anniston, Alabama. The typical magnetic data response to near-surface ferrous metallic debris is an asymmetric south high/north low signature. The upper sensor magnetic data are more useful than the lower sensor data for locating large buried objects because the lower sensor is more sensitive to small near-surface objects. The characteristic EM61 response over a buried metal object shows a positive-amplitude signal, with signal strength dependent upon the size of the object, distance from the transmitter/receiver coils, and the type of material. Upper and lower receiver coil readings are be processed to determine a differential value that can be used to approximate depth of source objects in the data. Although all EM61 data were evaluated during interpretation, only the bottom coil EM61 data are presented in the report since these data are most sensitive to buried metal objects. The characteristic EM31 anomaly over a near-surface metallic conductor consists of a narrow zone having strong negative amplitude centered over the target and a broader lobe of weaker, positive

amplitude on either side of the target. As the depth of the target increases, the characteristic EM31 response changes to a zone which has a positive amplitude centered over the target.

Anomalies present on the contour maps of magnetic data were field-checked and correlated with known metallic surface objects and other cultural surface features so that anomalies caused by subsurface sources could be determined. Anomalies identified to be caused by source objects potentially representing smoke pots or oil drums, as well as naturally occurring changes in the subsurface, have been identified on each of the contour maps and are discussed in the following text.

B.4.2 Training Area 22C Data Interpretation.

Anomaly B-1. Anomaly B-1 is located at approximately (60W, 70N). It occurs as a low-amplitude dipole in the magnetic upper sensor data with a response of approximately 75 nT (Figure B-3). Anomaly B-1 occurs in the lower sensor magnetic data as a low-amplitude monopole with magnetic field values 500 nT below background (Figure B-4). A localized conductivity low with a subtle in-phase response is seen in the EM31 profiles (Figure B-6). EM61 data show a sharp, localized 200 milliVolt (mV) response. Anomaly B-1 is interpreted to be caused by a near surface buried ferrous metal object, located approximately 130 feet west of the sinkhole.

Anomaly B-2. Anomaly B-2 is located in the southwest area of the site. Anomaly B-2 trends east-northeast and has a magnetic signature of approximately 180 nT above background (Figures B-3 and B-4). Anomaly B-2 is also evident in the vertical magnetic gradient data indicating a near surface origin (Figure B-5). The EM31 data profiles show Anomaly B-2 has a relatively flat conductivity response (approximately 1 mS/m) and a local peak in the in-phase component data. Anomaly B-2 is interpreted to be caused by naturally occurring variations in geology.

Anomaly B-3. Anomaly B-3 is located at approximately (70E, 98N). Anomaly B-3 has a low-amplitude magnetic response in both the upper sensor and lower sensor data (Figures B-3 and B-4). Anomaly B-3 is interpreted to be caused by topographic effects/sensor orientation within the surface depression.

B.5.0 Conclusions and Recommendations

A surface geophysical survey using the magnetic method was conducted on November 1 and December 1, 2000 at Training Area 22C. Follow up work to refine subsurface interpretations was conducted from January 3 through 5, 2001 using EM instruments. The survey objective was to screen the sinkhole for the presence of hazardous debris such as smoke pots and oil drums suggested in historical reports.

Geophysical data analysis indicates an area of elevated magnetic readings interpreted to be caused by local geologic conditions, one anomaly caused by a near-surface buried metal object(s), and one anomaly caused by topographic effects/magnetic sensor orientation. The geophysical interpretation map (Figure B-2) indicates the locations of these anomalies.

A hand drawn field map and GPS survey of site features provided a permanent record of the survey boundaries and anomaly locations. Features shown on the interpretation map are conservatively estimated to be accurate to within +/- 5 feet.

Based on the objectives and results of the geophysical survey presented in this report, no further geophysical effort is recommended at the Training Area 22C site.

ATTACHMENT C

GEOPHYSICAL SURVEY REPORT
FOR SURFACE DEPRESSION AT TRAINING AREA 24C

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List of Acronyms

G-856AX	Geometrics, Inc. G-856AX magnetometer
G-858G	Geometrics, Inc. G-858G magnetic gradiometer
GPS	global positioning system
IT	IT Corporation
MOA	Memorandum of Agreement
NAD	North American Datum
N-S	north to south
nT	nanoTeslas
nT/m	nanoTeslas/meter
TERC	Total Environmental Restoration Contract
USACE	U. S. Army Corps of Engineers
USCHPPM	U. S. Army Center for Health Promotion and Preventative Medicine

