Date Received for Clearance Process (MM/DD/YYYY)
12/05/2006

INFORMATION CLEARANCE FORM

S

A. Information Category

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- [ ] Summary
- [ ] Visual Aid
- [ ] Full Paper
- [ ] Journal Article
- [ ] Internet
- [ ] Software
- [x] Report
- [ ] Other _____

B. Document Number D&D-30708, Rev 0

C. Title
GEOPHYSICAL INVESTIGATIONS SUMMARY REPORT
200 Area Burial Grounds: 218-E-1, 218-E-2A, 218-E-8, 218-E-12A, 218-W-1, 218-W-2, 218-W-3 and 218-W-11

D. Internet Address

E. Required Information (MANDATORY)

1. Is document potentially Classified? (●) No ( ) Yes
   L.R. Fitch
   Manager Required (Print and Sign)
   If Yes _____
   ADC Required (Print and Sign) ( ) No ( ) Yes Classified
2. Official Use Only (●) No ( ) Yes Exemption No. ____
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4. UCNI (●) No ( ) Yes
5. Applied Technology (●) No ( ) Yes
6. Other (Specify) _____

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9. Release Level? (●) Public ( ) Limited

F. Complete for a Journal Article

1. Title of Journal

G. Complete for a Presentation

1. Title for Conference or Meeting _____
2. Group Sponsoring _____
3. Date of Conference _____
4. City/State _____
5. Will Information be Published in Proceedings? ( ) No ( ) Yes
6. Will Material be Handed Out? ( ) No ( ) Yes

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Approval by Direct Report to FH President (Speech/Articles Only) _____
(Print and Sign)

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APPROVED FOR RELEASE
OFFICIAL DOCUMENT
Date 12/06/2006

J. If Additional Comments, Please Attach Separate Sheet

A-6001-401 (10/06)

ADMINISTRATIVE DOCUMENT PROCESSING AND APPROVAL

DOCUMENT TITLE:
GEOPHYSICAL INVESTIGATIONS SUMMARY REPORT
200 Area Burial Grounds: 218-E-1, 218-E-2A, 218-E-8, 218-E-12A, 218-W-1, 218-W-2, 218-W-3 and 218-W-11

OWNING ORGANIZATION/FACILITY:
FH D&D Project, Waste Site Remediation

Document Number: D&D-30708

Revision/Change Number: 0

DOCUMENT TYPE *(Check Applicable)*

☐ Plan ☒ Report ☐ Study ☐ Description Document ☐ Other

DOCUMENT ACTION ◉ New ○ Revision ○ Cancellation

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DOCUMENT CONTROL

Does document contain scientific or technical information intended for public use? ◉ Yes ○ No

Does document contain controlled-use information? ○ Yes ◉ No

("Yes" requires information clearance review in accordance with HNF-PRO-184)

DOCUMENT REVISION SUMMARY

NOTE: Provide a brief description or summary of the changes for the document listed.

N/A -- New document

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RELEASE/ISSUE
DEC 06 2006
DATE:
STA: 15
HANFORD RELEASE
ID: 20

0075860

D&D-30708
Revision 0

Geophysical Investigations Summary Report

200 Areas Burial Grounds: 218-E-1, 218-E-2A, 218-E-8, 218-E-12A, 218-W-1, 218-W-2, 218-W-3, and 218-W-11

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management

Project Hanford Management Contractor for the
U.S. Department of Energy under Contract DE-AC06-96RL13200

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D&D-30708
Revision 0

Geophysical Investigations Summary Report

200 Areas Burial Grounds: 218-E-1, 218-E-2A, 218-E-8, 218-E-12A, 218-W-1, 218-W-2, 218-W-3, and 218-W-11

Date Published
December 2006

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FLUOR.
P.O. Box 1000
Richland, Washington

Release Approval 12/06/2006
Date

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TERMS

EM	electromagnetic
EMI	electromagnetic induction
FM	frequency modulation
GPR	ground-penetrating radar
GPS	Global Positioning System
mS/m	millisiemens per meter
NCR	Nonconformance Report
TMF	total magnetic field

METRIC CONVERSION CHART

Into Metric Units

If You Know	*Multiply By*	*To Get*
Length		
inches	25.4	Millimeters
inches	2.54	Centimeters
feet	0.305	Meters
yards	0.914	Meters
miles	1.609	Kilometers
Area		
sq. inches	6.452	sq. centimeters
sq. feet	0.093	sq. meters
sq. yards	0.836	sq. meters
sq. miles	2.6	sq. kilometers
acres	0.405	Hectares
Mass (weight)		
ounces	28.35	Grams
pounds	0.454	Kilograms
ton	0.907	metric ton
Volume		
teaspoons	5	Milliliters
tablespoons	15	Milliliters
fluid ounces	30	Milliliters
cups	0.24	Liters
pints	0.47	Liters
quarts	0.95	Liters
gallons	3.8	Liters
cubic feet	0.028	cubic meters
cubic yards	0.765	cubic meters
Temperature		
Fahrenheit	subtract 32, then multiply by 5/9	Celsius
Radioactivity		
picocuries	37	Millibecquerel

Out of Metric Units

If You Know	*Multiply By*	*To Get*
Length		
millimeters	0.039	inches
centimeters	0.394	inches
meters	3.281	feet
meters	1.094	yards
kilometers	0.621	miles
Area		
sq. centimeters	0.155	sq. inches
sq. meters	10.76	sq. feet
sq. meters	1.196	sq. yards
sq. kilometers	0.4	sq. miles
hectares	2.47	acres
Mass (weight)		
grams	0.035	ounces
kilograms	2.205	pounds
metric ton	1.102	ton
Volume		
milliliters	0.033	fluid ounces
liters	2.1	pints
liters	1.057	quarts
liters	0.264	gallons
cubic meters	35.315	cubic feet
cubic meters	1.308	cubic yards
Temperature		
Celsius	multiply by 9/5, then add 32	Fahrenheit
Radioactivity		
millibecquerel	0.027	picocuries

1.0 INTRODUCTION

This document summarizes the results of geophysical investigations conducted at eight burial grounds located within the 200 East and 200 West Areas of the Hanford Site. The geophysical investigations were performed by North Wind, Inc., (North Wind) for Fluor Hanford, Inc., (Fluor Hanford) during June 2006. The geophysical techniques used in the investigations were ground-penetrating radar (GPR), electromagnetic induction (EMI), and total magnetic field (magnetic) methods.

1.1 SCOPE AND OBJECTIVES

The following burial grounds were investigated:

- 218-E-1
- 218-E-2A
- 218-E-8
- 218-E-12A
- 218-W-1
- 218-W-2
- 218-W-3
- 218-W-11.

The geophysical surveys were reconnaissance-type surveys that were aimed at defining the following characteristics:

- Locations of burial ground trench edges, ends, and centerlines
- Locations of buried waste or other significant features/anomalies
- Presence and extent of voids within a given trench
- Definition of most likely waste container type (for example, wood, metal boxes, metal drums, cardboard, and/or waste item)
- Differentiation between different types of waste containers within a given trench
- Depth of soil cover above waste items
- Depth to trench bottom (where possible).

1.2 BACKGROUND

Characterization of waste placed in 200 Areas burial grounds is being performed to evaluate waste site conditions and to evaluate remediation alternatives to support cleanup/closure under the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980*. The waste sites addressed in this report are included in the 200-SW-2 Radioactive Landfills and

Dumps Operable Unit. Per a 2005 agreement between the U.S. Department of Energy, Richland Operations Office and the Washington State Department of Ecology, nonintrusive geophysical investigations should be performed to enhance conceptual site models for the 200-SW-2 Operable Unit burial grounds. The enhanced conceptual site models then are to be used during future collaborative data quality objectives development; the data quality objectives will, in turn, be used to support development and eventual approval of a sampling and analysis plan and a remedial investigation/feasibility study work plan for the 200-SW-2 Operable Unit waste sites.

An initial phase of geophysical investigations was performed at eight burial grounds waste sites in 2005 and documented in D&D-28379, *Geophysical Investigations Summary Report; 200 Area Burial Grounds: 218-C-9, 218-E-2A, 218-E-5, 218-E-5A, 218-E-8, 218-W-1A, 218-W-2A, and 218-W-11*. Data from these previous investigations indicated that three of the eight burial grounds investigated (218-E-2A, 218-E-8, 218-W-11) may have areas where the burial trenches extend beyond the areas initially surveyed. The current investigation, as described in this report, was designed to resolve these potential discrepancies. In addition, new geophysical investigations were performed at five older/inactive burial grounds (218-E-1, 218-E-12A, 218-W-1, 218-W-2, and 218-W-3).

1.3 GEOLOGIC SETTING

The depth of investigation for the geophysical instruments used in this work was limited to approximately 3 to 4 m. Therefore, only the shallowest aspects of site geology are pertinent to this investigation. Those aspects of the site geology are the Hanford formation and the surficial sediments.

The Hanford formation is the shallowest geologic formation recognized at the Hanford Site and consists of deposits of poorly sorted gravels and coarse sands indicative of a high-energy depositional environment. The surficial sediments overlying the Hanford formation are primarily eolian loess interspersed with lenses of sand and mixed gravels.

A comprehensive summary of the geology of the Hanford Site is presented in WHC-SD-EN-EE-004, *Revised Stratigraphy for the Ringold Formation, Hanford Site, South-Central Washington.*

2.0 METHODOLOGY

2.1 SURVEY GRID PARAMETERS

Fluor Hanford provided site drawings showing civil survey coordinates to North Wind to develop base grids at each site. Using the drawings, North Wind determined Washington State Plane coordinates (NAD83, *North American Datum of 1983*, as revised) to create base grids with 30 m nodes throughout the individual sites. The state plane coordinates were given to Fluor Hanford civil survey personnel who used global-positioning-system (GPS) instrumentation to stake the base grids in the field. North Wind personnel then marked data collection lines at 6 m intervals between the 30 m nodes, using nonmetallic, fluorescent pin flags.

Operators used the fluorescent pin flags to "dead-reckon" data collection along and in between the marked lines. Data positioning along the lines was accomplished by careful pacing or by marking 30 m fiducials, depending on the instrument.

The geophysical data plots are presented in local grid coordinates. The local grids generally were established by assigning to the southwestern-most base grid node the arbitrary location of North 100, East 100 (N100/E100). Positions (positive north and positive east) then were measured (in meters) from this local origin. In some instances, the grids were expanded south and/or west after establishment and therefore have coordinates less than N100/E100. The interpretation drawings for each site show Washington State Plane coordinates (in meters) for selected grid nodes, allowing a tie between them and the local grid coordinates.

2.2 GEOPHYSICAL METHODS

The geophysical techniques used in the investigations were the EMI, total magnetic field, and GPR methods. These methods were selected because they are cost effective and nonintrusive and have been successful in similar waste characterization projects conducted at the Hanford Site.

2.2.1 Frequency-Domain Electromagnetic Induction

The Geonics EM31 Terrain Conductivity Meter[1] is a frequency domain EMI instrument that is designed to measure the apparent electrical conductivity of soil and to detect ferrous and nonferrous metal objects to a depth of approximately 3 to 4 m (in ideal situations). The EM31 meter consists of a transmitter coil and receiver coil at either end of a 4 m-long boom. The transmitter generates pulses of electromagnetic energy (the primary field) at regular intervals, which are transmitted into the ground, where they induce eddy currents in electrically conductive material (soil and/or metal objects). The induced eddy currents generate their own

[1] Geonics EM31 is a trademark of Geonics Limited, Mississauga, Ontario, Canada.

electromagnetic field (the secondary field), which transmits back toward the instrument. The receiver coil on the EM31 meter measures and records the strength of the secondary field both in phase and out of phase with the primary field transmitter. The in-phase component of the measurement is most strongly influenced by the presence of metallic objects in the subsurface, while the out-of-phase component (quadrature component) is directly related to the electrical conductivity of the surrounding soil.

The in-phase component reading is given in parts per thousands of the amplitude of the secondary signal to the primary signal. The out-of-phase component reading is given in units of electrical conductivity (millisiemens per meter [mS/m]), which is the apparent conductivity of the soil in the vicinity of the instrument, assuming homogeneous conditions. This assumption becomes less valid in the presence of metal or other significant conductivity changes. However, generally it is the contrasts in conductivities that are used for interpretation, not the absolute values, so the validity of the assumption usually is irrelevant.

The EM31 meter is an ideal instrument for waste site characterization because of the relative speed and ease with which it can cover an area. The normal mode of operation is to mark out regularly spaced data collection lines and then walk down the lines with the instrument held at hip height, collecting data at regularly spaced intervals. Both the in-phase and out-of-phase (terrain conductivity) measurements are collected and plotted for analysis. The instrument is most useful for locating large concentrations of buried metallic objects and for detecting subtle shifts in background soil properties. While the EM31 meter is capable of detecting drum-size metallic objects to a depth of 3 to 4 m in ideal situations, the lateral resolution of the position of detected objects is on the order of +/- 1 m.

Conditions that limit the detection capability of the EM31 meter include high-background soil conductivities and proximity to cultural interference such as buildings and fences. High soil conductivities have the effect of limiting the depth of investigation of the instrument, because they significantly attenuate the propagation of the primary and secondary fields. (This is the same phenomenon that limits GPR depth of investigation in areas of high soil conductivity.) Large, metallic surface cultural features can effectively swamp the signal of the EM31 meter out to a distance of approximately 5 to 7 m. Sites with a significant number of buried utilities also may generate data that are difficult to interpret.

2.2.1.1 EM31 Data-Collection Procedures

Data-collection procedures are discussed in detail in Geonics, 1994, *EM31 Terrain Conductivity Operating Manual*. The EM31 meter has the following specific key data-collection and -processing attributes.

- Perform functional checks as outlined in the manufacturer-supplied operator's manual.
- Collect the data along profiles that are spaced a predetermined distance apart (data points are located at evenly spaced distances along the individual profiles).
- Estimate visually or pace the location of data points collected between surveyed grid points.

2.2.1.2 EM31 Data-Processing Procedures

The EM31 meter has the following specific data-processing parameters.

- Edit the data for mislabeled lines, view in raw form along each profile, and convert to XYZ.dat files.
- Contour the data with the grid nodes at the actual data points (with close-spaced data) using Golden Software's Surfer[2] or equivalent.

2.2.2 Time-Domain Electromagnetic Induction

The Geonics EM61-MK2 High Sensitivity Metal Detector[3] (EM61) is a highly sensitive, high-resolution time-domain electromagnetic tool that is commonly used to detect shallow (<3 m) ferrous and nonferrous objects. It consists of a transmitter that generates a pulsed primary magnetic field, which induces eddy currents in buried objects. The decay of these currents is measured over time by two receiver coils. The response is recorded in the field and later transferred to a computer for further processing and analysis.

The amplitude of the response is highly dependent upon the distance between the coil assembly and the target; therefore, small near-surface anomalies often will produce a response that has larger amplitude than much larger targets that are deeper. To reduce this effect, the EM61 metal detector uses two coils and processes the data by subtracting the response of a coil that is relatively close to the ground from the response from the more distant upper coil.

The arrangement of the coils makes the tool less sensitive to interference from nearby surface features such as fences. The EM61 metal detector provides good lateral discrimination of the detected features.

2.2.2.1 EM61 Data-Collection Procedures

Data-collection procedures are discussed in detail in Geonics, 2000, *EM61-MK2 4 Channel High Sensitivity Metal Detector Operating Manual*. Specific key data-collection and -processing attributes are described below.

- Perform functional checks as outlined in the operator's manual supplied by the manufacturer.
- Collect the data along profiles spaced a predetermined distance apart at data points along individual profiles at evenly spaced distances.

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[2] Surfer is a trademark of Golden Software, Inc., Golden, Colorado.

[3] Geonics EM61-MK2 is a trademark of Geonics Limited, Mississauga, Ontario, Canada.

- Estimate visually or pace the location of data points collected between surveyed grid points.

2.2.2.2 EM61 Data-Processing Procedures

Specific data processing parameters are described below.

- Edit the data for mislabeled lines, view in raw form along each profile, and convert to XYZ.dat files.
- Contour the data with the grid nodes at the actual data points (with close-spaced data) using Golden Software's SURFER or equivalent.

2.2.3 Total Magnetic Field / Vertical Magnetic Gradient

A magnetometer measures the intensity of the earth's magnetic field. The presence of ferrous material, man-made or natural, creates local variations in the strength of the earth's overall magnetic field. These variations are proportional to several factors, including the mass of the ferrous material and the distance between the ferrous material and the detector. The distance is significant, because it changes the response by a factor of one over the distance cubed. The primary measurement that will be taken is the total magnetic field (TMF) intensity. The TMF, as the name implies, is a summation of all of the magnetic variables around the sensor. When the ferromagnetic sources are close to the detector, large variations in the TMF can occur. Therefore, it often is difficult to differentiate individual anomalies based on the TMF alone.

To improve the resolution of a magnetic survey, the vertical magnetic gradient also can be measured. This is accomplished by making two simultaneous TMF measurements at each data point, using two sensors separated by a fixed vertical distance. The difference between the two measurements is the vertical magnetic gradient (hereinafter referred to in this document as the magnetic gradient). The response to ferrous material falls off at a rate of one over the distance to the fourth power. Because of this, the magnetic gradient measurement should help differentiate individual anomalies and waste boundaries better than the TMF alone. Both the TMF and the magnetic gradient values typically are displayed on contour maps for analysis.

A Geometrics G-858G Magnetometer/Gradiometer[4] consists of two cesium vapor magnetometers. The magnetometers are mounted vertically on a pole with a 0.75 m separation. This configuration is used to collect vertical gradient data. Each magnetometer independently records the total field magnetic intensity. The gradient measurement is the difference in the total field measurements between the two sensors. In essence, a single recording location consists of three values: a total field measurement from the upper sensor, a total field measurement from the lower sensor, and the magnetic gradient value.

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[4]Geometrics G-858G Magnetometer/Gradiometer is a trademark of Geometrics, Inc., San Jose, California.

Three types of errors occasionally occur during data collection with the G-858G magnetometer/ gradiometer. The first type of error is a consequence of the cesium sensors being insensitive to magnetic fields in certain orientations, creating "dead zones." To reduce this error, each sensor was oriented to a position that would minimize dead-zone readings. The second type of erroneous reading occurs when a recording is taken too close to a magnetically sensitive ferrous feature. This can result in a "null" reading. The bottom sensor typically is more sensitive to null readings, because it usually is the closest to magnetically sensitive ferrous objects. The third type of error is caused by poor connections between the sensors and the control unit.