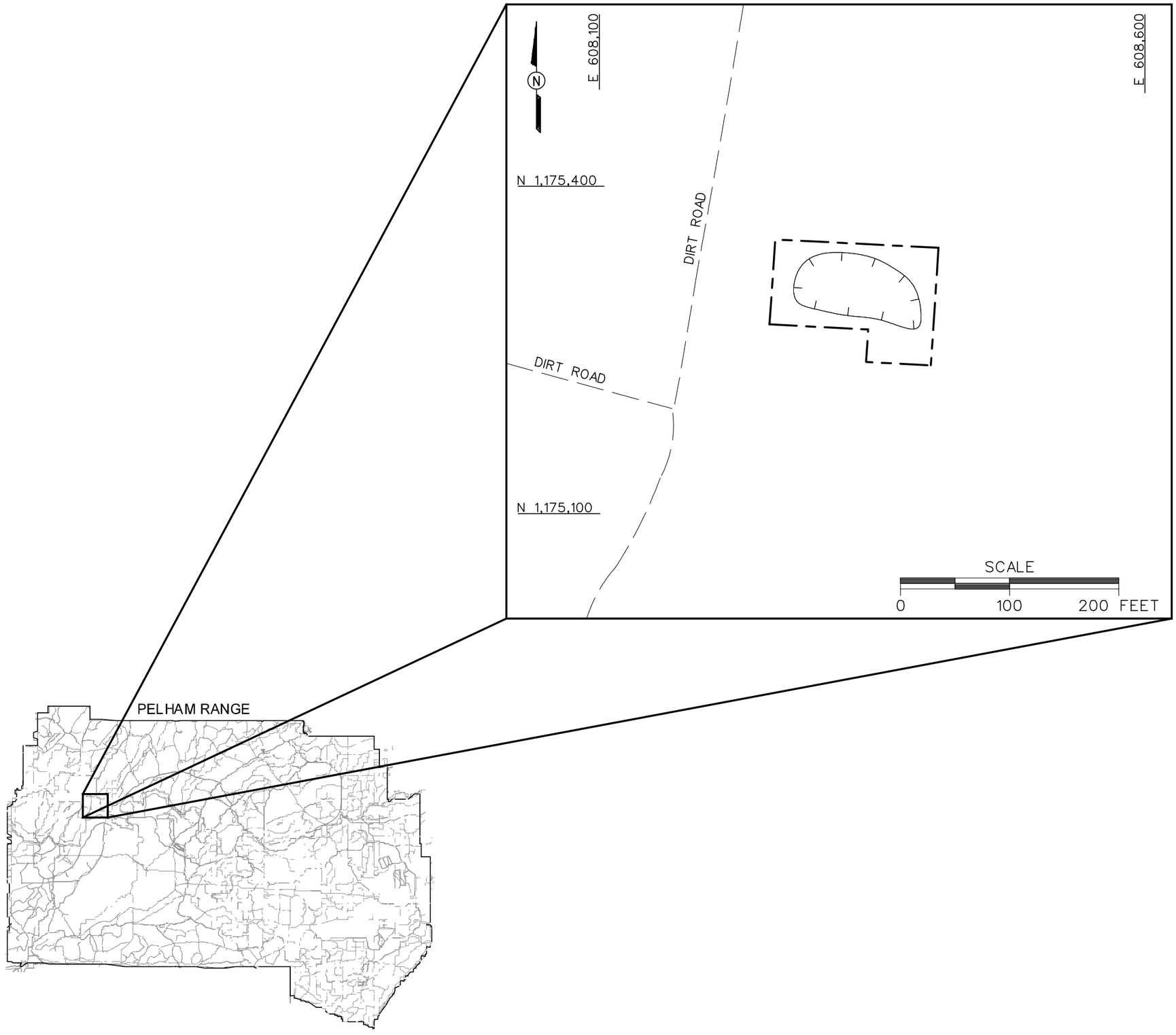
C.1.0 Introduction

IT Corporation (IT) conducted a surface geophysical survey at the surface depression location in Training Area 24C, at Pelham Range, Fort McClellan Army National Guard Training Center, in Calhoun County, Alabama, on October 31, 2000. This survey was conducted for the U.S. Army Corps of Engineers (USACE) Mobile District, under Total Environmental Restoration Contract (TERC) No. DACA21-96-D-0018, Delivery Order CK005. The geophysical activities were designed to fulfill requirements of the Memorandum of Agreement (MOA) between the National Guard and the US Army with regard to the transfer of Pelham Range to the Alabama National Guard. The geophysical survey objectives were to screen the site for the presence of hazardous debris such as smoke pots and oil drums suggested in historical reports. The total area surveyed was approximately 13,500 square feet (0.31 acres). The Vicinity Map (Figure C-1) shows the approximate location of the survey area.

To accomplish the objectives of the investigation, the magnetic method was used. The geophysical data were processed and color-enhanced to aid in interpreting subtle anomalies. Following geophysics fieldwork, a sub-meter global positioning system (GPS) was used to document the location of the site.

The survey area contained a deep east-west trending ravine as shown on the site map with geophysical interpretation (Figure C-2). The site is primarily tree covered and generally slopes to the east.

Field procedures used during the investigation are described in Chapter C.2.0. The data processing methods used during the investigation are presented in Chapter C.3.0. Data interpretation and criteria used to interpret geophysical anomalies are presented in Chapter C.4.0. Conclusions and recommendations derived from the geophysical surveys are presented in Chapter C.5.0. A description of the equipment and a theoretical discussion of the geophysical methods are presented in Attachment D.



LEGEND

- UNIMPROVED ROAD
- GEOPHYSICAL SURVEY AREA
- DEPRESSION

FIGURE C-1
VICINITY MAP
TRAINING AREA 24C
PELHAM RANGE

U. S. ARMY CORPS OF ENGINEERS
MOBILE DISTRICT
FORT McCLELLAN
CALHOUN COUNTY, ALABAMA
Contract No. DACA21-96-D-0018

Shaw™ Shaw Environmental, Inc.