Geometrics equipment provides some safeguards against these errors: an audio warning and a visual warning. The audio warning often is ineffective in noisy areas. Monitoring the data visually also has its limitations because of sun glare on the control unit screen. When erroneous readings are identified in the field, those data points typically are edited and re-collected. If they are not identified in the field, they can be noted during the data-reduction phase and can be edited at that time. If a null reading is recorded on either sensor, the gradient data are erroneous and also must be edited. The editing during data reduction typically has minimal effect on the results because of the close spacing of the individual data points.

2.2.3.1 Magnetic Data-Collection Procedures

Data-collection procedures are discussed in detail in Geometrics, 2001, *G-858 MagMapper 25309-OM*, Rev. D, *Operations Manual*. The G-858G magnetometer/gradiometer has the following specific key data collection attributes.

- The cesium vapor magnetic sensors need to warm up before data collection begins at each site. The warming up of the sensors is monitored on the control unit.
- Functional checks should be performed as outlined in the manufacturer-supplied operator's manual.
- Data typically are collected along profiles spaced a specified distance apart. The data are collected along the individual profiles at evenly spaced distances, either discretely or at constant time intervals, while walking at a constant rate.

2.2.3.2 Magnetic Data Processing Procedures

Specific data-processing procedures are as follows.

- Download the magnetic field data to a laptop computer via Geometrics software, MagMap2000[5].
- Edit the data with all null readings (sensor failures) removed from the data.

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[5]Geometrics MagMap2000 is a trademark of Geometrics, Inc., San Jose, California.

- Convert the data files to XYZ.dat format, which is compatible to Golden Software's Surfer or equivalent.
- Contour the data using "standard" contour packages such as Surfer software. Contour maps are the foundation for interpretation.

2.2.4 Ground-Penetrating Radar

Ground-penetrating radar uses a transducer to transmit frequency modulation (FM) frequency electromagnetic energy into the ground. Interfaces in the ground, defined by contrasts in dielectric constants, magnetic susceptibility, and, to some extent, electrical conductivity, reflect the transmitted energy. The GPR system then measures the travel time between transmitted pulses and the arrival of reflected energy. Buried objects (such as pipes, barrels, foundations, wires) can cause all or a portion of the transmitted energy to be reflected back toward a receiving antenna. Geologic features such as cross-bedding, lateral and vertical changes in soil properties, and rock interfaces also can cause reflections of a portion of the electromagnetic (EM) energy.

The velocity of the EM energy primarily is controlled by the dielectric constant and magnetic susceptibility of the medium. For calculating depth, values of EM velocities are determined by measurement, experience in an area, ties to known buried reflectors, and knowledge of the subsurface medium.

The effective depth of investigation is a function of the transmitted power, receiver sensitivity, frequency of the antenna, and attenuation of the transmitted energy from the geologic medium. The maximum depth of investigation may vary significantly as a result of changing soil conditions. High attenuation and, therefore, smaller penetration depths of the EM energy typically occur where the soil conductivity is greater than 10 mS/m and/or in areas with numerous reflective interfaces. Depth of investigation also is affected by highly conductive material, such as metal drums or pipes, that essentially reflects all the energy. The method cannot "see" directly below areas of highly reflective material, because all of the energy is reflected.

The reflected energy provides the means for mapping the subsurface features of interest, whether synthetic or geologic. Display and interpretation of GPR data are similar to that of seismic reflection data (i.e., data displayed as horizontal distance versus time depicting pseudo cross-sections of the earth). When numerous adjacent profiles are collected, often in two orthogonal directions, a plan-view map showing the location and depth of the detected features can be generated.

2.2.4.1 Ground-Penetrating Radar Data Collection Procedures

Generic data collection procedures are discussed in detail in Geophysical Survey Systems, 1993, *SIR-10A User's Manual*. The subsurface interface radar, or SIR-10A[6], has the following specific key data-collection and -processing attributes.

- Select the antenna best suited to meet the survey objectives.
- Set the filters, gains, and other data-collection parameters best suited for the local soil conditions.
- Pull the antenna along a series of parallel profiles within the established survey grid, then collect data along profiles in the orthogonal direction, specifically when mapping unknown linear features in various orientations.
- Record the data on the system hard drive.
- Conduct post-processing of data if warranted, and print records for interpretation.
- Interpret data using all available historical records, drawings, maps of surface features, and other geophysical data sets.

For these investigations, GPR data were collected by mounting the control instrumentation inside an all-terrain vehicle and pulling the antenna in a sled behind the vehicle.

2.2.4.2 Ground-Penetrating Radar Data-Processing Procedures

Data processing of the GPR data consisted of applying various horizontal filters as necessary before printing the data records for interpretation. The horizontal filters, when used, had the effect of removing coherent noise and/or background information so that anomalies were more visible in the records. When filters were used on records, unfiltered data also were plotted to give multiple images of the data for interpretation.

2.3 APPROACH TO DATA COLLECTION

Data collection lines were marked out such that EM31 meter and magnetic data would be collected perpendicular to the predicted centerlines of the trenches within a burial ground. This orientation offers the highest possibility of detecting anomalies caused by trench contents relative to background readings. In each of the investigations, the EM31 meter and magnetic field data were collected along profiles spaced 3 m apart. For the magnetic field data, recordings were at a constant time interval of 0.5 s, yielding data-point recordings approximately every 0.5 m. In the EM31 data, recordings were taken at 1.5 m intervals (paced) along each profile. Data were downloaded from the field instruments daily and reviewed regularly.

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[6] SIR-10A is a trademark of Geophysical Survey Systems, Inc., North Salem, New Hampshire.

GPR data were collected both perpendicular to and parallel to the trench strike except at the 218-E-2A Burial Ground, where railroad tracks prevented GPR data collection in both directions. The GPR data were collected in a continuous mode along each profile. Profile spacing varied from 2 m to 15 m to provide regional coverage. Preliminary plots of the EM31 meter and magnetic field data were used to locate specific GPR profiles, at the closer profile spacing, over anomalies of interest.

EM61 metal detector data were collected at the 218-E-2A and 218-E-8 Burial Grounds. Profiles were spaced 1.5 m apart, with data recordings at 0.19 m along the profiles. Details of the data collection at each burial ground are discussed in the site investigation summaries (Appendix A).

3.0 RESULTS

Summary-level interpretations of the geophysical data are presented in Figures 1 through 7. These interpretation maps represent an integration of all of the geophysical data and other site information and engineering drawings, as available. Note that on the interpretation drawings, depths are presented in decimeters; 1 dm equals 1/10 m. Decimeters are used on drawings to avoid using decimal points, which often are lost when drawings are copied and transmitted.

Appendix A presents plots of the EMI and magnetic data collected, along with details of the investigation at each site. The large volume of GPR paper records makes presentation of these data impractical; they will be retained in the 200-SW-2 Operable Unit Project File for reference.

Appendix B presents overlays of the geophysical interpretation maps with Hanford Site H-2 drawings for each burial ground. When computer-aided drafting and design versions of the engineering drawings were not available, then the scanned versions typically were enlarged for these displays. Enlargement can distort feature size and locations (for example, line widths can become the equivalent of many feet on the ground). While the scale and alignment are considered generally good, they have not been fully checked and verified for absolute accuracy. Therefore, these overlays should be used for information only.

3.1 GEOPHYSICAL DATA INTERPRETATION

Interpreting geophysical data requires some art as well as science. Each site investigated has a unique combination of soil conditions, types of buried debris, and surrounding cultural interferences. Therefore, data presentation and interpretation approaches may vary slightly from site to site. For example, the type of data (EMI, magnetic, or GPR) that is most useful at one site may not be as important at another site because of soil/geologic conditions, depths of burial, types of burial material, and background "noise." The amplitude scale or other plot parameters for single data types may be varied between sites to highlight information. Experience of the interpreter is invaluable in assessing all of the available data to arrive at a confident interpretation for each site. The following paragraphs discuss some aspects of interpreting the different types of geophysical data collected in this investigation.

EMI data interpretation typically involves looking for horizontal contrasts in readings of the two components recorded. Absolute amplitude and the rate of change in amplitude also may be analyzed. These observations are used to identify anomalous locations. Anomalies then are used to infer the location of buried objects and/or debris. Comparing the presence of in-phase versus terrain conductivity (quadrature-phase) anomalies gives additional information. The in-phase component is significantly more sensitive to large, discrete metallic objects than the quadrature phase. The quadrature phase, in general, is more sensitive to long, extended targets such as pipelines and to the overall terrain conductivity.

Magnetic field data are interpreted by identifying contrasts (anomalies) in readings that are indicative of buried ferrous (iron-containing) metal objects. The locations of the anomalies are used to infer the location of buried objects or debris. As discussed in Section 2.2.3, the magnetic

data of the most use are the vertical gradient readings of the total magnetic field. For simplicity of data plotting, the absolute value of the vertical field often is used to minimize the dipole effect produced by some anomalies.

GPR data are interpreted by locating anomalies on the paper data records and then determining their depth and spatial location. The location and depth of the anomalies are hand plotted onto a map of the site by the interpreter. A representative number of these anomalies are then digitized in computer-aided drafting and design software to be plotted on the interpretation map. Because of the large number of anomalies normally interpreted in GPR data, the discretion of the interpreter is used to decide which anomalies get transferred to the computer-aided drafting and design drawing to indicate the important information about the site. On Figures 1 through 7, the majority of the anomaly locations and depths are taken directly from the GPR data.

3.2 GENERAL DISCUSSION OF RESULTS

The geophysical surveys were reconnaissance-type surveys that were aimed at defining the characteristics listed in Section 1.1. Following is a discussion of the specific objectives of the geophysical investigations and how they were addressed.

- **Locations of burial ground trench edges, ends, and centerlines.** The geophysical methods employed for this investigation were successful at detecting and mapping the general location of buried objects within the target burial grounds. Where objects and debris were in concentrated packages, the edges, ends, and centerlines of trenches could be determined. Additionally, at several of the sites, GPR results enabled mapping of the excavation boundaries for the pits/trenches.

- **Locations of buried waste or other significant features/anomalies.** At some locations, buried waste was not in concentrations that indicated discrete trenches or pits. However, in most instances, the location of this waste still could be determined.

- **Presence and extent of voids within a given trench.** The data were not sufficient to differentiate voids from other types of anomalies. It is possible that voids are present; however, the reconnaissance nature of the GPR data collection did not supply sufficient data for their identification. Areas with concentrations of anomalies have the highest likelihood of voids.

- **Definition of most likely waste container type (for example, wood, metal boxes, metal drums, cardboard) and/or waste item.** Comparison of anomalies detected by different geophysical methods at the same location gives the best information of the type of material in the waste. The variable density of the GPR data (reconnaissance level) was not adequate to reliably make this level of interpretation in most cases. The primary distinctions used for interpretation are metallic, ferrous metal, and nonmetallic, based on EMI and/or magnetic data analysis. The geophysical data do not directly allow for distinguishing the container type, only the metallic and ferrous metallic content. Thus, a cardboard box containing 10 lb of metal will produce an anomaly similar to a 10-lb metal drum filled with cardboard. Most of the anomalies interpreted in this investigation were associated with waste that had a high metallic, particularly ferrous metal, content.

Cardboard or wood boxes buried adjacent to metallic objects typically could not be differentiated in the data.

- **Differentiation between different types of waste containers within a given trench.** As discussed above, metal content is the most strongly detected characteristic of waste. Most other characteristics of waste are not discernible if the metal content is too high, other than the possible indication of relatively large flat surfaces on the top of the waste containers, as determined by GPR.

- **Depth of soil cover above waste items.** On those sites where GPR was effective at detecting buried waste, the depth of the soil cover could be determined. Soil properties were such at some sites that few-to-none of the buried waste objects inferred in the EMI and magnetic data were detected with GPR. In those cases, the depth of soil cover could not be determined reliably.

- **Depth to trench bottom (where possible).** GPR data are the only data collected here that are capable of giving accurate depths in the subsurface. Trench bottoms were not detected at any of the sites; therefore, direct knowledge of trench depths is unavailable. In some data sets (none in this work), trench bottoms can be observed directly when they are not beyond the capable depth limit of the methods and the trenches/pits only are filled with soils or moderate amounts of soft waste that allow signal propagation. The data cannot "see" past the tops of highly reflective debris. When excavation boundaries are detected, as they were at many of these sites, they can be used to infer trench depth by assuming a side-slope ratio and a trench bottom width. Experience has shown that this method can be very inaccurate, because side slopes can range from near vertical to greater than 2:1, and the trench bottom widths may not follow plans. Given the assumptions implicit in this method, the method was not performed for this investigation.

The geophysical interpretation figures (Figures 1 through 7) show the locations of buried waste (objects) and give qualitative information about the material in the waste (primarily metallic content). At most locations of buried waste, the depth of soil cover above some of the waste was determined, and representative values for broad areas are shown on the figures.

Most sites have a significant number of isolated, shallow buried objects that were detected in the data. Not all of these anomalies are shown on the interpretation drawings. Experience at other locations on the Hanford Site shows that isolated, shallow anomalies usually are caused by small amounts of metallic debris in the fill/stabilization material over the site. This debris may include items such as railroad spikes or other track hardware, small metal flanges, pipe fittings, or other pieces of inert material that do not necessarily represent hazardous material.

3.2.1 Reliability / Accuracy of the Results

Reliability of the results is a function of the quality of the geophysical data and the ability of the interpreter to determine what they mean. The quality of the geophysical data depends on factors such as soil conditions, topography, accessibility to the area, and amount of site disturbance by past human activity. Experience in the area, knowledge of local geology, understanding of project objectives, and skill are factors that the interpreter adds to the reliability of the results.

Although EMI, magnetic, and GPR instruments are capable of recording accurate and precise quantitative measurements, the final results of the investigation are based on the subjective interpretation and understanding of the data.

In most cases, the interpreter is able to assess all the factors that affect the reliability of the results and can provide a level of confidence in the reliability of the results. Because so many factors are unknown in advance, the ultimate test of the reliability of the results comes from excavating and visibly examining the buried material in the trenches.

Given the reconnaissance nature of the surveys, interpretations were performed with the intent of determining the boundaries of all of the waste within a burial ground and providing representative information about its content and depth. Not all detected anomalies are shown on the interpretation figures. Locations of objects detected in the data (i.e., position in the horizontal plane) have a nominal accuracy of +/-1.0 m. Where depth to the top of the waste is presented, its accuracy is nominally +/-0.3 m.

3.3 218-E-1 BURIAL GROUND

Interpretation of the geophysical data indicates that the 218-E-1 Burial Ground contains 15 trenches with variable amounts of metallic material contained in each (see Figure 1). The buried material does not appear to be continuous throughout the entire length of most trenches. It is possible that there is continuous material that may not be detected by the instruments. More detail of individual trenches is provided in Table A1-1.

Based on Hanford Site Drawing H-2-124, *218-E-1 Dry Waste Burial Ground*, Rev. 3, the original burial ground includes 15 trenches, which correlates with the geophysical data. The area inside the burial ground monuments, east of line E210, is part of a later expansion. No trenches or anomalies that would be associated with buried debris were detected east of E210. It is possible that this area could contain deeply buried, nonmetallic waste that was not detected with the instruments. This is not expected, however, because the trench design for the first 15 trenches was for a maximum trench depth of 3 m (10 ft).

3.4 218-E-2A BURIAL GROUND

Hanford Site Drawing H-2-55534, *218-E2, E2A, E4, E5, E5A, & E9 Industrial Burial Ground Plan & Details*, Rev. 16, indicates one East-West-oriented trench in the 218-E-2A Burial Ground. Interpretation of the geophysical data indicates a large buried object that is located just inside the burial ground monuments (see Figure 2). This caused the anomaly that appears to extend beyond the western edge of the burial ground. No buried debris or objects are interpreted to be west of the burial ground boundary. A more thorough discussion is included in Appendix A.

3.5 218-E-8 BURIAL GROUND

Interpretation of the geophysical data collected in the expansion area, immediately east of the 218-E-8 Burial Ground boundary, indicates that there are buried objects and/or debris outside of the marked burial ground (see Figure 3). Near the burial ground monuments is one buried object (or concentration of smaller objects) that may be associated with the burial ground. An area of diffuse anomalies may indicate widely spaced buried objects or fill material that has some metallic material contained within.

A significant pit of buried debris, not fully characterized by this investigation, was located approximately 60 m east of the burial ground.

EMI data strongly indicate a buried utility along the northern boundary of the investigation area, although this was not corroborated by any other method or on any engineering drawings. Only Hanford Site Drawing H-2-33276, *Dry Waste Burial Ground 218-E-12B*, Rev. 6, Sheet 3, and Rev. 17, Sheet 1,were found to indicate a location for this burial ground. A more thorough discussion is included in Appendix A.

3.6 218-E-12A BURIAL GROUND

The ability to locate and map trenches at the 218-E-12A Burial Ground in the 200 East Area was heavily influenced by the width of the trench, the type of waste that is buried in the trench, and the changing soil conditions. Fifteen trenches were documented as being 9.1 m (30 ft) wide and containing dry waste in Hanford Site Drawing H-2-32095, Sheets 1 & 2, *218-W-2A Industrial Burial Ground & 218-W-3 Dry Waste Burial Ground*, Rev. 11. Each of these trenches was identified and mapped with the geophysical data (See Figure 4).

The remaining 13 trenches are documented as containing acid-soaked material and are shown to be either 1.5 or 3.7 m (5 or 12 ft) wide in drawing H-2-32560. With a typical layback similar to the trench design in the 218-E-1 Burial Ground, these trenches would be only 0.6 to 1.8 m (2 to 6 ft) deep. None of the narrower trenches were detectable. In the western half of the site, the wider trenches were readily detected, and the results are consistent with the documented size and location portrayed in drawing H-2-32560. A more thorough discussion of the results is presented in Appendix A. Individual discussions for each trench are included in Table A4-1.

3.7 218-W-1 BURIAL GROUND

Interpretation of the geophysical data for the 218-W-1 Burial Ground indicates pockets of debris in each of the identified trenches (see Figure 5). Discrete concentrations of metallic waste were identified in most of the trenches. Nonmetallic waste is interpreted to be mixed with the metallic waste. Most of the waste is at least 1 to 2 m deep and occasionally deeper. It is possible that there is more debris in the trenches than was detected in the data and plotted on the interpretation map.

Most of the trenches were clearly evident in the data, with the exception of Trenches 1, 1A, 4A, and 6. These four trenches lack even subtle anomalies and, therefore, their existence cannot be confirmed. Based on Hanford Site Drawing H-2-75149, *Dry Waste Burial Ground 218-W-1*,

Rev. 1, trench series 1 through 6 all were designed to be about 2.5 m deep with about 1.3 m separation. Given the proximity of the trenches in the 1 through 6 series, it is quite possible that a trench could have been constructed and not be apparent in the geophysical data. Trenches 1 through 6 may have been opened and backfilled with similar soils or never opened. According to the drawing, trenches 7 and 8 are separated by 1 m. These trench centerlines were mapped, although the boundary between them could not be distinguished.

Three East-West-oriented trenches were identified that are not shown on drawing H-2-75149. They are north of the northernmost trench shown on the drawing (Trench 9) and south of the 218-W-11 Burial Ground. They have a character similar to that of the other trenches in the 218-W-1 Burial Ground. Additionally, two pit-like areas not shown on the drawing also were identified in this northern area; one of the pits has significant metallic content (coordinate N360/E241). Individual discussions for each trench are included in Table A5-1.

3.8 218-W-2 BURIAL GROUND

Interpretation of the geophysical data for the 218-W-2 Burial Ground indicates that pockets/zones of debris are located and mapped in each of the identified trenches (see Figure 5). Discrete concentrations of metallic waste were identified in most of the trenches. Nonmetallic waste is interpreted to be mixed with the metallic waste. The vast majority of the anomalies are greater that 1 m below the surface and more typically are 1.5 to 2+ m deep. It is possible that there is more debris in the trenches than was detected in the data and plotted on the interpretation map.

All 20 of the trenches shown on Hanford Site Drawing H-2-2503, *218-W-2 Dry Waste Burial Ground*, Rev. 3, were clearly evident in the data. They all are generally the same length and width as shown on the drawing. Some of the trench centerlines, from the geophysics, are a few meters different than the drawing indicates, but the geophysics centerlines are based on debris concentrations and not necessarily on the actual trench opening. Individual discussions for each trench are included in Table A6-1.

3.9 218-W-3 BURIAL GROUND

Interpretation of the geophysical data for the 218-W-3 Burial Ground indicates that there are approximately 14 East-West-oriented trenches containing varying amounts of metallic debris (see Figure 6). The trenches appear to be in groups of 2 to 3, with very little space between them, which makes distinction of individual trenches within the groups difficult. One North-South-oriented trench is interpreted along the eastern edge of the site, although this may be an artifact in the data caused by the gravel road located here. All of the debris within the trenches appears to be buried greater than 1 m, some up to 2 m, deep.

Hanford Site Drawing H-2-32095, Sheets 1 & 2, *218-W-2A Industrial Burial Ground & 218-W-3 Dry Waste Burial Ground*, Rev. 11, shows 20 regularly spaced trenches at this burial ground, although a note on the drawing states that centerlines and locations were based on ground indications and judgment after the trenches were filled and covered. Other than the two

southernmost trenches, the interpreted trench locations do not correlate with the locations shown on the drawing. Individual discussions for each interpreted trench are included in Table A7-1.

3.10 218-W-11 BURIAL GROUND

Two engineering drawings are available for reference for the 218-W-11 Burial Ground. The older drawing, H-2-31268, *Solid Waste Burial Grounds Plot Plan*, Rev. 8, shows only one trench at this burial ground. A newer, revised drawing, H-2-94250, *Dry Waste Burial Ground 218-W-11*, Rev. 1, shows two East-West-oriented trenches. The northernmost trench in the newer drawing correlates with that shown on the older drawing, but is shown to extend farther to the west.

As reported in the previous investigation report (D&D-28379) one trench and one "pit" make up the 218-W-11 Burial Ground/Regulated Storage Site. The trench location correlates very well with the trench documented in drawing H-2-31268 (see Figure 7). An interpreted discrete pit is about 18 m east of this trench and is not depicted on any available drawings. Given the quality of the geophysical data at this site, the interpreters are confident that the southern trench shown in H-2-94250 does not exist.

Investigation continued to the area just north of the 218-W-11 Burial Ground. Five trenches were identified north of N160, which is in the southern part of the 218-W-4A Burial Ground. There is a clear data character change at about N160. This correlates with the documented location of the southern boundary of the 218-W-4A Burial Ground, which was not specifically part of this investigation. The mapped trenches extend from about E115 to E295. Pockets/zones of debris were located and mapped in each of the identified trenches in the 218-W-4A Burial Ground. Discrete concentrations of metallic waste were identified in most of the trenches. Nonmetallic waste is interpreted to be mixed with the metallic waste. The vast majority of the anomalies are greater that 1 m below the surface. It is possible that there is more debris in the trenches than was detected in the data and plotted on the interpretation map (see Figure 7).

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4.0 SOFTWARE PROBLEM REPORTING AND VALIDATION AND VERIFICATION INFORMATION

North Wind currently maintains a quality management system that is compliant with the quality standards described in International Standard ISO 9001:1994, *Quality Management Systems: Requirements*, and is in the process of transitioning to ISO 9001:2000. This quality management system also is designed to meet similar quality system requirements specified in corresponding ANSI/ASME NQA-1, 2004, *Quality Assurance Requirements for Nuclear Facility Applications*, Basic Requirements sections. Furthermore, the North Wind Quality Management System also is designed to comply with the ten quality assurance criteria specified in the DOE Order 414.1C, *Quality Assurance*, implementation of 10 CFR 830, Subpart A, *Quality Assurance Requirements*.

In accordance with the statement of work, the following sections discuss the procedure that was in place for reporting problems that could have been encountered with software. In addition, the method used to document the validation and verification of software used to perform calculations also is presented. Note that no errors or problems were observed with the software used for this project. No nonconformance reports were generated.

4.1 SOFTWARE PROBLEM AND ERROR REPORTING

North Wind quality assurance procedure, QAP-10-151, *Control of Nonconforming Items*, defines the system for identifying requirements and responsibilities for controlling items that do not conform to customer requirements, to prevent unintended installation, use, or delivery. This procedure applies to all North Wind functions and operations and encompasses all products that fail receiving, in-process, or final inspections and tests.

The primary objective of the nonconforming items control process is to prevent the unintended use or further processing of products that fail to pass required inspections or tests upon receipt or throughout any stage of production and delivery. Five phases are used to control a nonconforming item: (1) identification, (2) segregation, (3) disposition and notification, (4) correction, and (5) analysis.

The Project Manager corrects the nonconforming items and summarizes the disposition and correction activity on the Nonconformance Report (NCR), with input from the Quality Assurance Manager, Quality Engineer or Quality Representative, and the customer, as needed. The Project Manager forwards the NCR to the Quality Engineer or Quality Representative to reexamine and validate correction activities.

The Quality Engineer or Quality Representative reinspects, retests, or assesses, as appropriate, the reworked items to their original specifications, upon completion of the correction. The Quality Engineer validates correction activities, completes the NCR, and forwards the completed NCR and supporting documentation to the Quality Assurance Manager for analysis.

The Quality Assurance Manager reviews the NCR and supporting documentation, verifies that all related actions are complete, signs the completed NCR, and forwards it along with supporting documentation to the Document Control Specialist for maintenance as a quality record.

4.2 VALIDATION AND VERIFICATION INFORMATION

4.2.1 Software Information

Title: Surfer	Version: 8.05
Manufacturer:	Golden Software, Inc., Golden, Colorado
Function:	Surface Mapping System
Operating System:	Microsoft Windows 2000, Version: 5.0[7]
Calculations Performed:	Calculates and outputs a contoured grid from regularly spaced data values

4.2.2 Validation and Verification

Validation is the process of confirming the appropriateness of using software for the purpose to which it is being applied. Verification is the process of confirming the correctness of the output of the software. To verify that the software used on this project produced correct results, input parameters and conditions similar to those used in the project were generated.

To demonstrate proper contour calculation and placement, a regular grid of arbitrary numbers was created and subsequently processed by the software. The numbers were posted on a map, and the contour intervals were superimposed over the numbers. The contour placement then was examined. The analysis indicated that the software performs correctly under conditions similar to those used on this project. The entire data file and a brief summary of the test and its outcome are presented in Appendix C.

[7] Windows 2000 is a trademark of Microsoft Corporation, Redmond, Washington.

5.0 REFERENCES

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D&D-28379, 2006, *Geophysical Investigations Summary Report; 200 Area Burial Grounds: 218-C-9, 218-E-2A, 218-E-5, 218-E-5A, 218-E-8, 218-W-1A, 218-W-2A, and 218-W-11*, Rev. 0, prepared by CH2M HILL, Inc., for Fluor Hanford, Inc., Richland, Washington.

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- H-2-124, *218-E-1 Dry Waste Burial Ground*, Rev. 3
- H-2-2503, *218-W-2 Dry Waste Burial Ground*, Rev. 3
- H-2-31268, Rev. 8, *Solid Waste Burial Grounds Plot Plan*, Rev. 8
- H-2-32095, Sheets 1 & 2, *218-W-2A Industrial Burial Ground & 218-W-3 Dry Waste Burial Ground*, Rev. 11
- H-2-32560, *As-Built Dry Waste Burial Site #218-E-12A*, Rev. 2
- H-2-33276, Sheet 1 of 24, *Dry Waste Burial Ground 218-E-12B*, Rev. 17 and Sheet 3 of Rev. 6
- H-2-55534, *218-E2, E2A, E4, E5, E5A, & E9 Industrial Burial Ground Plan & Details*, Rev. 16

- H-2-75149, *Dry Waste Burial Ground 218-W-1*, Rev. 1
- H-2-94250, *Dry Waste Burial Ground 218-W-11*, Rev. 1

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QAP-10-151, 2006, *Control on Nonconforming Items*, North Wind, Inc., Richland, Washington.

WHC-SD-EN-EE-004, 1991, *Revised Stratigraphy for the Ringold Formation, Hanford Site, South-Central Washington*, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

Figure 1. Geophysical Investigation Results, 218-E-1 Burial Ground.

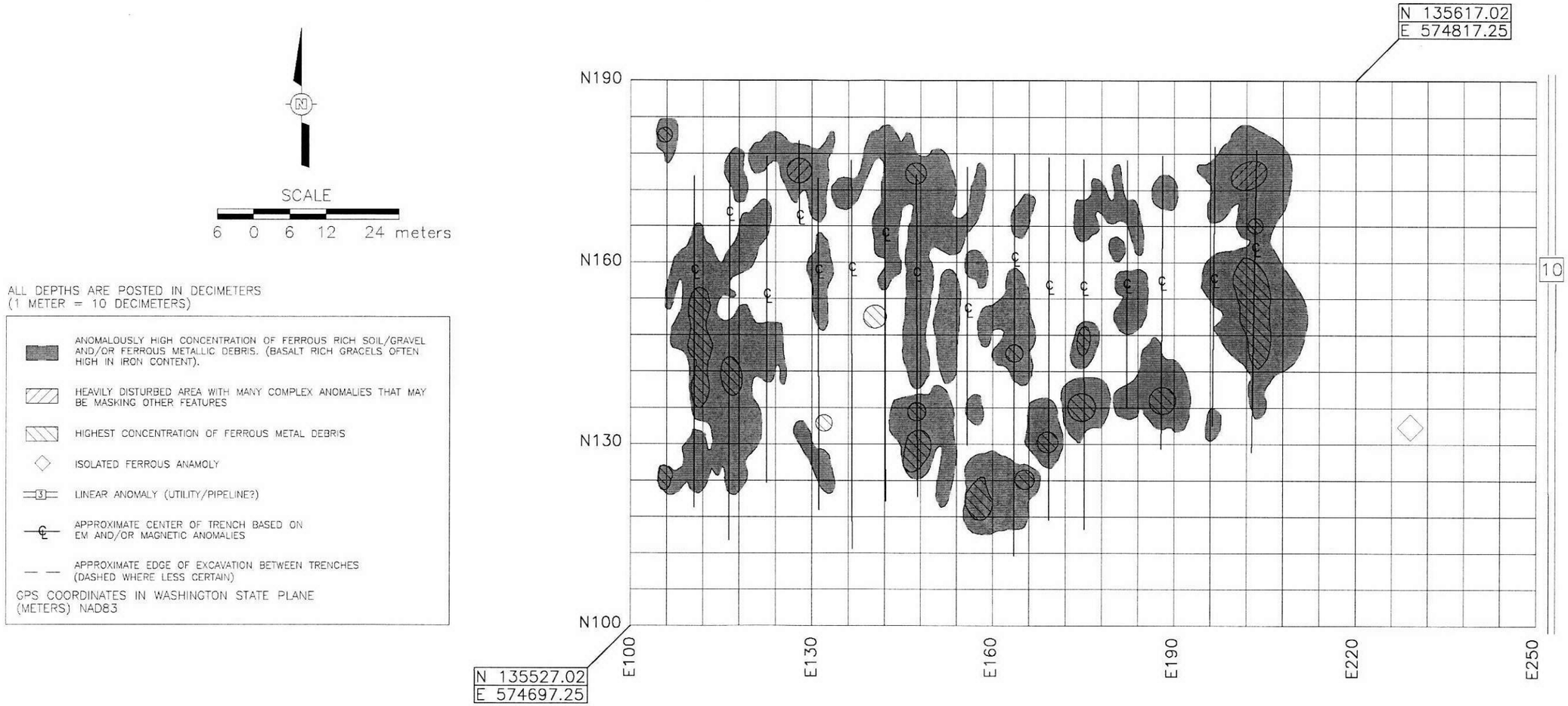


Figure 2. Geophysical Investigation Results, 218-E-2A Burial Ground.

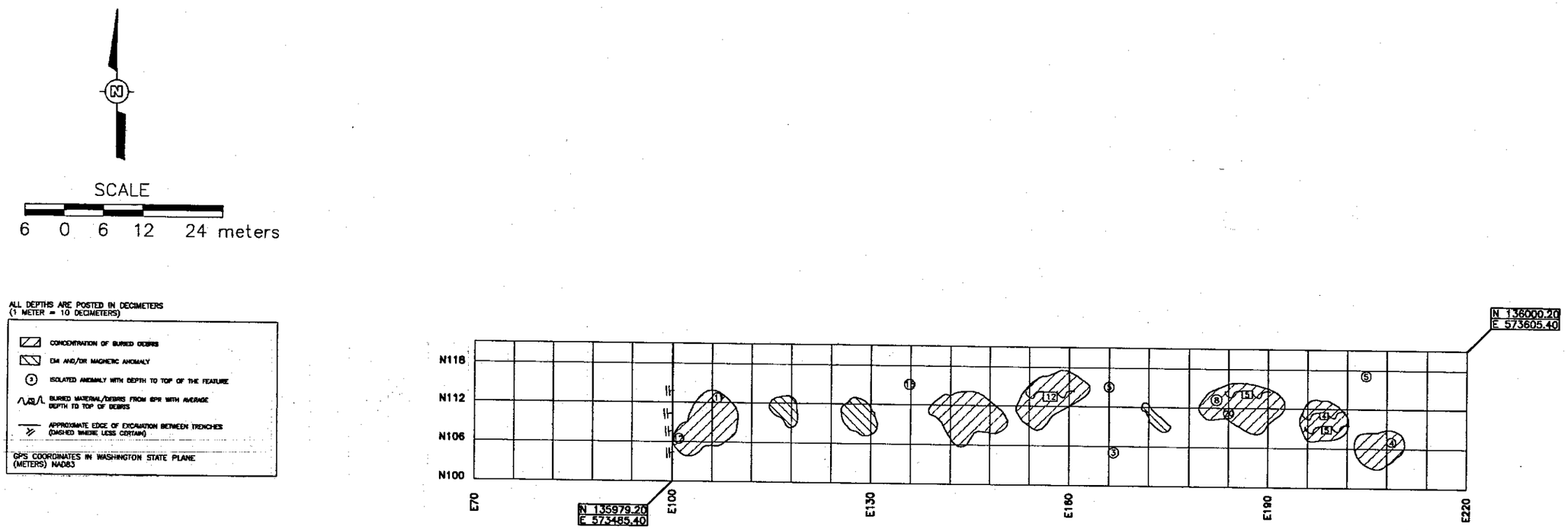


Figure 3. Geophysical Investigation Results, 218-E-8 Burial Ground.

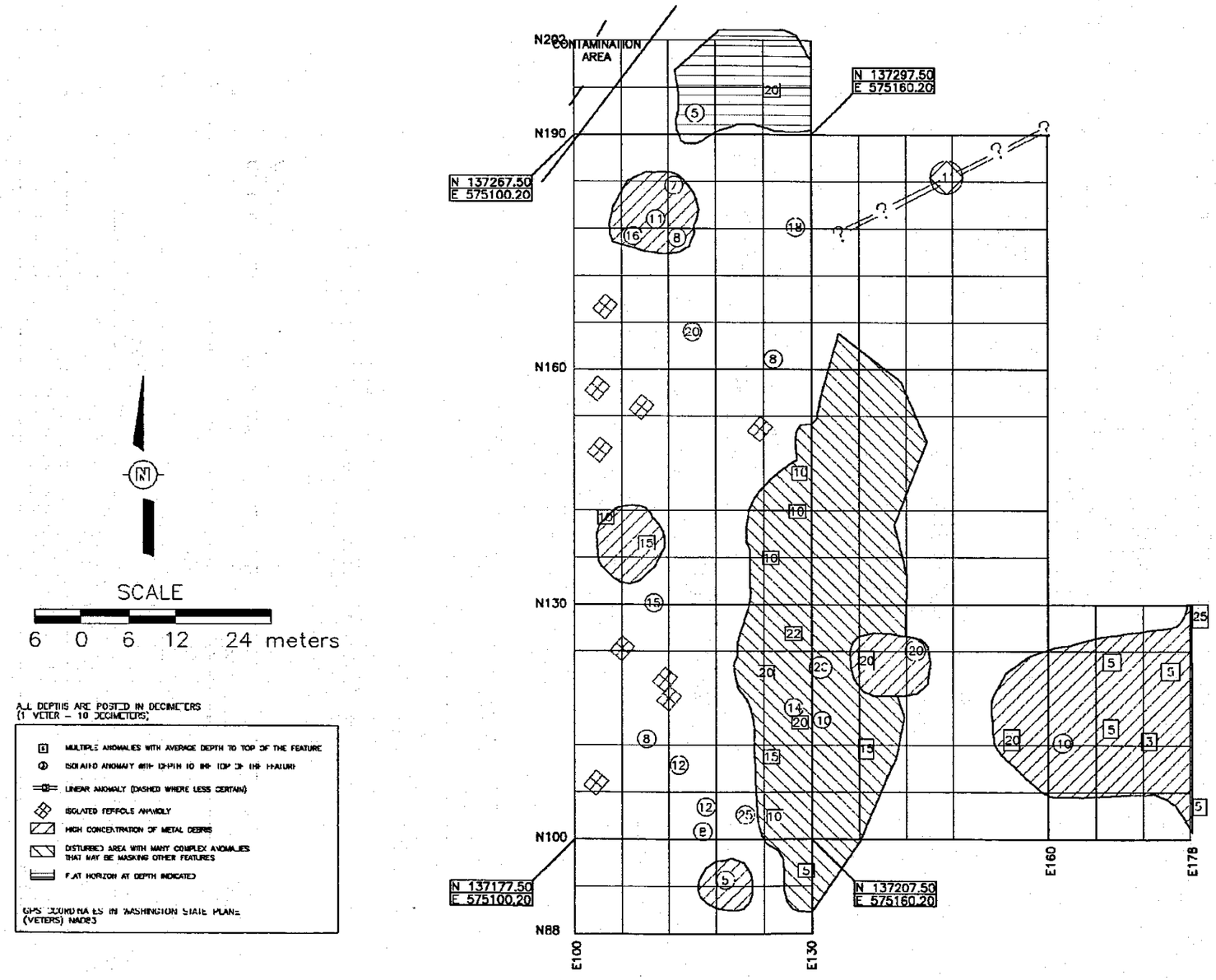


Figure 4. Geophysical Investigation Results, 218-E-12A Burial Ground.