DRAFT. CHCK. BY:
ENGR. CHCK. BY: C. SCHMALZ
PROJ. MGR.: J. YACOUB
INITIATOR: C. SCHMALZ
DWG. NO.: ...\774645es.690
PROJ. NO.: 774645
DATE LAST REV.:
DRAWN BY:
STARTING DATE: 12/14/00
DRAWN BY: D. BOMAR
5/18/2004
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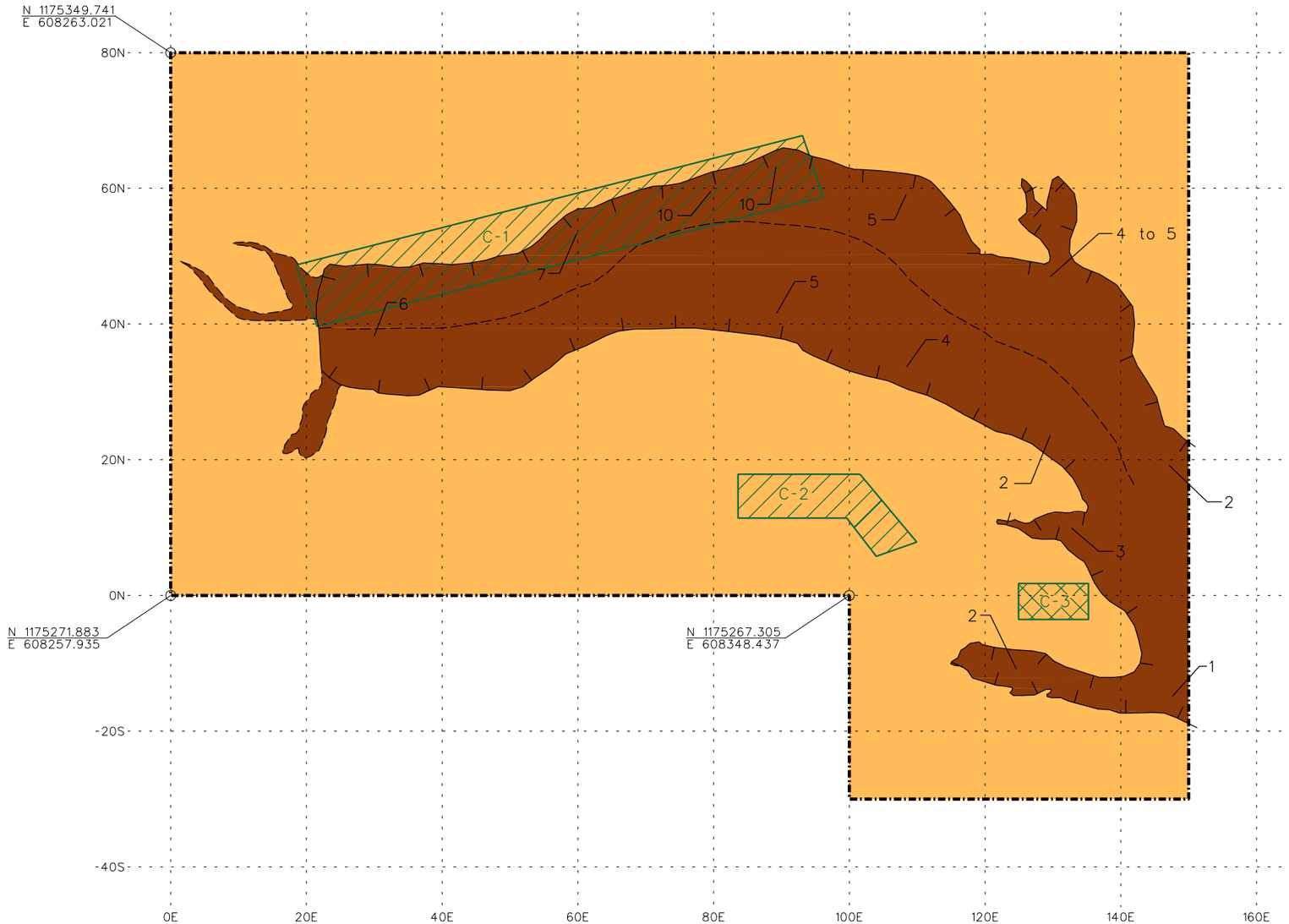

LEGEND

- GEOPHYSICAL SURVEY BOUNDARY
- C-1 — ANOMALY CAUSED BY GEOLOGIC VARIATIONS (DISCUSSED IN TEXT)
- C-3 — ANOMALY CAUSED BY GEOLOGIC VARIATIONS AND POSSIBLE BURIED METAL
- N 1161932.546 / E 609979.644 — ALABAMA EAST ZONE COORDINATE SYSTEM NORTH AMERICAN DATUM [NAD] 1983
- 2 — APPROXIMATE DEPTH TO BOTTOM OF DEPRESSION IN FEET
- DEPRESSION
- DRAINAGE

NOTES

1. LOCATION OF FEATURES OUTSIDE SURVEY AREA ARE APPROXIMATE.
2. SURVEY COORDINATES ARE APPROXIMATE SUB-METER GPS SYSTEM USED.

SCALE
0 20 40 FEET

FIGURE C-2
SITE MAP WITH GEOPHYSICAL INTERPRETATION
TRAINING AREA 24C
PELHAM RANGE

U. S. ARMY CORPS OF ENGINEERS
MOBILE DISTRICT
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DWG. NO.: ...\774645es.721
PROJ. NO.: 774645
DATE LAST REV.:
DRAWN BY:
STARTING DATE: 01/31/01
DRAWN BY: D. BOMAR
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C.2.0 Field Procedures

Field procedures are presented in this chapter, including discussions of the survey control and site map, field equipment, data acquisition parameters, and field verification of geophysical anomalies.

C.2.1 Survey Control

The geophysical survey area was identified in the site specific work plan based on historical site information compiled by IT and information obtained from Assessment No. 38-EH-1775-99 by the U.S. Army Center for Health and Preventative Medicine (USCHPPM). The geophysics crew established a base grid on 100-foot centers throughout the site. Using the base grid as a reference, control points were marked on 10-foot centers with surveyor's paint to provide the resolution required for the investigation. Due to the uncertainty of true field positions inherent when establishing a survey area using 300-foot fiberglass tapes in the presence of wind and surface obstructions (e.g., trees and rough terrain), the lateral precision for the survey area and anomalies is estimated to be within +/- 5 feet. Following geophysics field work, a GPS survey was conducted at the site referencing the U.S. State Plane Coordinate System (Alabama East Zone, North American Datum 1983 [NAD-83]). The GPS survey provided sub-meter resolution in XY coordinates for the site.

A detailed site map was hand-drawn in the field. The map included any surface cultural features within the survey area, or near the perimeter, that could potentially affect the geophysical data (e.g., topographic slopes and drainage features). The map also shows reference features, such as the ravine/depression that could later aid in reconstructing the site boundaries. All pertinent reference information documented on the hand-drawn site map was placed on the site interpretation map (Figure C-2). GPS coordinates are included on the site map to help relocate the survey area.

C.2.2 Geophysical Survey

Field Instruments. The magnetic instruments used during the investigation consisted of a Geometrics Inc. G-858G magnetic gradiometer (G-858G) for collecting survey data and a Geometrics G-856AX for collecting magnetic base station data.

All geophysical data were collected using the following IT standard operating procedures:

- ITGP-001 Surface Magnetic Surveys
- ITGP-012 Geophysical Data Management.