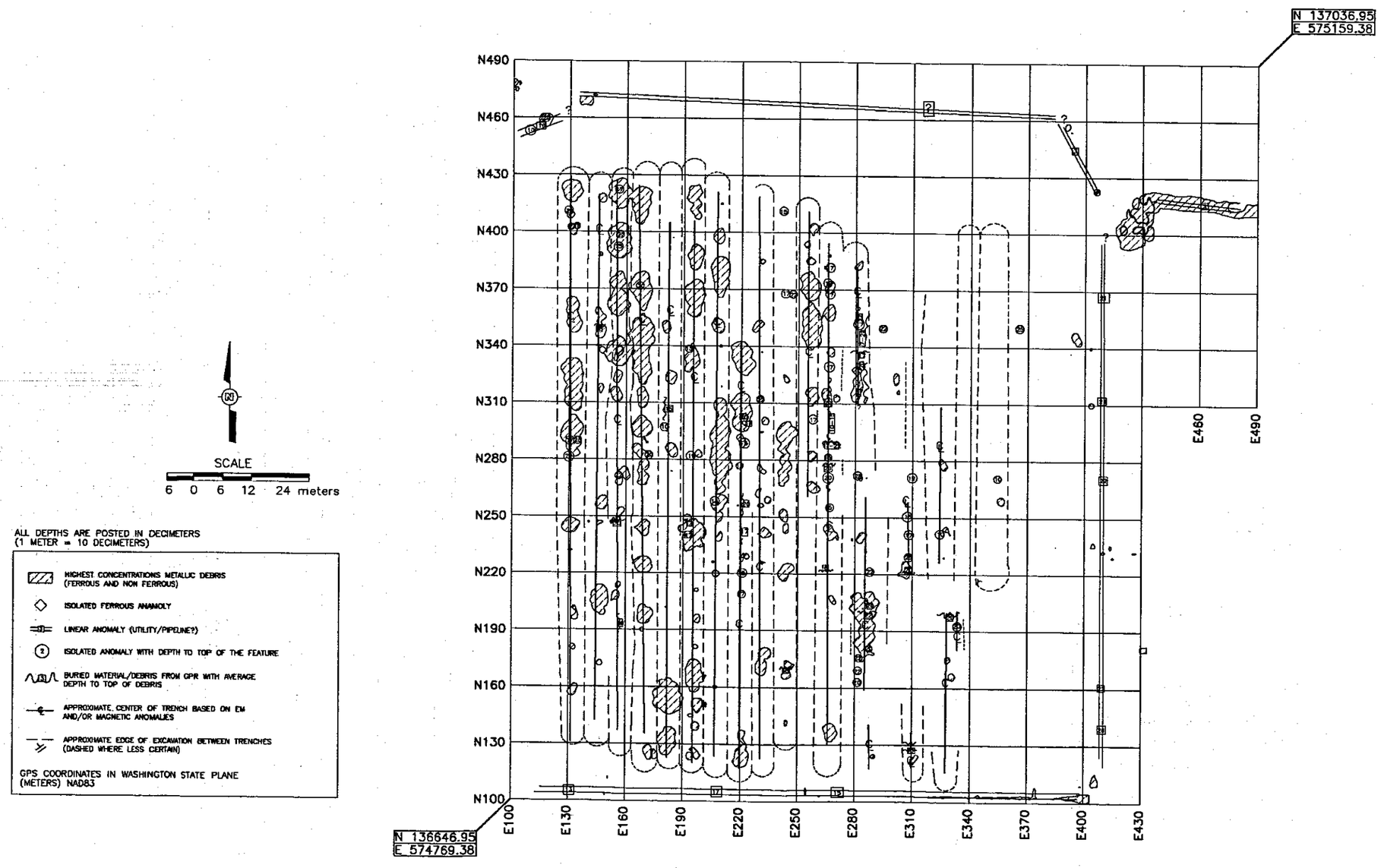


Figure 5. Geophysical Investigation Results, 218-W-1 / 218-W-2 Burial Grounds.

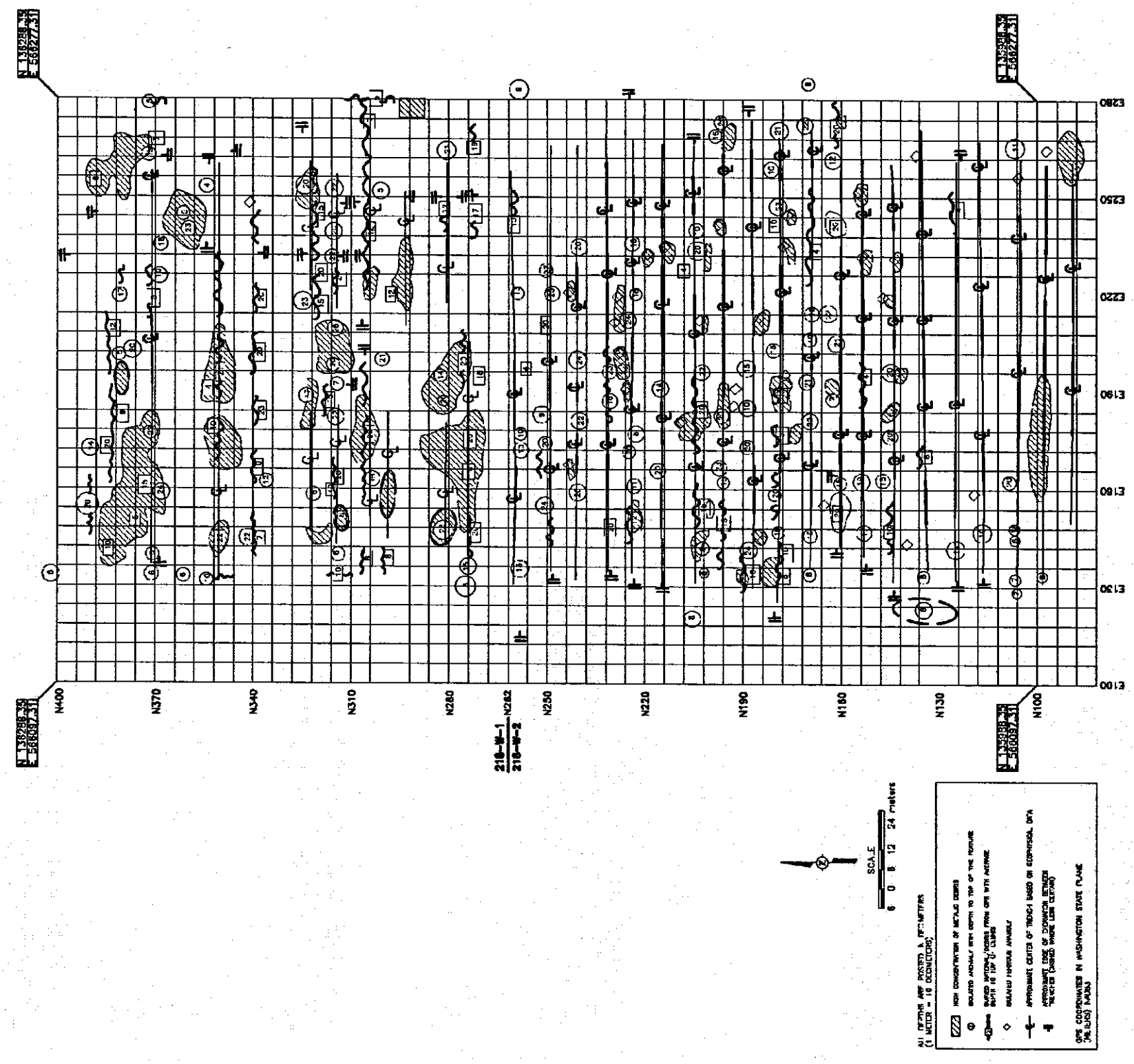


Figure 6. Geophysical Investigation Results, 218-W-3 Burial Ground.

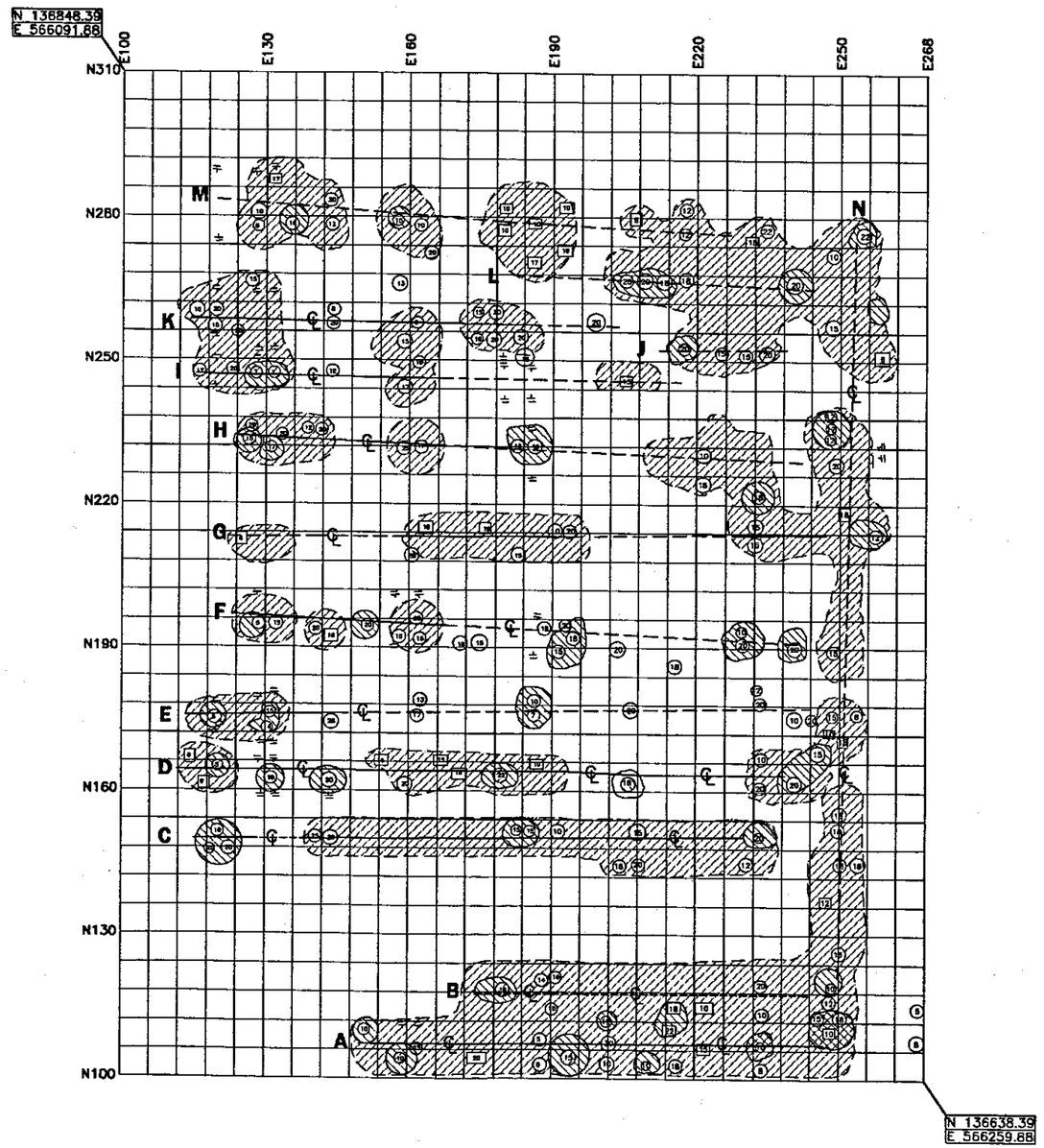
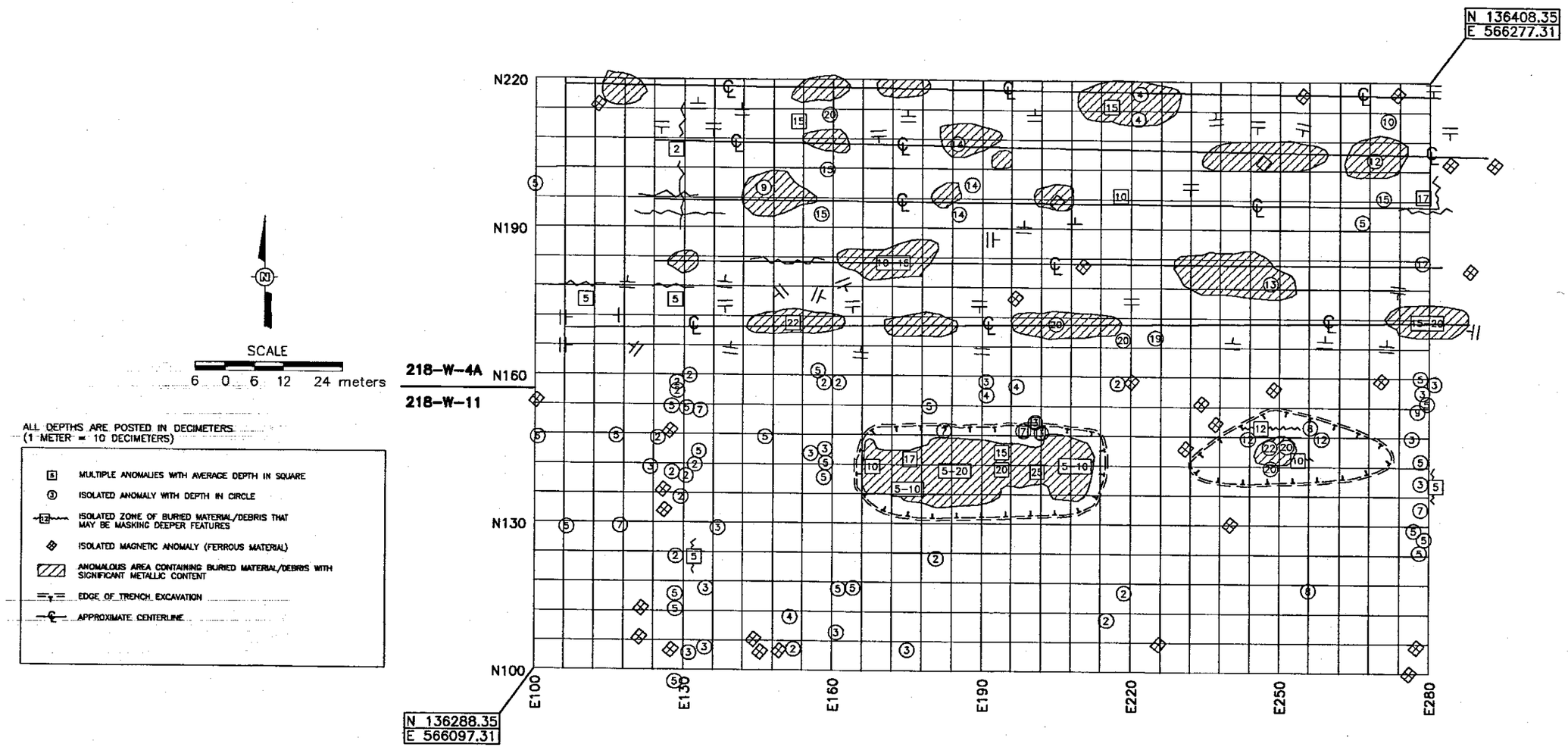


Figure 7. Geophysical Investigation Results, 218-W-11 Burial Ground.



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APPENDIX A

DATA PLOTS AND SITE INVESTIGATION DETAILS

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APPENDIX A

DATA PLOTS AND SITE INVESTIGATION DETAILS

Information is provided on the ground-penetrating radar, electromagnetic induction, and magnetic data collected, along with details of the investigation, for each burial ground discussed in this document.

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A1.0 218-E-1 BURIAL GROUND GEOPHYSICAL INVESTIGATION SUMMARY AND DATA PLOTS

Geophysical Investigation Summary Sheet	
Site Name	218-E-1 Burial Ground
Location	200 East Area
Approximate size	90 m x 120 m (~3.2 acres)
Burial Ground Information	Per Hanford Site Drawing H-2-124, burial ground contains 15 North-South-oriented trenches, approximately 200 ft (66 m) long, 16-20 ft (5-6 m) wide, and 8-10 ft (2.5-3 m) deep.
Terrain	Generally flat; slightly mounded with stabilization fill
Vegetation/ground cover	No vegetation. Silty gravel surface material, some fly ash visible
Hydrological properties	Surface dry at time of data collection. Rain event approximately 1 week before data collection.
Limitations/obstacles	No significant surface obstacles to data collection. Fly ash significantly degraded ground-penetrating radar data.
Overall assessment for geophysical investigation	Electromagnetic induction and magnetic methods effective at meeting project objectives. Ground-penetrating radar data were unusable because of attenuation by fly ash.
Equipment	
Ground Penetrating Radar (GPR)	Geophysical Survey Systems, Inc., SIR-10A GPR system with 200 MHz antenna
Electromagnetic Induction (EMI)	Frequency domain EMI: Geonics Limited, EM31 Ground Conductivity Meter with Wescor, Inc., Polycorder 720.
Total Magnetic Field	Geometrics, Inc., G-858/G Cesium Vapor Magnetometer/Gradiometer
Data Collection and Processing Parameters	
Grid location control and data collection lines	Base grid staked at 30 m centers by Fluor personnel using Global Positioning System instruments and coordinates supplied by North Wind, which were based on Hanford Site Drawing H-2-124. Base grid was 90 m N-S, 120 m E-W; data collection lines were flagged at 6 m centers in North-South direction along base grid.
SIR-10A	Data were collected with the antenna towed behind a 4 x 6 all-terrain vehicle (Gator Utility Vehicle [1]). Marks were placed in the data as the instrument passed position flags or stakes. Data were stacked (2 signals), recording window 108 ns, gains and filters set in field to match soil conditions. Hard copy plots of data were printed in the office on a thermal printer for interpretation. [1] Gator Utility Vehicle is a trademark of John Deere & Company, Moline, Illinois.