Field Instrument Base Station. A field instrument base station was established at the Training Area 24C site to provide quality control for the geophysical survey data collected. The base station location was chosen to be free of surface and subsurface cultural features that could affect the geophysical data. Standard field procedures were to occupy the base station and collect readings with the magnetic gradiometer before and after each data collection session. These base station files were then reviewed to assess instrument operation. Base station file names and average data values within them were recorded on base station summary forms.

C.2.2.1 Magnetic Survey

Magnetic Base Station. A magnetic base station was established at Fort McClellan to record the background fluctuation (diurnal drift) of the Earth's magnetic field. The magnetic base station was located in a field of small pine trees on the south side of Sixth Avenue (near Parcel 151), a location which was determined to be free of surface and subsurface cultural features that could affect the data. The G-856AX base station magnetometer was time-synchronized with the G-858G field survey instrument and programmed to record the Earth's background magnetic field at 10-second intervals during the magnetic survey. These base station data were later used during data processing to "drift-correct" the G-858G survey data for variations in the Earth's magnetic field.

G-858G Data Collection. Magnetic field measurements were made with the two sensors of the G858-G spaced 2.5 feet (0.76 meters) apart vertically; the lower sensor was 2.0 feet above the ground surface and the upper sensor was 4.5 feet above the ground surface. At the start and end of each data collection session, approximately 60 readings were recorded with the G-858G at the field instrument base station to verify that the instrument was operating properly and to provide a quantitative record of instrument variation during the survey period. A review of these base station files indicated the instrument was operating properly and the instrument drift was within acceptable limits. Magnetic survey data were collected at 0.5-second intervals (approximately 2.0- to 2.5-foot intervals) along North to South (N-S) oriented survey lines spaced 10 feet apart, for a total of approximately 1,460 linear feet of survey coverage.

The magnetic data were stored in the internal memory of the G-858G, along with corresponding line and station numbers and time of acquisition. Magnetic survey data were screened in the field to assess data quality prior to completing the investigation. All magnetic survey and base station data were downloaded to a personal computer, backed up on IOMEGA® compatible zip disks, and are retained in project files.

C.2.2.2 Anomaly Verification

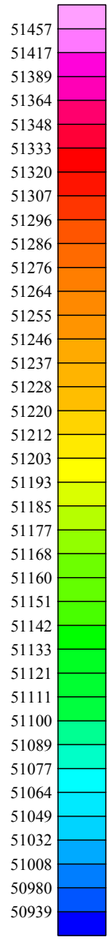
Preliminary color-contour maps of the magnetic data were generated and field-checked to differentiate between anomalies caused by surface and subsurface sources. Geophysical anomalies verified as being caused by surface features were labeled as such on the field data maps. Anomalies potentially caused by buried metallic objects were carefully located in the field and marked on the site map.

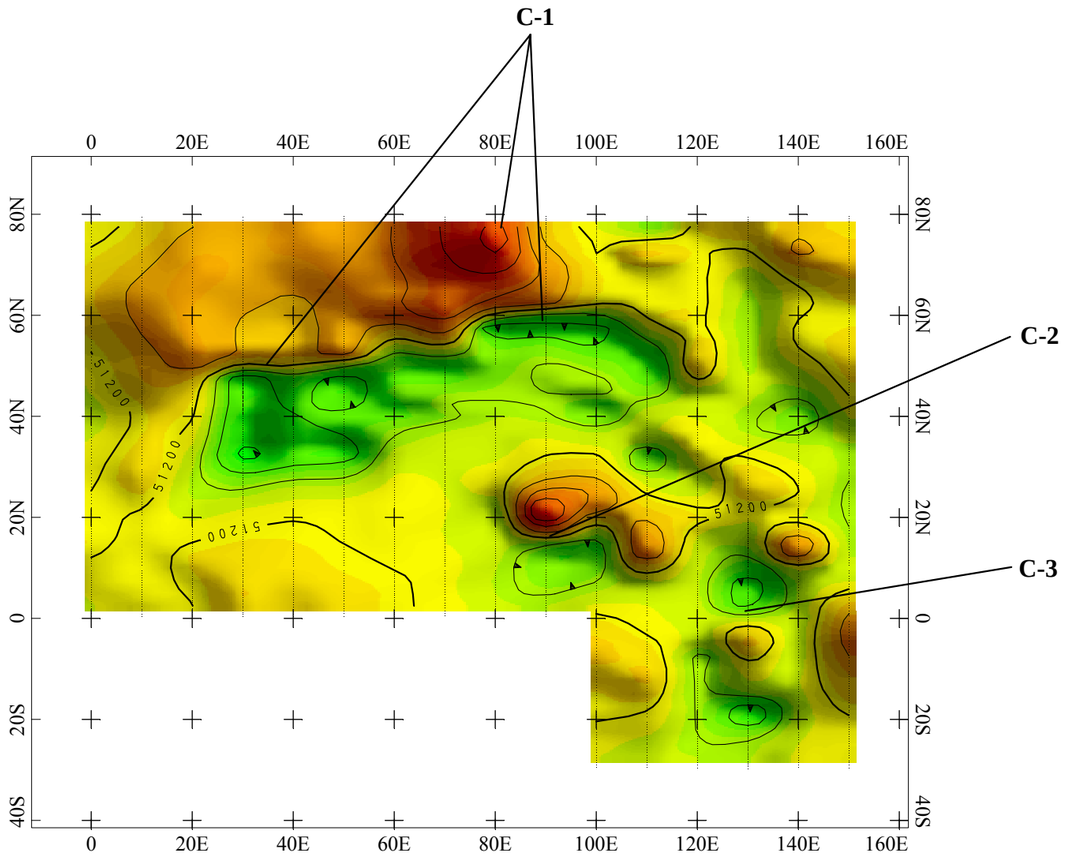
C.3.0 Data Processing

Color contour maps of magnetic data were generated using the OASIS Montaj® geophysical mapping system from Geosoft, Inc. The maps were color-enhanced to aid with interpreting subtle anomalies. The magnetic data contour maps from this site are presented as Figures C-3 through C-5.

A series of data processing steps were required to generate the contour maps. Magnetic gradiometer data were downloaded from the field instrument and converted to an ASCII file using the Geometrics, Inc. MAGMAP2000® program. The ASCII data files were then reviewed to assess line numbers, station ranges, and overall data quality. Field data file names and corresponding base station data files were recorded on the data file tracking form. Data screening results were then recorded on the base station summary form. Following data quality assessment, geometry corrections to field data files were made, if necessary, using a text editor and recorded on the geophysical data editing form.

Final, corrected magnetic data files containing local geophysical station coordinates (X,Y) and the geophysical measurement (Z) were converted to OASIS Montaj® format and imported into the geophysical mapping software. The data were then gridded using bi-directional gridding with an Akima spline. The grid cell size for the magnetic data was chosen to be 1.25 feet. Color contouring was used to enhance data anomalies. The names of files generated and processing parameters used were recorded on data processing forms. Final processed map names are shown in the data processing box found in the lower left corner of each contour map presented. All completed forms of magnetic data collected during the investigation are retained in project files.





LEGEND:

..... GEOPHYSICAL SURVEY LINES
C-1 GEOPHYSICAL ANOMALY DISCUSSED IN TEXT

Scale 1:360

25 0 25 50
feet

MINIMUM CONTOUR INTERVAL: 20 nanoTeslas

NAME: Nicholas Muloshi	DATE: January 12, 2001
PROJECT NUMBER: 774645	LOCATION: C:\IT Projects\FtMcCllelan\22C\MAG\cor\24CT_rdg.map

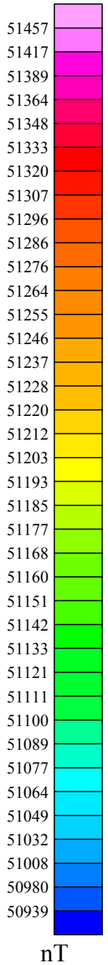
FIGURE C-3

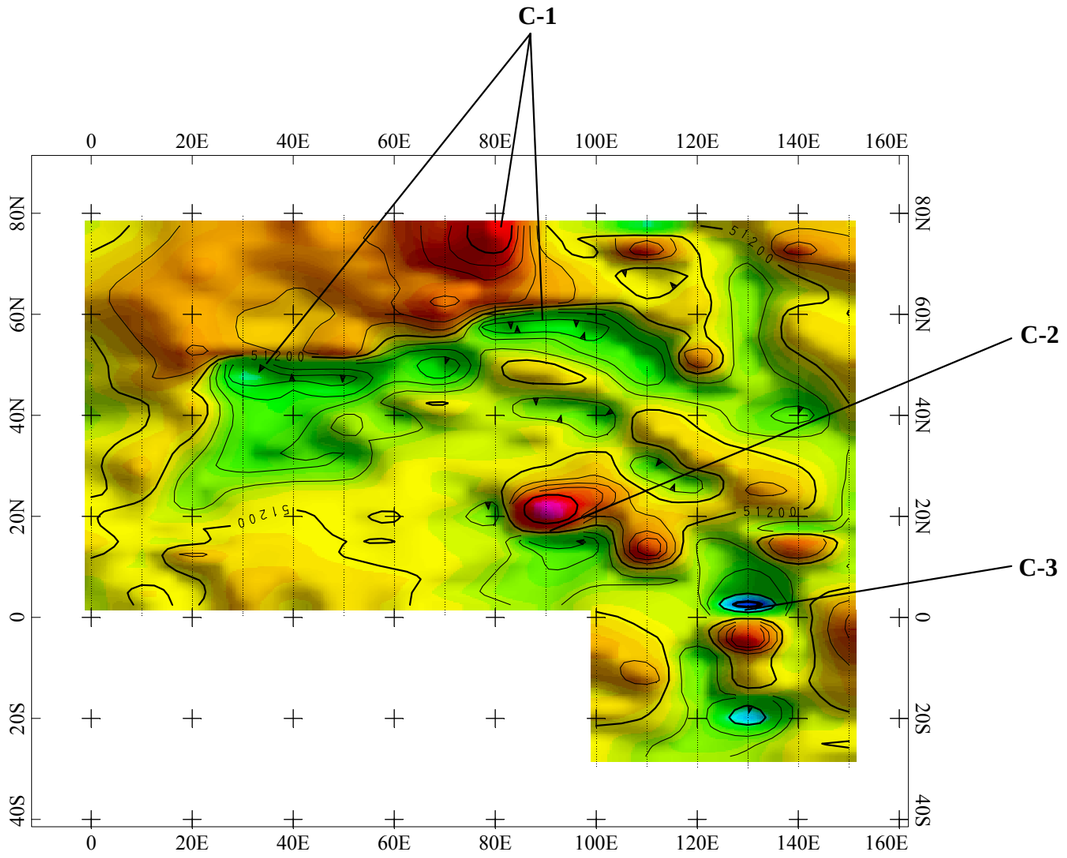
TRAINING AREA 24C
FORT McCLELLAN-PELHAM RANGE

G-858G TOTAL MAGNETIC FIELD
UPPER SENSOR (4.5 FT ABOVE GROUND SURFACE)
NORTH-SOUTH SURVEY LINES

U.S. ARMY CORPS OF ENGINEERS
MOBILE DISTRICT
FORT McCLELLAN
CALHOUN COUNTY, ALABAMA
Contract No. DACA21-96-D-0018

Shaw Shaw Environmental Inc.