Geophysical Investigation Summary Sheet	
EM31	Data were collected at hip height in the vertical dipole mode on 1.5 m station spacing and 3 m line spacing on East-West-oriented lines. Data were downloaded from the Polycorder and written to a .xyz data file using Geonics DAT31.exe. Corrections of position errors during data collection (if any) are made in standard spreadsheet software such as Microsoft Excel [2]. Data were gridded and plotted using Surfer [3]. Cell size for data plots is nominally 3 m (cross line) x 1.5 m (down line). ---------- [2] Excel is a trademark of Microsoft Corporation, Redmond, Washington. [3] Surfer is a trademark of Golden Software, Inc., Golden, Colorado.
G-858/G	Data were collected with sensors 0.5 and 1.5 m above the ground in continuous sampling mode with samples recorded every 0.5 seconds (nominal 0.5 m data spacing), and fiducial positioning marks placed every 30 m, on lines spaced 3 m apart. Data were collected in East-West direction with the sensors oriented East-West at a 45-degree angle to the horizon. Data were downloaded from the field instrument, filtered for spikes and dropouts (if any), corrected for position errors (if any), and written to a .xyz file using Geometrics, Inc., MagMapper2000.exe. Data were gridded and plotted using Surfer. Grid cell size for the data plots is nominally 3 m (cross line) x 0.5 m (down line).
Results	
Data Discussion	Refer to data plots A1-1 through A1-4 and Table A1-1 for the following discussion. EMI and magnetic data show low- and high-amplitude anomalies oriented North-South. Terrain conductivity readings greater than 10 mS/m occur over much of the site. These readings are quite high for the Hanford Site and may be caused by fly ash used as cover or stabilization fill material. Both EMI and magnetic data show few to no anomalies east of approximately line E210 in the burial ground. GPR data show a highly reflective layer at approximately 0.5 m depth. This layer may be fly ash and is blocking detection of buried material below. Based on alignment with magnetic data anomalies, trenches in this burial ground are interpreted to be located at conductivity lows in the EM31 data.
Interpretation	This burial ground contains 15 interpreted trenches with variable amounts of metallic material contained in each. Centerlines of the trenches are interpreted to be at approximately E110, E117, E122, E128, E132, E140, E147, E157, E163, E170, E174, E182, E188, E196, and E203. The buried material does not appear to be continuous throughout the entire length of most trenches. More detail of individual trenches is provided in Table A1-1. Based on drawing H-2-124, the original burial ground is represented by the interpreted 15 trenches, and the area inside the burial ground monuments east of E210 is a later expansion. No trenches are interpreted east of E210 in this burial ground, although it is possible that this area contains deeply buried, nonmetallic waste that was not detected with the instruments.
Lessons learned	As observed at other Hanford sites, fly ash significantly degrades GPR data, rendering it ineffective as an investigation tool at sites where it is found on the surface.

Table A1-1. Summary of Results from Burial Ground 218-E-1, 200 East Area. (2 Pages)

Best Trench Correlation, Based on Drawing H-2-124	Approx. Center of Trench, Based on Geophysical Data	Approx. Ends of Trench, Based on Geophysical Data	Documented Waste Type	Approx. Center of Trench, Based on Drawing H-2-124	Approx. Ends of the Trench, Based on Drawing H-2-124	Comments
1	E110	N178 – N120	Dry Waste	E112	N178 – N120	Reasonable correlation between the geophysical data and the documented centerline of the trench. Geophysical data suggest a mix of metallic and nonmetallic waste. High concentration of ferrous metal between N124 and N160. Two magnetic anomalies appear outside of trench at approximately N183, E106 and N127, E106. These may be caused by metal objects in backfill material.
2	E117	N178 – N120	Dry Waste	E118	N178 – N120	Good correlation between the geophysical data and the documented centerline and length of the trench. Geophysical data suggest a mix of metallic and nonmetallic waste. Data indicate a generally low concentration of ferrous metal in trench other than large object(s) at N142.
3	E122	N178 – N120	Dry Waste	E125	N178 – N120	Reasonable correlation between the geophysical data and the documented centerline of the trench. Geophysical data suggest a mix of metallic and nonmetallic waste. No significant ferrous metal anomalies evident in data.
4	E128	N178 – N120	Dry Waste	E131	N178 – N120	Trenches 4 through 7 show poor correlation between centerlines, based on geophysical data and the documented centerline. The interpreted trenches may be mismatched with those shown on Hanford Site Drawing H-2-124. Geophysical data suggest a mix of metallic and nonmetallic waste. A significant ferrous metal anomaly is evident in data at N175.
5	E132	N178 – N120	Dry Waste	E138	N178 – N120	Trenches 4 through 7 show poor correlation between centerlines, based on geophysical data and the documented centerline. The interpreted trenches may be mismatched with those shown on Hanford Site Drawing H-2-124. Geophysical data suggest a mix of metallic and nonmetallic waste.
6	E140	N178 – N120	Dry Waste	E144	N178 – N120	Trenches 4 through 7 show poor correlation between centerlines, based on geophysical data and the documented centerline. The interpreted trenches may be mismatched with those shown on Hanford Site Drawing H-2-124. Geophysical data suggest a mix of metallic and nonmetallic waste. Data indicate a generally low concentration of ferrous metal in trench.
7	E147	N178 – N120	Dry Waste	E152	N178 – N120	Trenches 4 through 7 show poor correlation between centerlines, based on geophysical data and the documented centerline. The interpreted trenches may be mismatched with those shown on Hanford Site Drawing H-2-124. Geophysical data suggest a mix of metallic and nonmetallic waste. Large ferrous metal objects throughout trench.

Table A1-1. Summary of Results from Burial Ground 218-E-1, 200 East Area. (2 Pages)

Best Trench Correlation, Based on Drawing H-2-124	Approx. Center of Trench, Based on Geophysical Data	Approx. Ends of Trench, Based on Geophysical Data	Documented Waste Type	Approx. Center of Trench, Based on Drawing H-2-124	Approx. Ends of the Trench, Based on Drawing H-2-124	Comments
8	E157	N178 – N120	Dry Waste	E157	N178 – N120	Good correlation between the geophysical data and the documented location and length of the trench. Geophysical data suggest a mix of metallic and nonmetallic waste. Isolated large ferrous metal object(s) at N122, N136, and N160.
9	E163	N178 – N120	Dry Waste	E164	N178 – N120	Good correlation between the geophysical data and the documented location and length of the trench. Geophysical data suggest a mix of metallic and nonmetallic waste. Isolated large ferrous metal object(s) at N122, N145, and N150.
10	E170	N178 – N120	Dry Waste	E170	N178 – N120	Good correlation between the geophysical data and the documented location and length of the trench. Geophysical data suggest a mix of metallic and nonmetallic waste. Isolated large ferrous metal object(s) at N130.
11	E174	N178 – N120	Dry Waste	E177	N178 – N120	Poor correlation between the geophysical data and the documented centerline of the trench. Geophysical data suggest a mix of metallic and nonmetallic waste. Isolated large ferrous metal object(s) at N136, N148.
12	E182	N178 – N130	Dry Waste	E183	N178 – N120	Good correlation between the geophysical data and the documented location of the trench. Geophysical data suggest a mix of metallic and nonmetallic waste. Isolated ferrous metal object(s) at N136, N151, and N157.
13	E188	N178 – N130	Dry Waste	E189	N178 – N120	Good correlation between the geophysical data and the documented location of the trench. Geophysical data suggest a mix of metallic and nonmetallic waste. Isolated large ferrous metal object(s) at N136. Smaller ferrous metal object(s) at N172.
14	E196	N178 – N130	Dry Waste	E196	N178 – N120	Good correlation between the geophysical data and the documented location of the trench. Geophysical data suggest that waste may be primarily nonmetallic. No significant ferrous metal anomalies evident in data.
15	E203	N178 – N130	Dry Waste	E203	N178 – N120	Good correlation between the geophysical data and the documented location of the trench. Very high concentration of ferrous metal objects between N142 and N178.

Figure A1-1. Geophysical Investigation Results, 218-E-1 Burial Ground, 200 East Area, June 2006.

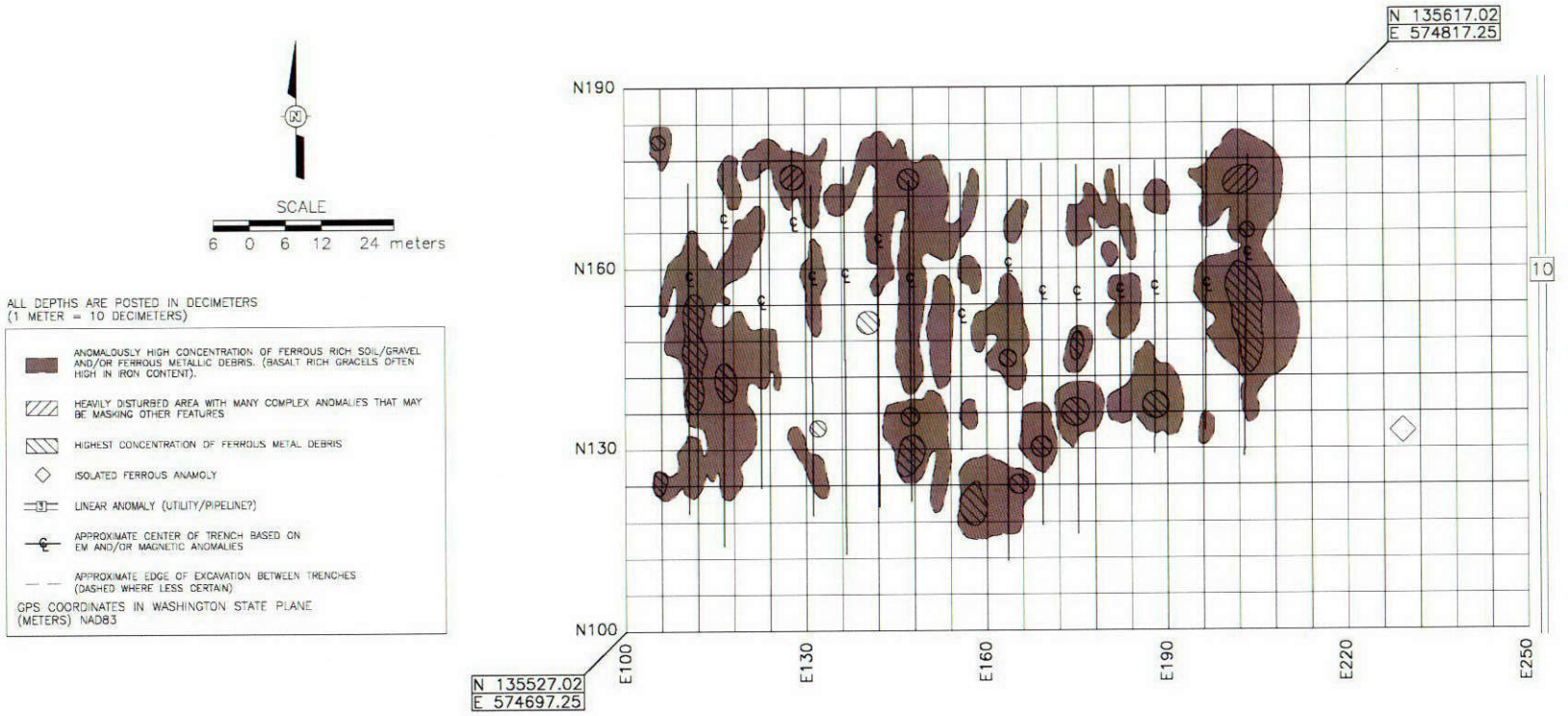


Figure A1-2. Electromagnetic Induction (EM31) Ground Conductivity Data, 218-E-1 Burial Ground, 200 East Area, June 9, 2006.

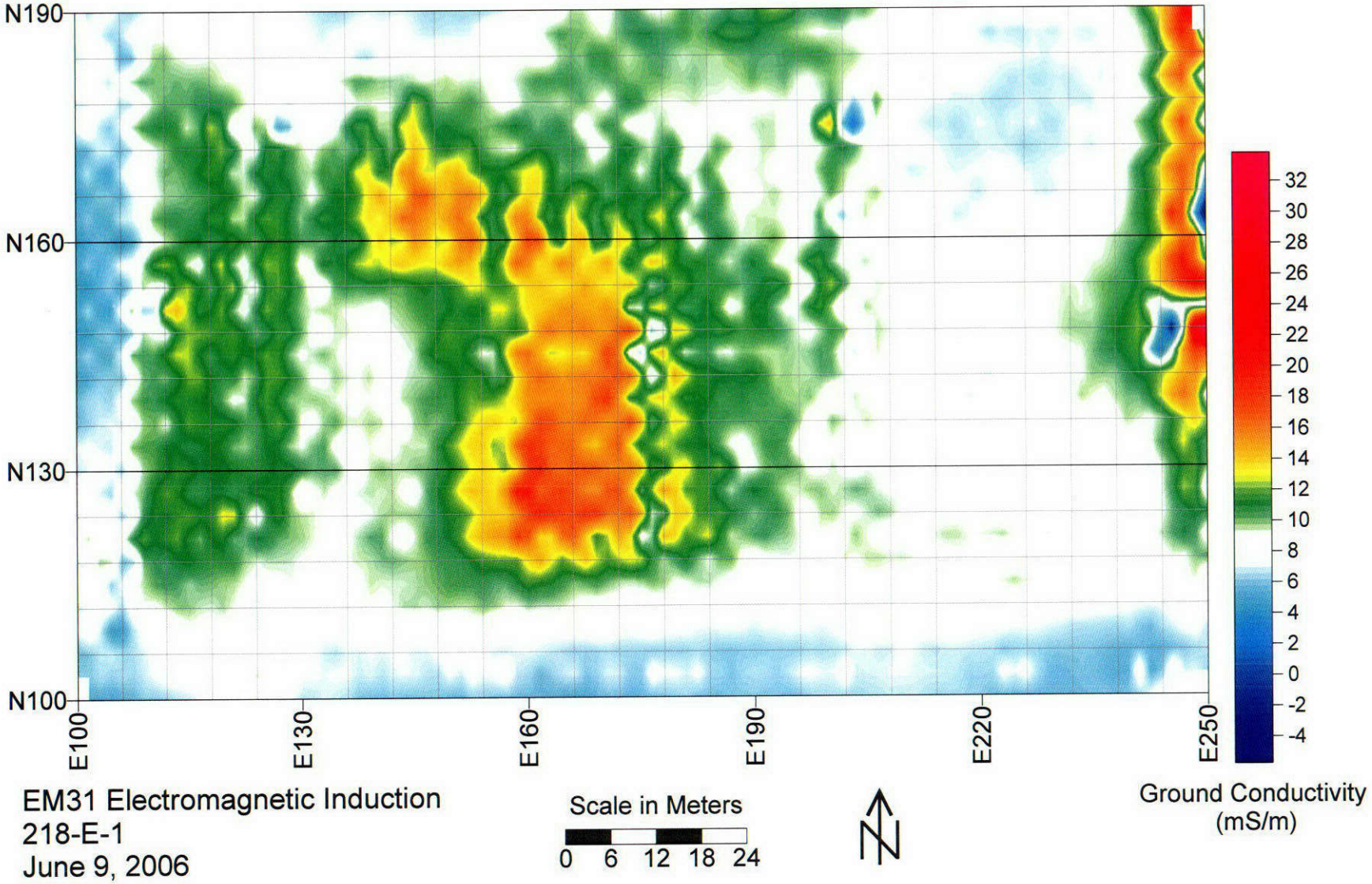


Figure A1-3. Electromagnetic Induction (EM31) In-Phase Data, 218-E-1 Burial Ground, 200 East Area, June 9, 2006.