LEGEND:

..... GEOPHYSICAL SURVEY LINES
C-1 GEOPHYSICAL ANOMALY DISCUSSED IN TEXT

Scale 1:360

25 0 25 50
feet

MINIMUM CONTOUR INTERVAL: 20 nanoTeslas

NAME:	DATE:
Nicholas Muloshi	January 12, 2001
PROJECT NUMBER: 774645	LOCATION: C:\IT Projects\FtMcClIelan\24C\MAG\cor\24cBot.map

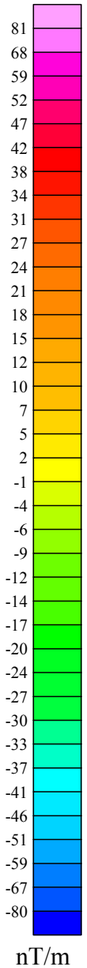
FIGURE C-4

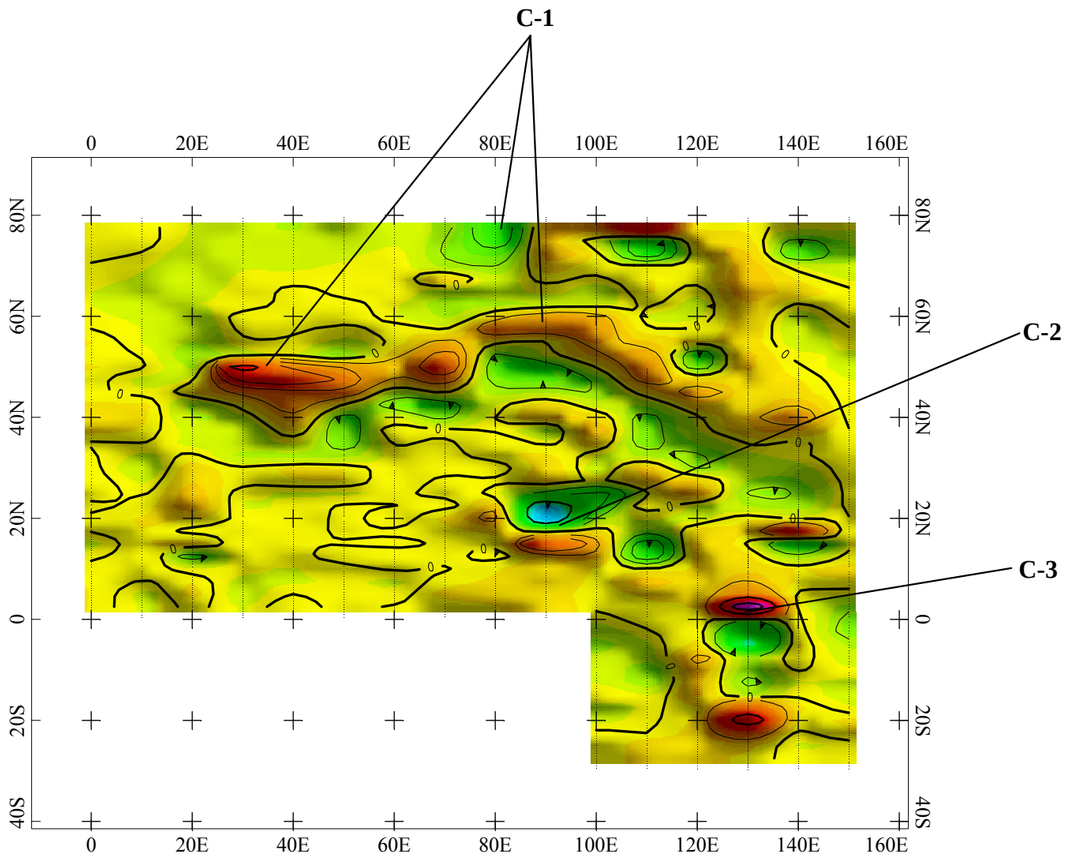
TRAINING AREA 24C
FORT McCLELLAN-PELHAM RANGE

G-858G TOTAL MAGNETIC FIELD
LOWER SENSOR (2.0 FT ABOVE GROUND SURFACE)
NORTH-SOUTH SURVEY LINES

U.S. ARMY CORPS OF ENGINEERS
MOBILE DISTRICT
FORT McCLELLAN
CALHOUN COUNTY, ALABAMA
Contract No. DACA21-96-D-0018

Shaw Shaw Environmental, Inc.





LEGEND:

..... GEOPHYSICAL SURVEY LINES
C-1 GEOPHYSICAL ANOMALY DISCUSSED IN TEXT

Scale 1:360

25 0 25 50
feet

MINIMUM CONTOUR INTERVAL: 20 nanoTeslas per meter

NAME: Nicholas Muloshi	DATE: January 12, 2001
PROJECT NUMBER: 774645	LOCATION: C:\IT Projects\FtMcCllelan\24c\mag\cor\24cVert.map

FIGURE C-5

TRAINING AREA 24C
FORT McCLELLAN-PELHAM RANGE

G-858G TOTAL MAGNETIC FIELD
VERTICAL GRADIENT
NORTH-SOUTH SURVEY LINES

U.S. ARMY CORPS OF ENGINEERS
MOBILE DISTRICT
FORT McCLELLAN
CALHOUN COUNTY, ALABAMA
Contract No. DACA21-96-D-0018

Shaw Shaw Environmental, Inc.

C.4.0 Interpretation of Geophysical Data

The method by which the geophysical data were interpreted and the results of that interpretation are presented in this chapter.

Figure C-2 presents the site map with geophysical interpretation. Interpreted color-contour maps of total magnetic field for the upper sensor, lower sensor, and vertical gradient are presented as Figures C-3 through C-5, respectively. A theoretical background is presented as in Attachment D. The attachment discusses the factors influencing the observed geophysical response for the various methods and equipment used to conduct the survey at the sinkhole location in Training Area 24C.

In addition to the geophysical interpretation, the site map (Figure C-2) contains detailed information on reference features (e.g., topographic slopes and the ravine/depression), so that the survey area and the geophysical anomaly locations can be relocated in the future. Anomalies shown on the site interpretation map correspond to those seen in the magnetic data. Surface reference features shown on the site interpretation map were translated from the hand-drawn site map made in the field. The site interpretation map also references the U.S. Alabama East State Plane NAD-83 coordinate system.

C.4.1 Data Interpretation Criteria

Anomalies shown on the magnetic data contour maps range from high to low and from negative to positive values. The observed anomalies in the contour map of total magnetic field for the upper sensor have values above and below the average magnetic field intensity of 51,200 nanoTeslas (nT) for Anniston, Alabama. The typical magnetic data response to near-surface ferrous metallic debris is an asymmetric south high/north low signature. The upper sensor magnetic data are more useful than the lower sensor data for locating large buried objects because the lower sensor is more sensitive to small near-surface objects.

Anomalies present on the contour maps of magnetic data were field-checked and correlated with known metallic surface objects and other cultural surface features so that anomalies caused by subsurface sources could be determined. Anomalies identified to be caused by buried sources, such as changes in geologic conditions or metal objects potentially representing smoke pots or oil drums have been identified on each of the contour maps and are discussed in the following text.

C.4.2 Training Area 24C Data Interpretation

Anomaly C-1. Anomaly C-1 occurs as a broad magnetic anomaly located in the central portion of the survey area. Anomaly C-1 has a low-amplitude reverse polarity magnetic response of approximately 150 nT in both the upper and lower sensor data (Figures C-3 and C-4). Anomaly C-1 is interpreted to be caused by variations in geology.

Anomaly C-2. Anomaly C-2 is located at approximately (90E, 16N). Anomaly C-2 has a low-amplitude reverse polarity magnetic response of 110 nT in the upper sensor and 280 nT in the lower sensor data (Figures C-3 and C-4, respectively). Anomaly C-2 is interpreted to be caused by variations in geology.

Anomaly C-3. Anomaly C-3 is located at approximately (130E, 0N). Anomaly C-3 occurs as a low-amplitude magnetic response of 50 nT in the upper sensor and 320 nT in the lower sensor data (Figures C-3 and C-4, respectively). The relatively high response in the lower sensor data compared to the upper sensor is indicative of near-surface source materials. Anomaly C-3 is interpreted to be caused by variations in local geologic conditions with an increase in the volume of high magnetic susceptibility rocks at or near the surface. However, the possibility exists that the source of Anomaly C-3 could be a very small buried metal object.

C.5.0 Conclusions and Recommendations

A surface geophysical survey using the magnetic method was conducted on October 31, 2000 at the surface depression location in Training Area 24C. The survey objective was to screen the site for the presence of hazardous debris such as smoke pots and oil drums suggested in historical reports.

Geophysical data analysis indicates two areas of elevated magnetic readings interpreted to be caused by local geologic conditions and one anomaly interpreted to be caused by local geologic conditions or possibly a very small buried metal object. The geophysical interpretation map (Figure C-2) indicates the locations of these anomalies.

A hand drawn field map and GPS survey of site features provided a permanent record of the survey boundaries and anomaly locations. Features shown on the interpretation map are conservatively estimated to be accurate to within +/- 5 feet.

Based on the objectives and results of the geophysical survey presented in this report, no further geophysical effort is recommended at the Training Area 24C site.

ATTACHMENT D

THEORETICAL BACKGROUND FOR PELHAM RANGE GEOPHYSICAL REPORTS

Table of Contents

List of Acronyms

EM	electromagnetic induction
EM31	Geonics Limited EM31 Terrain Conductivity Meter
EM61	Geonics Limited EM61 High-Resolution Metal Detector
G-856	Geometrics Inc. G-856 Magnetometer
G-858G	Geometrics Inc. G-858G Magnetic Gradiometer
9860-BRL	Metrotech Inc. 9860-BRL EM utility locator
mV	millivolts
mS/m	milliSiemens/meter
nT	nanoTeslas
nT/m	nanoTeslas/meter
ppt	parts per thousand
RF	radiofrequency
UXO	unexploded ordnance

D.1.0 Magnetic Method

The magnetic instruments used during the Fort McClellan surface geophysical surveys were a Geometrics, Inc., G-858G "walking mode" magnetic gradiometer (G-858G) for acquiring survey data and a Geometrics, Inc., G-856 for collecting magnetic base station data.

The G-858G, which is an optically-pumped cesium vapor instrument, measures the intensity of the Earth's magnetic field in nanoTeslas (nT) and the vertical gradient of the magnetic field in nanoTeslas per meter (nT/m). The vertical gradient is measured by simultaneously recording the magnetic field with two sensors at different heights. To determine the vertical magnetic gradient, the upper sensor reading is subtracted from the lower sensor reading, and the result is then divided by the distance between the sensors. The distance between sensors for this investigation was 2.5 feet (0.76 meters). The vertical magnetic gradient measurement allows for better definition of shallower anomalies.

During operation of the G-858G magnetic gradiometer, a direct current is used to generate a polarized monochromatic light. Absorption of the light occurs within the naturally precessing cesium atoms found in the instrument's two vapor cells or sensors. When absorption is complete, the precessing atoms become a transfer mechanism between light and a transverse radiofrequency (RF) field at a specific frequency of light known as the Larmor frequency. The light intensity is used to monitor the precession and adjusts the RF allowing for the determination of the magnetic field intensity (Sheriff, 1991).

The Earth's magnetic field is believed to originate in currents in the Earth's liquid outer core. The magnetic field varies in intensity from approximately 25,000 nT near the equator, where it is parallel to the Earth's surface, to approximately 70,000 nT near the poles, where it is perpendicular to the Earth's surface. In Alabama, the intensity of the Earth's magnetic field varies from 51,000 nT to 52,000 nT and has an associated inclination of approximately 54 degrees.

Anomalies in the Earth's magnetic field are caused by induced or remnant magnetism. Remnant magnetism is caused by naturally occurring magnetic materials. Induced magnetic anomalies result from the induction of a secondary magnetic field in a ferromagnetic material (e.g., pipelines, drums, tanks, or well casings) by the Earth's magnetic field. The shape and amplitude of an induced magnetic anomaly over a ferromagnetic object depend on the geometry, size, depth, and magnetic susceptibility of the object and on the magnitude and inclination of the

Earth's magnetic field in the study area (Dobrin, 1976; Telford, et al., 1976). Induced magnetic anomalies over buried objects such as drums, pipes, tanks, and buried metallic debris generally exhibit an asymmetrical, south high/north low signature (maximum amplitude on the south side and minimum on the north in the Northern Hemisphere). Magnetic anomalies caused by buried metallic objects generally have dimensions much greater than the dimensions of the objects themselves. As an extreme example, a magnetometer may begin to sense a buried oil well casing at a distance of greater than 50 feet.