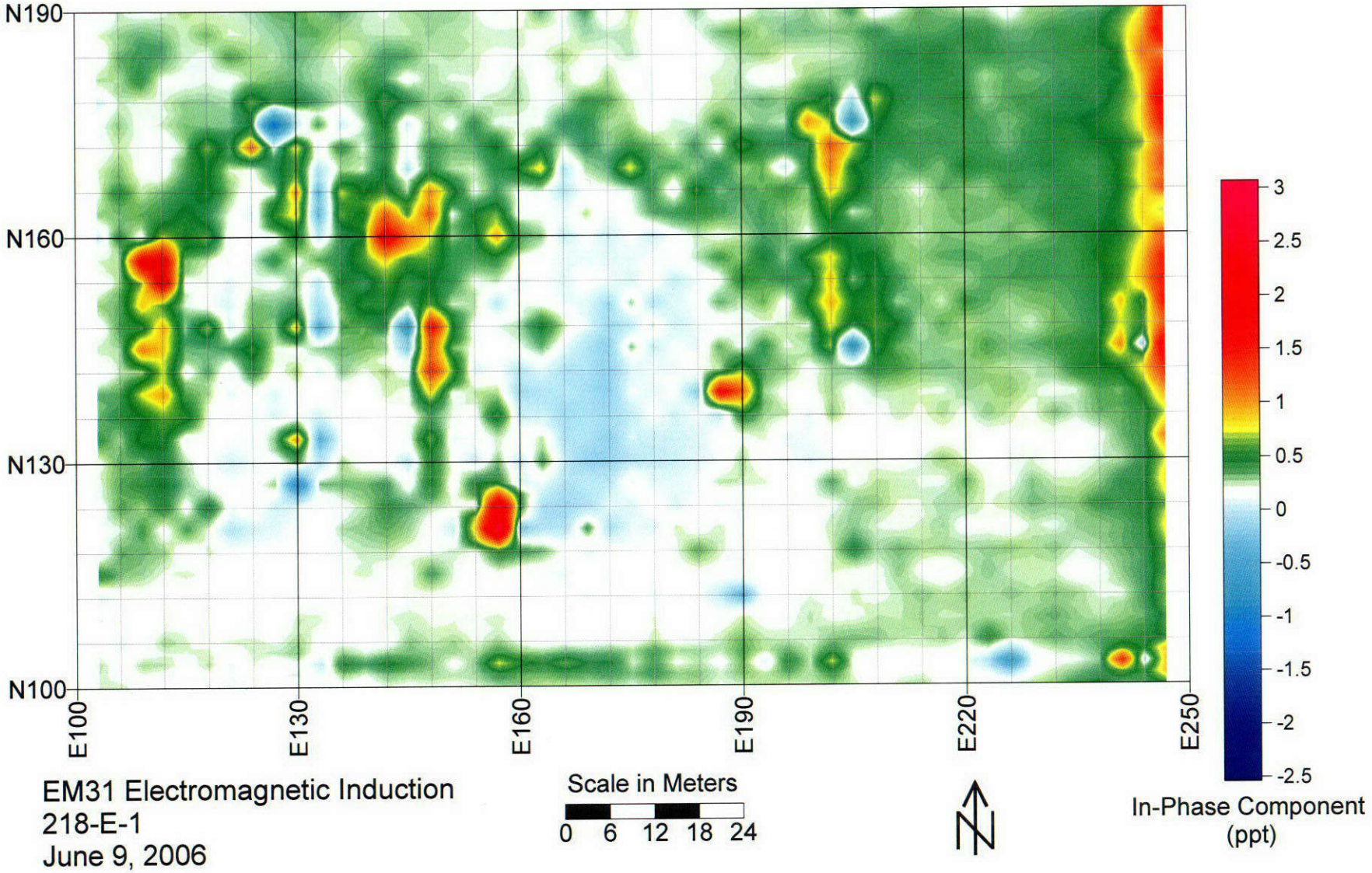
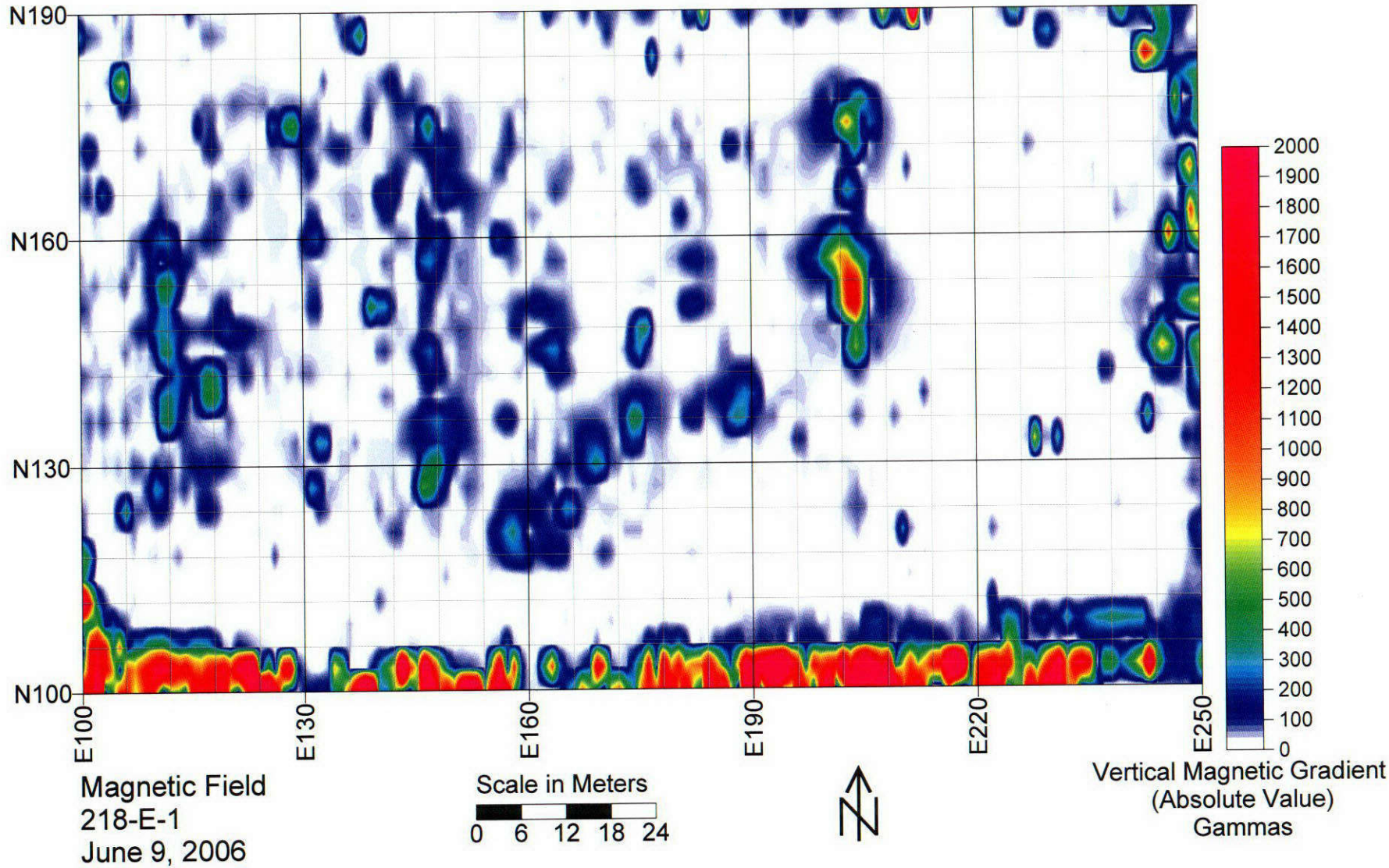


Figure A1-4. Total Magnetic Field (G-858/G) Data, 218-E-1 Burial Ground, 200 East Area, June 9, 2006.



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A2.0 218-E-2A BURIAL GROUND GEOPHYSICAL INVESTIGATION SUMMARY AND DATA PLOTS

Geophysical Investigation Summary Sheet	
Site Name	218-E-2A Burial Ground
Location	200 East Area
Approximate size	150 m x 21 m (~0.3 acre)
Burial Ground Information	Per Hanford Site Drawing H-2-55534, this burial ground contains one East-West-oriented trench.
Terrain	Generally flat, slightly sloped down from north to south away from the adjacent railroad tracks.
Vegetation/ground cover	Primarily bunch grass; also cheat grasses and other weeds. Silty gravel surface material.
Hydrological properties	Surface dry at time of data collection. Rain event approximately 1 week before data collection.
Limitations/obstacles	Railroad constrained ground-penetrating radar data collection to east-west direction only. Capping or shallow fill material within marked burial ground significantly degraded ground-penetrating radar signal.
Overall assessment for geophysical investigation	Electromagnetic induction and magnetic methods effective at meeting project objectives. Ground-penetrating radar data were adequate in extension area to meet project objectives.
Equipment	
Ground Penetrating Radar (GPR)	Geophysical Survey Systems, Inc., SIR-10A GPR system with 200 MHz antenna.
Electromagnetic Induction (EMI)	Frequency domain EMI: Geonics Limited, EM31 Ground Conductivity Meter with Wescor, Inc., Polycorder 720.
	Time domain EMI: Geonics Limited, EM61-MK2 High Sensitivity Metal Detector with Juniper Systems, Inc., PRO4000 Data Logger
Total Magnetic Field	Geometrics, Inc., G-858/G Cesium Vapor Magnetometer/Gradiometer
Data Collection and Processing Parameters	
Grid location control and data collection lines	Base grid staked at 30 m centers by Fluor personnel using Global Positioning System instruments and coordinates supplied by North Wind, which were based on Hanford Site Drawing H-2-55534. Original base grid was 30 m N-S, 120 m E-W. Expansion area was 21 m N-S, 30 m E-W. Data collection lines were flagged at 6 m centers in North-South direction along base grid.
SIR-10A	Data were collected with the antenna towed behind a 4 x 6 all-terrain vehicle (Gator Utility Vehicle [1]). Marks were placed in the data as the instrument passed position flags or stakes. Data were stacked (2 signals), recording window 108 ns, gains and filters set in field to match soil conditions. Hard copy plots of data were printed in the office on a thermal printer for interpretation.

[1] Gator Utility Vehicle is a trademark of John Deere & Company, Moline, Illinois.

Geophysical Investigation Summary Sheet	
EM31	Data were collected at hip height in the vertical dipole mode on 1.5 m station spacing and 3 m line spacing on East-West-oriented lines. Data were downloaded from the Polycorder and written to a .xyz data file using Geonics DAT31.exe. Corrections of position errors during data collection (if any) are made in standard spreadsheet software such as Microsoft Excel [2]. Data were gridded and plotted using Surfer [3]. Cell size for data plots is nominally 3 m (cross line) x 1.5 m (down line). [2] Excel is a trademark of Microsoft Corporation, Redmond, Washington. [3] Surfer is a trademark of Golden Software, Inc., Golden, Colorado.
EM61-MK2	Data were collected with instrument-in-cart mode; 0.19 m station spacing on lines spaced 1.5 m apart; differential mode (3 lower coil readings, one upper coil reading). Data were downloaded from the Pro4000 using Lynx, a HarvestMaster brand electronic data acquisition system owned by Juniper Systems, Inc. Position corrections, such as line starts and stops, and writing to a .xyz file were performed using Geonics DAT61.exe. Data were gridded and plotted using Surfer. Grid cell size for data plots is nominally 1.5 m (cross line) x 0.75 m (down line).
G-858/G	Data were collected with sensors 0.5 and 1.5 m above the ground in continuous sampling mode, with samples recorded every 0.5 seconds (nominal 0.5 m data spacing), and fiducial positioning marks placed every 30 m, on lines spaced 3 m apart. Data were collected in East-West direction with the sensors oriented East-West at a 45-degree angle to the horizon. Data were downloaded from the field instrument, filtered for spikes and dropouts (if any), corrected for position errors (if any), and written to a .xyz file using Geometrics, Inc., MagMapper2000.exe. Data were gridded and plotted using Surfer. Grid cell size for the data plots is nominally 3 m (cross line) x 0.5 m (down line).
Results	
Data Discussion	Refer to data plots A2-1 through A2-5 for the following discussion. This investigation was an expansion of the area covered in a previous investigation. Results of the previous investigation appeared to show anomalies extending beyond the edge of the burial ground to the west. The newly collected EMI and magnetic data show no anomalies of significance west of the monuments marking the western boundary of the burial ground. Surface conditions within the marked burial ground completely attenuate the GPR signal at a shallow depth. Therefore, the GPR data were of minimal use. This condition is similar to that encountered in the 218-E-1 Burial Ground investigation. GPR data collected west of the burial ground monuments do not show any significant anomalies.
Interpretation	Interpretation of the data indicates a large buried object located just inside the burial ground monuments. No other buried debris or objects are interpreted to the west of the burial ground boundary.
Lessons learned	This site appears to have been stabilized with fill material that is not conducive to GPR data collection. This is similar to other burial grounds at the Hanford Site and can limit the amount of useful information to be gained through geophysical investigations.

Figure A2-1. Geophysical Investigation Results, 218-E-2A Burial Ground, 200 East Area, June 2006.

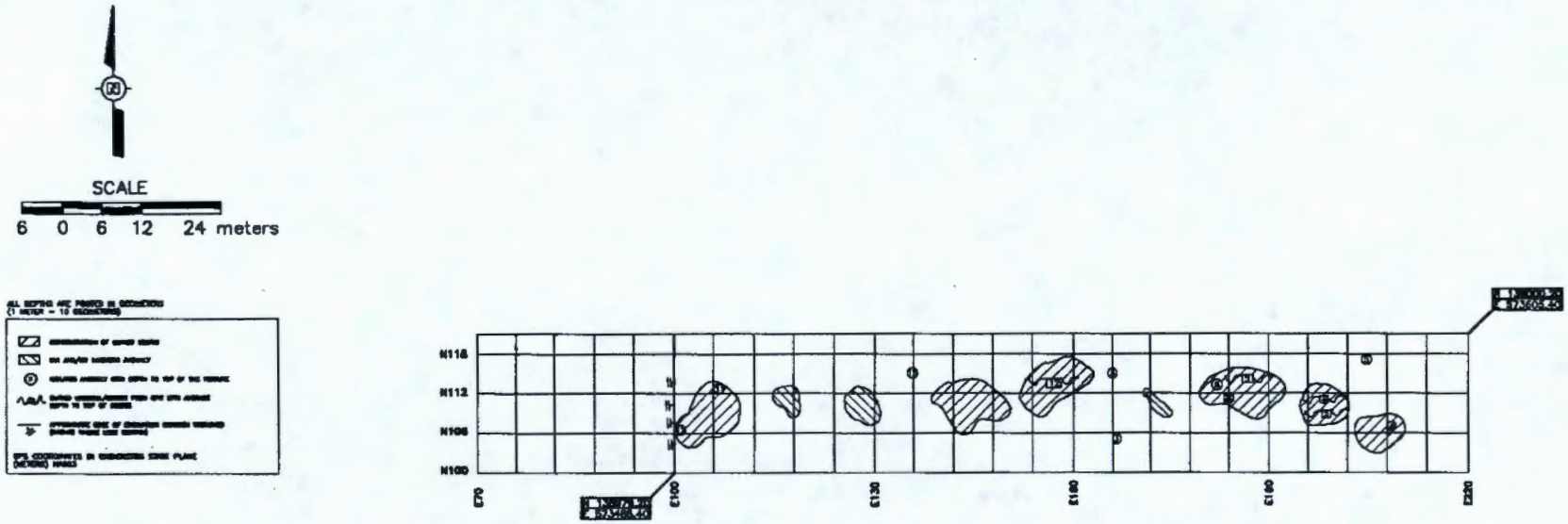


Figure A2-2. Electromagnetic Induction (EM31) Ground Conductivity Data, 218-E-2A Burial Ground, 200 East Area, June 11, 2006.

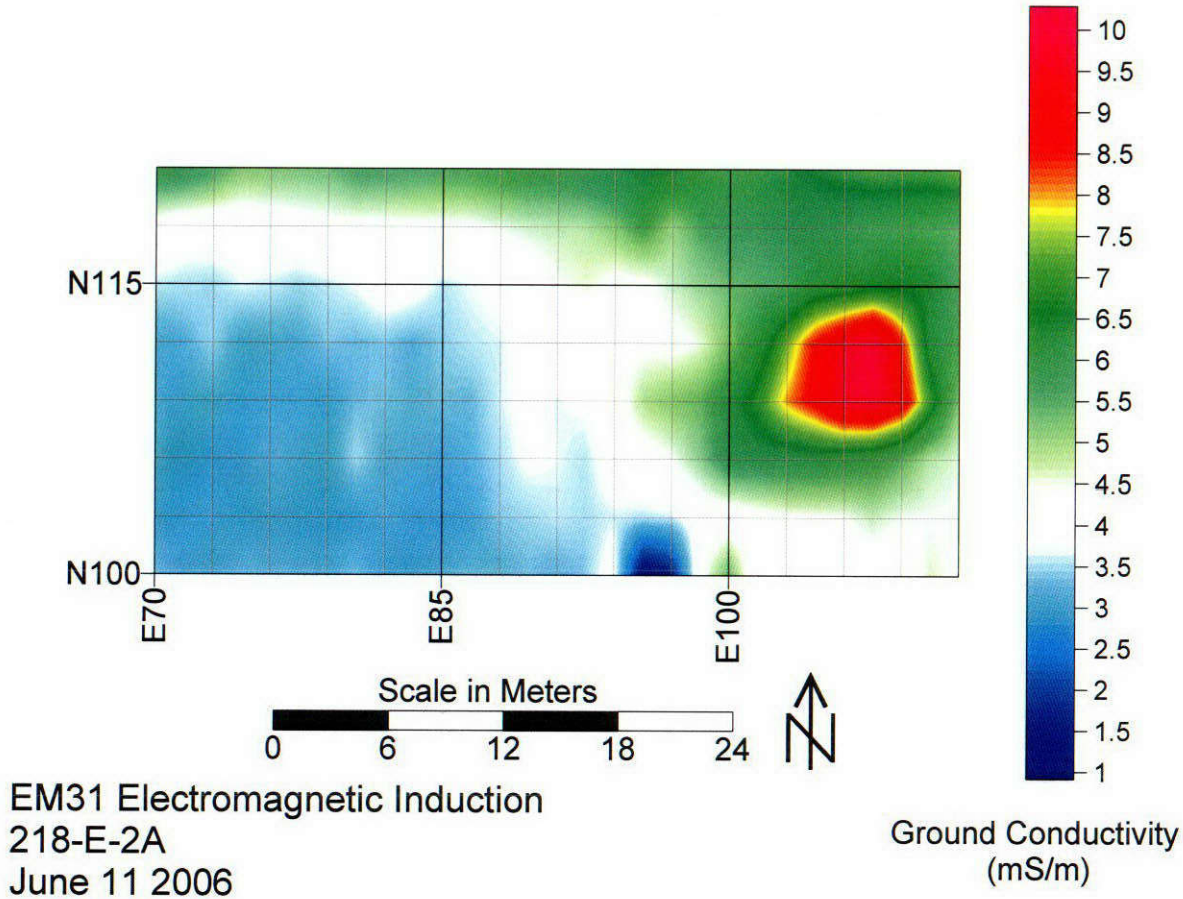


Figure A2-3. Electromagnetic Induction (EM31) In-Phase Data, 218-E-2A Burial Ground, 200 East Area, June 11, 2006.