The magnetic method is not effective in areas with ferromagnetic material at the surface because the signal from the surface material obscures the signal from any buried objects. Also, the presence of an alternating current electrical power source can render the signal immeasurable because of the high precision required in the measurement of the frequency at which the protons precess (Breiner, 1973). The precession signal may also be sharply degraded in the presence of large magnetic gradients (exceeding approximately 600 nT/m).

The magnetic field measured at any point on the Earth's surface undergoes low-frequency diurnal variation, called magnetic drift, associated with the Earth's rotation. The source of magnetic drift is mainly within the ionosphere, and its magnitude is sometimes large enough to introduce artificial trends in survey data. The G-856 base station magnetometer was used to record this drift for removal from the G-858G survey data during processing.

Applications of the magnetic method include delineating old waste sites and mapping unexploded ordnance (UXO), drums, tanks, pipes, abandoned wells, and buried metallic debris. The method also is useful in searching for magnetic ore bodies, delineating basement rock, and mapping subsurface geology characterized by volcanic or mafic rocks.

D.2.0 Frequency-Domain EM Method

Frequency-domain electromagnetic induction equipment used during this investigation consisted of a Geonics EM31 terrain conductivity meter (EM31) coupled to an Omnidata DL720 digital data logger. The EM31 consists of a 12-foot-long plastic boom with a transmitter coil mounted at one end and a receiver coil at the other. An alternating current is applied to the transmitter coil, causing the coil to radiate a primary EM field. As described by Faraday's law of induction, this time-varying magnetic field generates eddy currents in conductive subsurface materials. These eddy currents have an associated secondary magnetic field with a strength and phase shift (relative to the primary field) that are dependent on the conductivity of the medium. The combined effect of the primary and secondary fields is measured by the receiver coil in-phase (in-phase) and 90 degrees out-of-phase (quadrature) with the primary field. Most geologic materials are poor conductors. Current flow through geologic materials takes place primarily in the pore fluids (Keller and Frischknecht, 1966); as such, conductivity is predominantly a function of soil type, porosity, permeability, pore fluid ion content, and degree of saturation. The EM31 is calibrated so that the out-of-phase component is converted to electrical conductivity in units of millisiemens per meter (mS/m) (McNeill, 1980), and the in-phase component is converted to parts per thousand (ppt) of the secondary field to the primary EM field. The in-phase component is a relative value that is generally set to zero over background materials at each site.

The depth of penetration for EM induction instruments depends on the transmitter/receiver separation and coil orientation (McNeill, 1980). The EM31 has an effective exploration depth of approximately 18 feet when operating in the vertical dipole mode (horizontal coils). In this mode, the maximum instrument response results from materials at a depth of approximately two-fifths the coil spacing (or, approximately 2 feet below ground surface with the instrument at the normal operating height of approximately 3 feet), providing that no large metallic features such as tanks, drums, pipes, and reinforced concrete are present. Single buried drums typically can be located to depths of approximately 5 feet, whereas clusters of drums can be located to significantly greater depths if background noise is limited or negligible. In the horizontal dipole mode (vertical coils), the EM31 has an effective exploration depth of approximately 9 feet and is most sensitive to materials immediately beneath the ground surface.

The EM31 generally must pass over or very near a buried metallic object to detect it. Both the out-of-phase and in-phase components exhibit a characteristic anomaly over near-surface

metallic conductors. This anomaly consists of a narrow zone having strong negative amplitude centered over the target and a broader lobe of weaker, positive amplitude on either side of the target. For long, linear conductors such as pipelines, the characteristic anomaly is as described when the axis of the coil (instrument boom) is at an angle to the conductor. However, when the instrument boom is oriented parallel to the conductor, a positive amplitude anomaly is obtained.

The application of frequency-domain EM techniques includes mapping conductive groundwater contaminant plumes in very shallow aquifers, delineating oil brine pits, landfill boundaries and pits and trenches containing buried metallic and nonmetallic debris, and locating buried pipes, cables, drums, and tanks.

D.3.0 Time-Domain EM Method

Time-domain electromagnetic induction equipment used during this investigation consisted of a Geonics EM61 high-resolution metal detector (EM61) coupled to an Omnidata DL720 digital data logger. The EM61 consists of one transmitter and two receiver coils each 1-meter square. The transmitter and one receiver coil are co-incident within the instrument, the second receiver coil is separated by 0.5 meters (m). Comparison of the readings in the two receiver coils allows for discrimination between shallow and deeply buried metal objects. In operation, a pulse of current in the transmitter coil generates a primary magnetic field that induces eddy currents in nearby metallic conductors, as described by Faraday's law of induction. These eddy currents produce secondary magnetic fields that are measured by the time-dependant, decaying voltage they produce in the receiver coils. The internal electronics of the EM61 are designed such that readings are taken in a very narrow time window following transmitter turn-off. The measurement secondary fields in the absence of a primary field allows for the high sensitivity measurements obtained with the system. Since the current ring diffuses down and outward, readings taken immediately after current shut-off are most affected by near-surface conditions and the later readings by the electrical properties of the deeper subsurface.

The EM61 is generally adjusted in the field to have a zero millivolts (mV) response over background conditions.

The EM61 depth of penetration depends primarily on the size of the target, and to a lessor degree on the type of metal (Geonics, 1997). The EM61 has an effective exploration depth in excess of 10 feet for locating large conductive features, such as tanks.

The EM61 generally must pass over, or very, near a buried metallic object to detect it. The EM61 characteristic anomaly consists of readings elevated 10 to 20 mV above background for small conductors and up to several thousand mV for large conductors, such as tanks. For mapping long, linear conductors, the EM61 data is most useful when measurements are taken perpendicular to the orientation of the conductor.

The application of near-surface time-domain EM techniques with instruments such as the EM61, includes detecting and mapping metallic objects (buried pipes, cables, drums, and tanks), and mapping the boundaries of landfill, pits or trenches containing buried metallic debris.

D.4.0 References

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