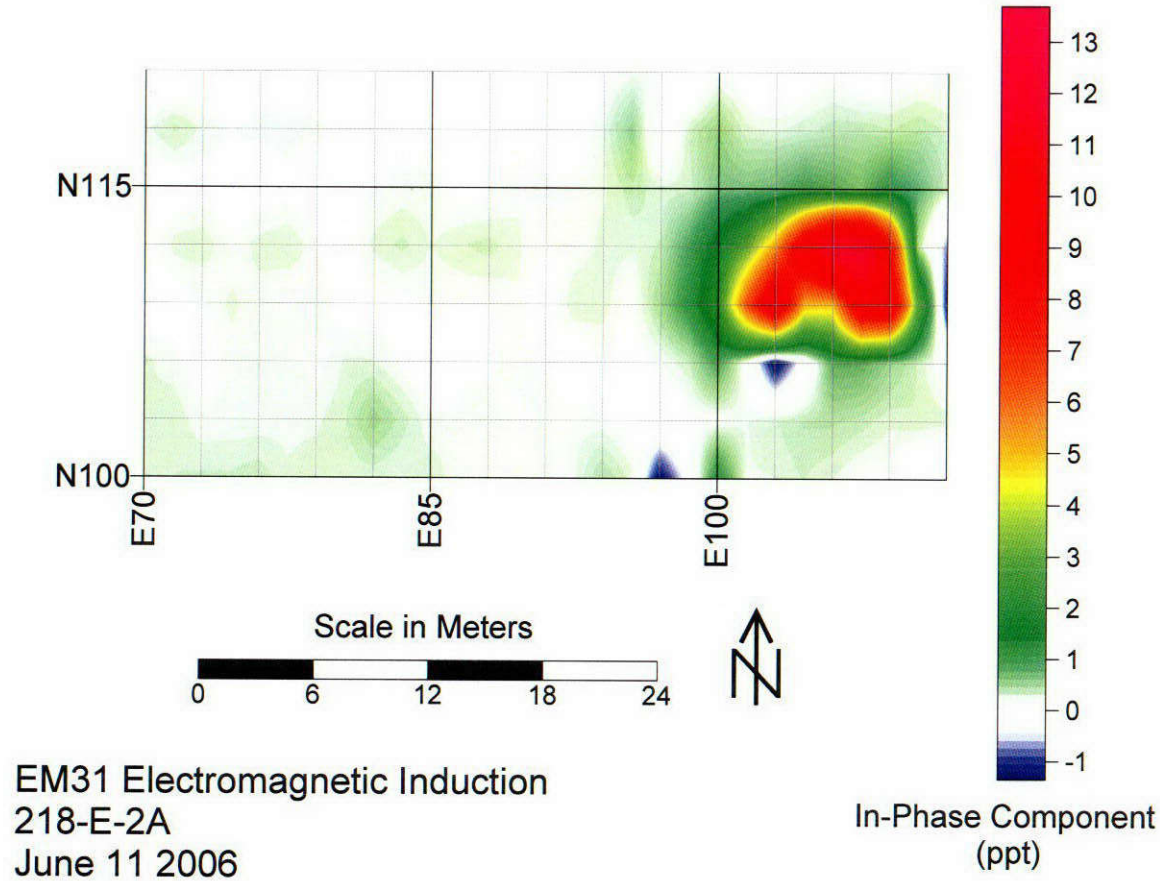


Figure A2-4. Total Magnetic Field (G-858/G) Data, 218-E-2A Burial Ground, 200 East Area, June 11, 2006.

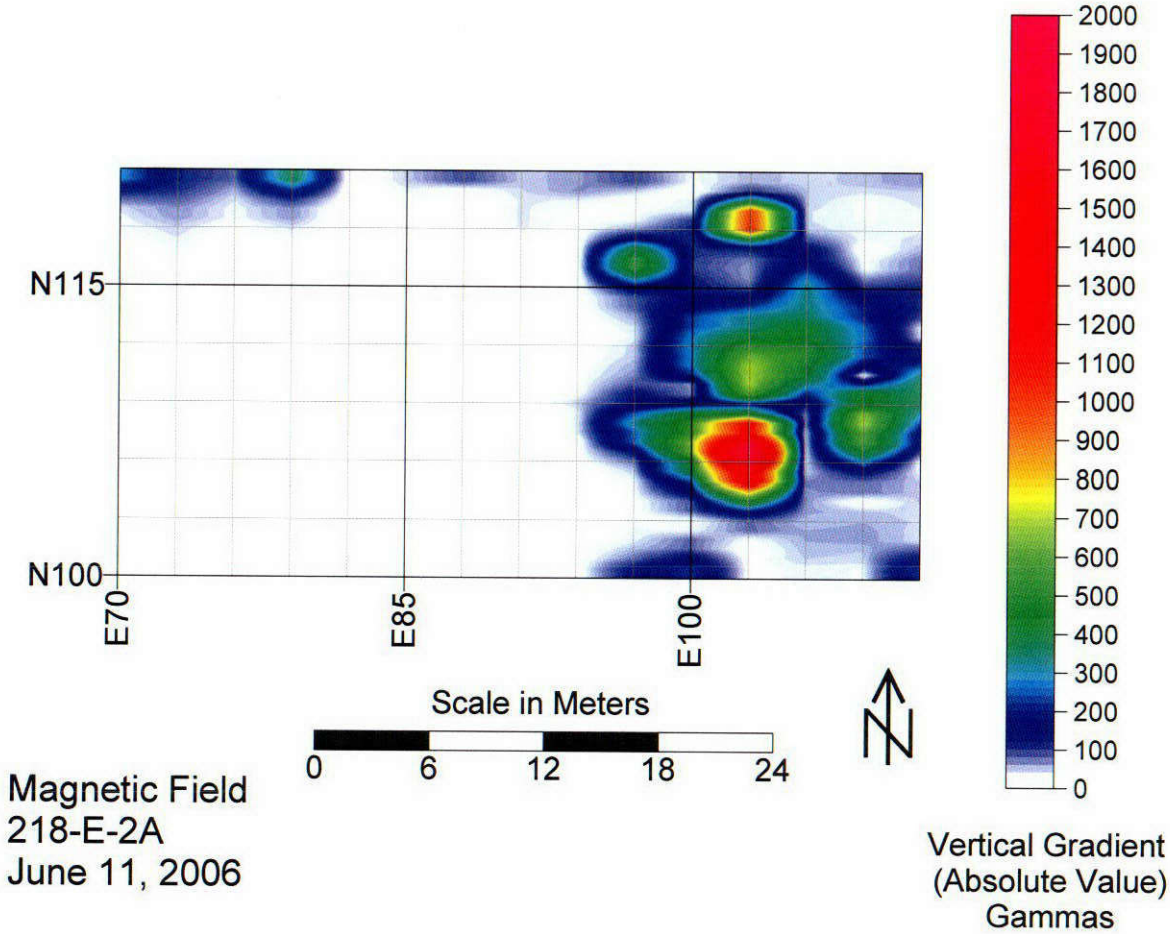
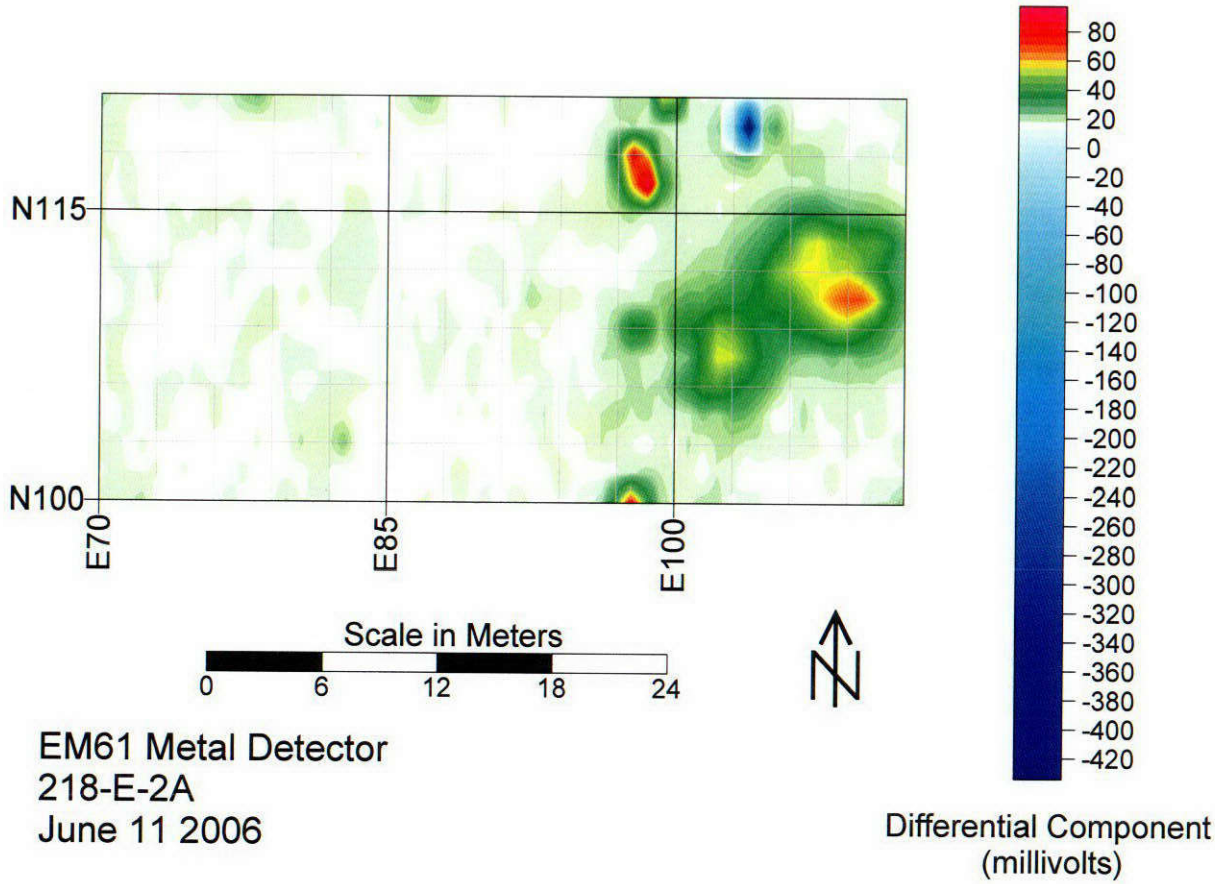


Figure A2-5. Electromagnetic Induction (EM61) Data, 218-E-2A Burial Ground, 200 East Area, June 11, 2006.



A3.0 218-E-8 BURIAL GROUND GEOPHYSICAL INVESTIGATION SUMMARY AND DATA PLOTS

Geophysical Investigation Summary Sheet	
Site Name	218-E-8 Burial Ground
Location	200 East Area
Approximate size	60 m x 114 m (~1.1 acres)
Burial Ground Information	No information available on the number of trenches or their orientation.
Terrain	Westernmost portion of the site (inside burial ground monuments) is sloped down from west to east approximately 4-5 m. Eastern portion is generally flat with an uneven walking surface.
Vegetation/ground cover	Primarily bunch grass, also cheat grasses and other weeds inside marked burial ground. East of marked burial ground surface is primarily gravel and cobbles with some silty gravel.
Hydrological properties	Surface dry at time of data collection. Rain event approximately 1 week before data collection.
Limitations/obstacles	Contamination area to the south of the investigation area limited the ability to collect data in that area.
Overall assessment for geophysical investigation	Data were adequate in the expansion area to meet project objectives.
Equipment	
Ground Penetrating Radar (GPR)	Geophysical Survey Systems, Inc., SIR-10A GPR system with 200 MHz antenna.
Electromagnetic Induction (EMI)	Frequency domain EMI: Geonics Limited, EM31 Ground Conductivity Meter with Wescor, Inc., Polycorder 720.
	Time domain EMI: Geonics Limited, EM61-MK2 High Sensitivity Metal Detector with Juniper Systems, Inc., PRO4000 Data Logger
Total Magnetic Field	Geometrics, Inc., G-858/G Cesium Vapor Magnetometer/Gradiometer
Data Collection and Processing Parameters	
Grid location control and data collection lines	Base grid staked at 30 m centers by Fluor personnel using Global Positioning System instruments and coordinates supplied by North Wind, which were based on Hanford Site Drawing H-2-33276, Rev. 6, Sheet 3, and Rev. 17, Sheet 1. Base grid was 90 m N-S, 60 m E-W; data collection lines were flagged at 6 m centers in North-South and East-West directions along base grid.
SIR-10A	Data were collected with the antenna towed behind a 4 x 6 all-terrain vehicle (Gator Utility Vehicle [1]). Marks were placed in the data as the instrument passed position flags or stakes. Data were stacked (2 signals), recording window 108 ns, gains and filters set in field to match soil conditions. Hard copy plots of data were printed in the office on a thermal printer for interpretation. --- [1] Gator Utility Vehicle is a trademark of John Deere & Company, Moline, Illinois.

Geophysical Investigation Summary Sheet	
EM31	Data were collected at hip height in the vertical dipole mode on 1.5 m station spacing and 3 m line spacing on East-West-oriented lines. Data were downloaded from the Polycorder and written to a .xyz data file using Geonics DAT31.exe. Corrections of position errors during data collection (if any) are made in standard spreadsheet software such as Microsoft Excel [2]. Data were gridded and plotted using Surfer [3]. Cell size for data plots is nominally 3 m (cross line) x 1.5 m (down line). --- 2 Excel is a trademark of Microsoft Corporation, Redmond, Washington. 3 Surfer is a trademark of Golden software, Inc., Golden, Colorado.
EM61-MK2	Data were collected with instrument-in-cart mode; 0.19 m station spacing on lines spaced 1.5 m apart; differential mode (3 lower coil readings, one upper coil reading). Data were downloaded from the Pro4000 using Lynx, a HarvestMaster brand electronic data acquisition system owned by Juniper Systems, Inc. Position corrections, such as line starts and stops, and writing to a .xyz file were performed using Geonics DAT61.exe. Data were gridded and plotted using Surfer. Grid cell size for data plots is nominally 1.5 m (cross line) x 0.75 m (down line).
G-858/G	Data were collected with sensors 0.5 and 1.5 m above the ground in continuous sampling mode, with samples recorded every 0.5 seconds (nominal 0.5 m data spacing), and fiducial positioning marks placed every 30 m, on lines spaced 3 m apart. Data were collected in East-West direction with the sensors oriented East-West at a 45-degree angle to the horizon. Data were downloaded from the field instrument, filtered for spikes and dropouts (if any), corrected for position errors (if any), and written to a .xyz file using Geometrics, Inc., MagMapper2000.exe. Data were gridded and plotted using Surfer. Grid cell size for the data plots is nominally 3 m (cross line) x 0.5 m (down line).
Results	
Data Discussion	Refer to data plots A3-1 through A3-5 for the following discussion. EMI and magnetic data show diffuse, low-amplitude anomalies in the area immediately east of the marked burial ground. High-amplitude anomalies caused by surface metal debris also are visible. EMI data show a linear anomaly consistent with a buried pipeline or other utility in the northern portion of the investigation area, oriented NW-SE. EMI and magnetic data both show a zone of high-amplitude anomalies in the southeast corner of the investigation area. The GPR data indicate buried debris and/or objects throughout the investigation area. Experience shows that basalt boulders can produce GPR anomalies, and that is the preferred interpretation for this site. GPR data also show major concentrations of buried debris, especially in the southeast corner of the investigation area. The anomalies in the southeast corner of the investigation area are beyond the designed investigation area and were detected during system demobilization. Because of the amplitude of these anomalies, another 30 m x 30 m expansion was added to the designed investigation to help determine the source of the anomalous readings.

Geophysical Investigation Summary Sheet	
Interpretation	Interpretation of the geophysical data collected in the expansion area indicates that there are buried objects and/or debris outside of the marked burial ground. Near the burial ground monuments is one buried object (or concentration of smaller objects) that may be associated with the burial ground. An area of diffuse anomalies may indicate widely spaced buried objects or fill material that has some metallic material contained within. Approximately 60 m east of the burial ground begins a significant pit of buried debris that was not fully characterized by this investigation. EMI data indicate a buried utility along the northern boundary of the investigation area, although this was not corroborated by any other method.
Lessons learned	By expanding the area of the previous investigation, buried objects/debris were verified outside of the marked burial ground.

Figure A3-1. Geophysical Investigation Results, 218-E-8 Burial Ground, 200 East Area, June 2006.

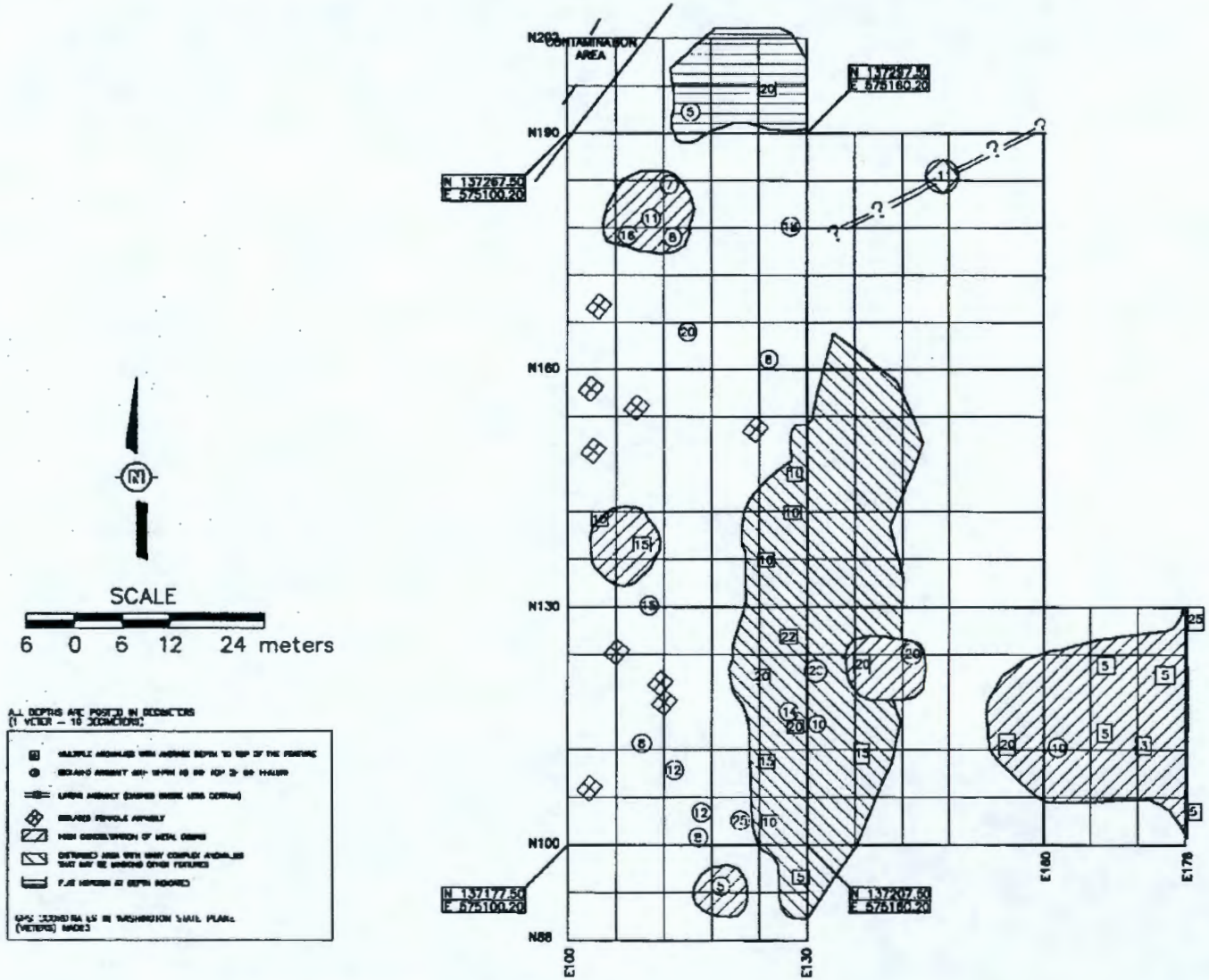


Figure A3-2. Electromagnetic Induction (EM31) Ground Conductivity Data, 218-E-8 Burial Ground, 200 East Area, June 11, 2006.

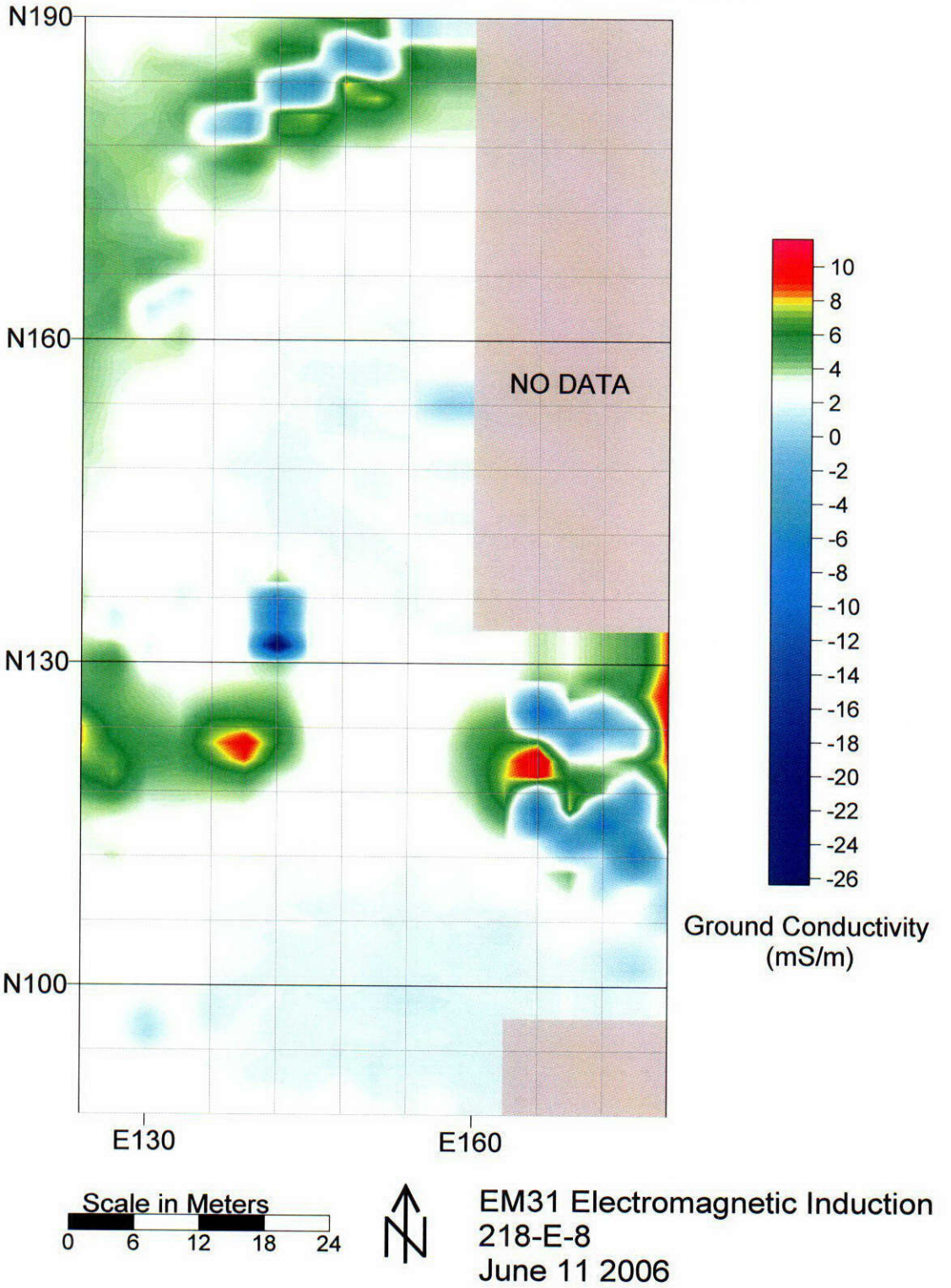


Figure A3-3. Electromagnetic Induction (EM31) In-Phase Data, 218-E-8 Burial Ground, 200 East Area, June 11, 2006.

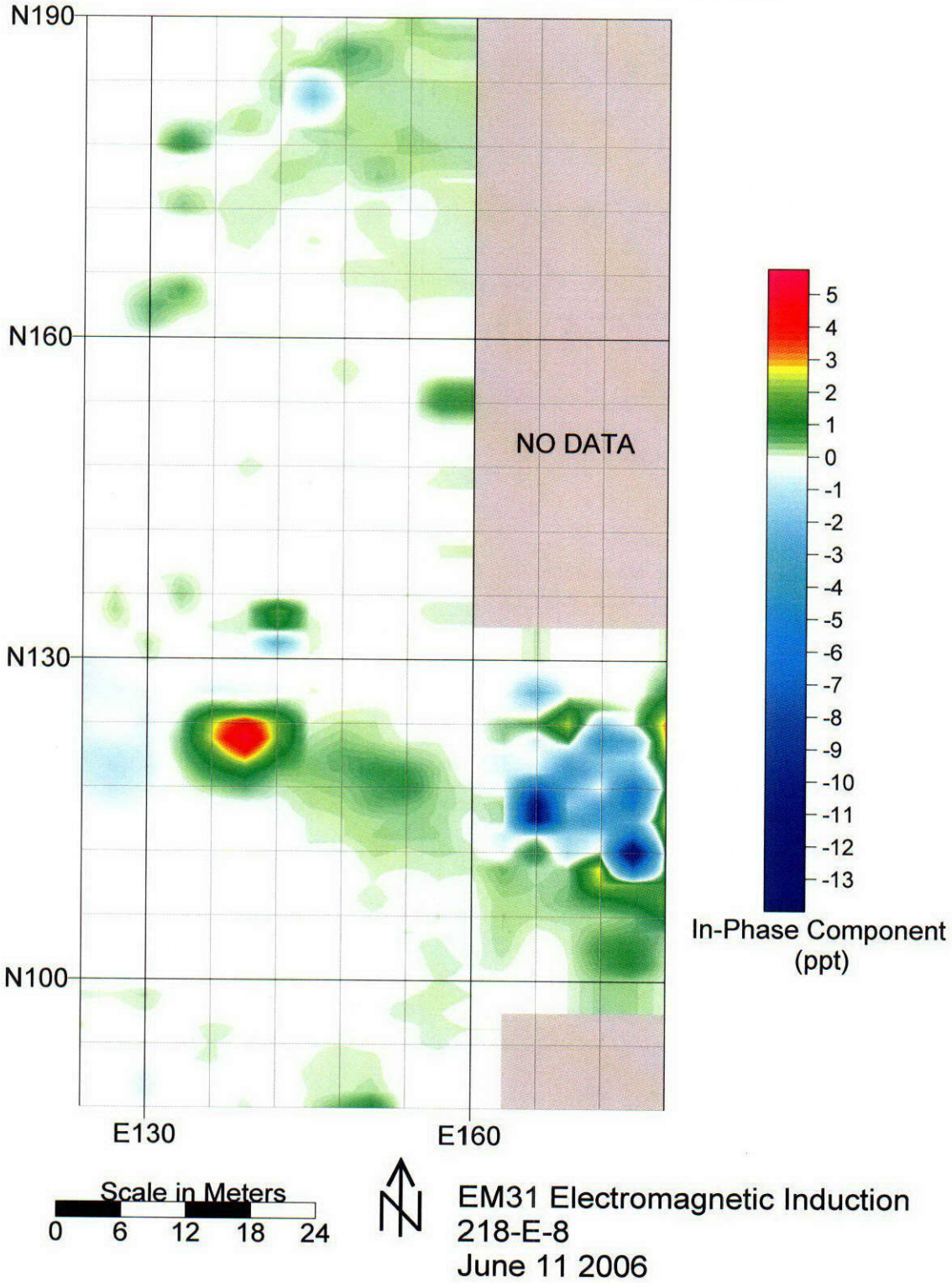


Figure A3-4. Total Magnetic Field (G-858/G) Data,
218-E-8 Burial Ground, 200 East Area, June 11, 2006.

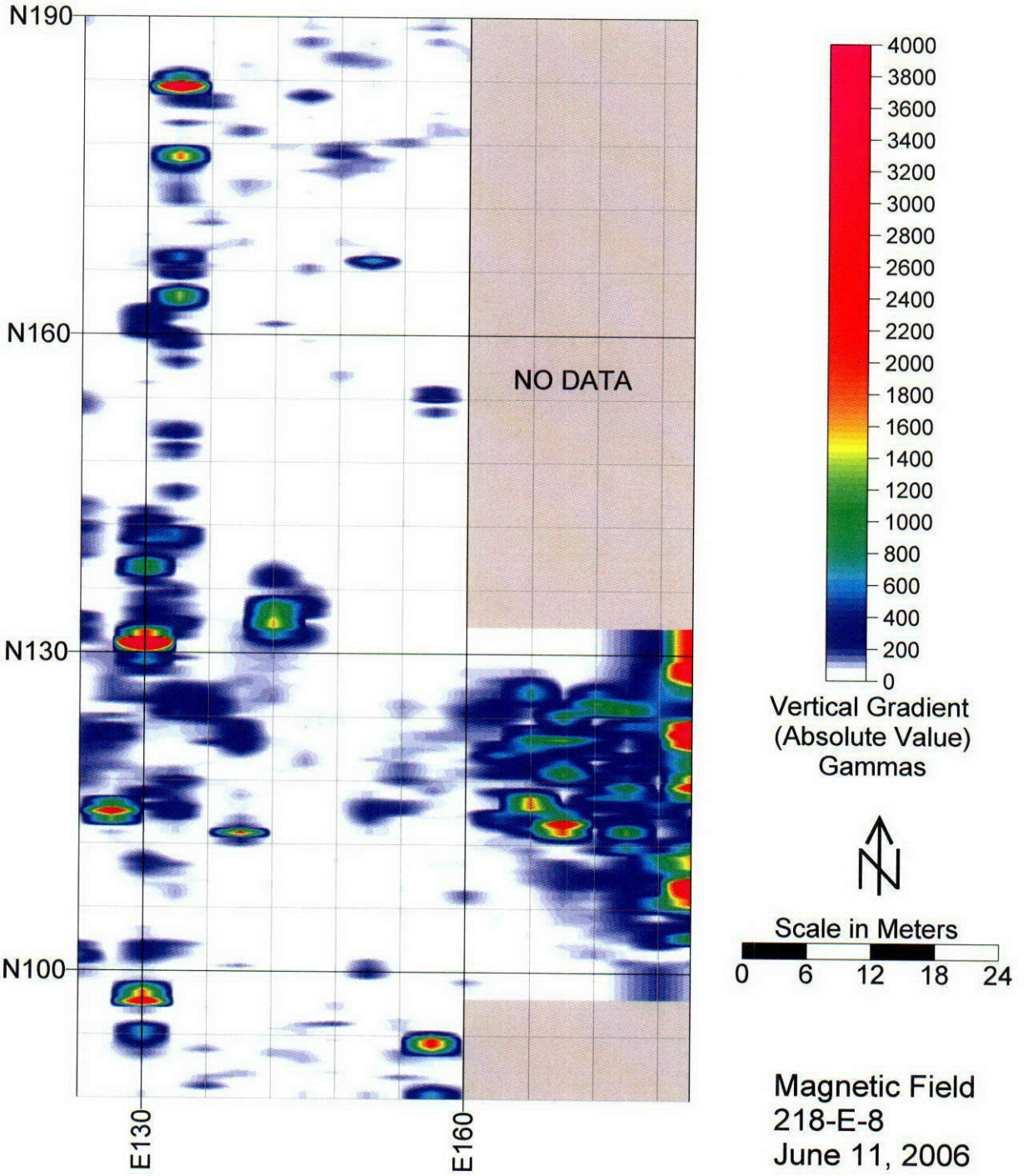
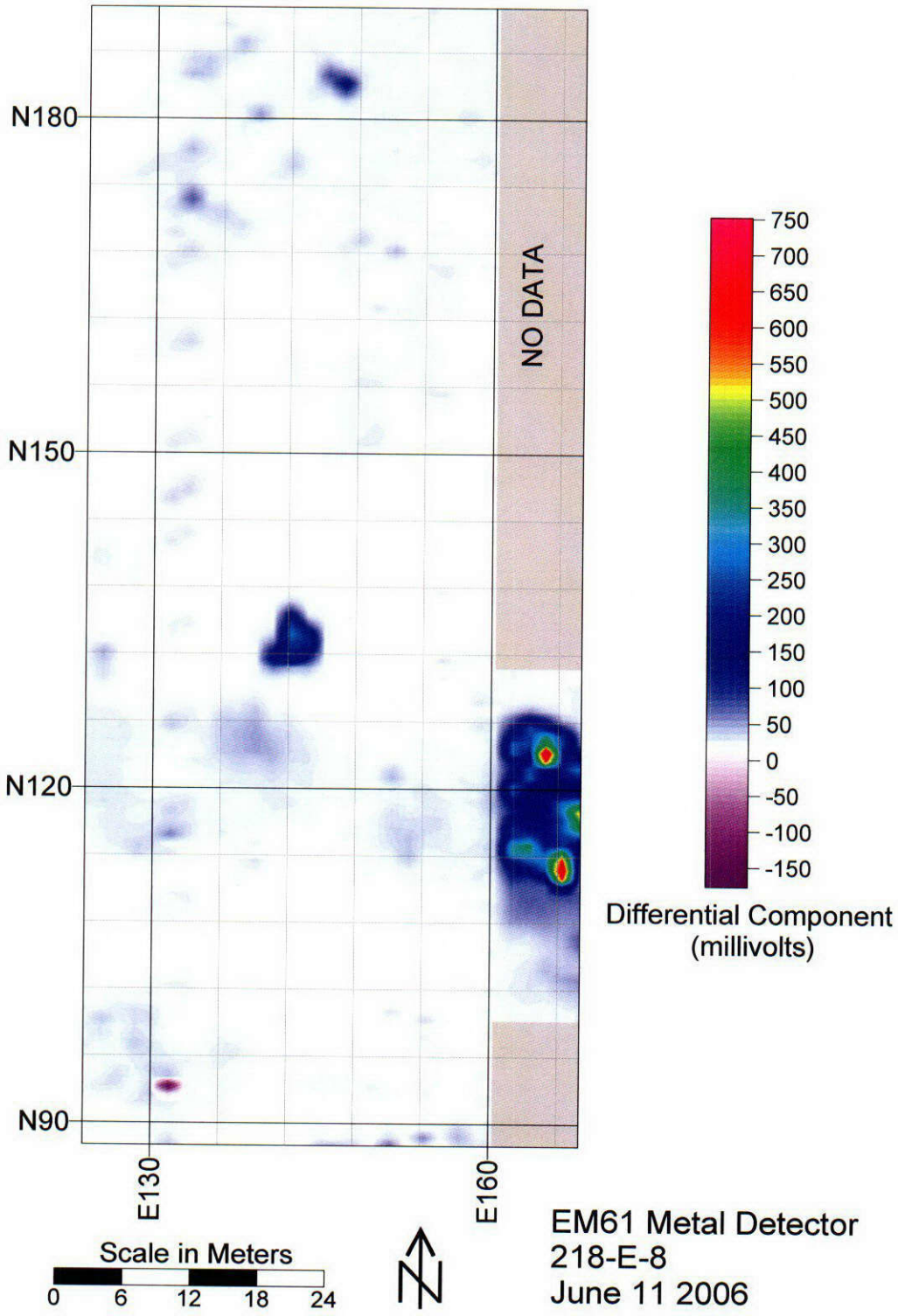


Figure A3-5. Electromagnetic Induction (EM61) Data, 218-E-8 Burial Ground, 200 East Area, June 11, 2006.



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A4.0 218-E-12A BURIAL GROUND GEOPHYSICAL INVESTIGATION SUMMARY AND DATA PLOTS

Geophysical Investigation Summary Sheet	
Site Name	218-E-12A Burial Ground
Location	200 East Area
Approximate size	360 m x 390 m (~28.4 acres)
Burial Ground Information	Per Hanford Site Drawing H-2-32560, this burial ground contains 28 North-South-oriented trenches of various lengths and widths.
Terrain	Generally flat throughout most of the site. Slopes west to east starting at E430 to eastern boundary. East-West berm over buried pipeline near N460.
Vegetation/ground cover	Primarily bunch grass with scattered cheat grasses and other weeds. Sandy gravel surface material with a few areas that are mounded with additional crushed gravel.
Hydrological properties	Surface dry at time of data collection.
Limitations/obstacles	East-West mound over pipeline with steep northern flank.
Overall assessment for geophysical investigation	Electromagnetic induction and magnetic methods were the most effective at meeting project objectives. GPR data quality varied from average to poor.
Equipment	
Ground Penetrating Radar (GPR)	Geophysical Survey Systems, Inc., SIR-10A GPR system with 200 MHz antenna.
Electromagnetic Induction (EMI)	Frequency domain EMI: Geonics Limited, EM31 Ground Conductivity Meter with Wescor, Inc., Polycorder 720.
Total Magnetic Field	Geometrics, Inc., G-858/G Cesium Vapor Magnetometer/Gradiometer
Data Collection and Processing Parameters	
Grid location control and data collection lines	Base grid staked at 30 m centers by Fluor personnel using Global Positioning System instruments and coordinates supplied by North Wind, which were based on Hanford Site Drawing H-2-32560. Base grid was 360 m N-S, 390 m E-W; data collection lines were flagged at 6 m centers in North-South direction along base grid.
SIR-10A	Data were collected with the antenna towed behind a 4 x 6 all-terrain vehicle (Gator Utility Vehicle [1]). Marks were placed in the data as the instrument passed position flags or stakes. Data were stacked (2 signals), recording window 108 ns, gains and filters set in field to match soil conditions. Hard copy plots of data were printed in the office on a thermal printer for interpretation. Two East-West profiles were collected along each 30 m baseline. Additional profiles were collected roughly every 6-12 m between the bases. Selected North-South profiles were collected down the estimated center of some trenches, as depicted from the EM31 and/or magnetic data.

[1] Gator Utility Vehicle is a trademark of John Deere & Company, Moline, Illinois.

Geophysical Investigation Summary Sheet	
EM31	Data were collected at hip height in the vertical dipole mode on 1.5 m station spacing and 3 m line spacing on East-West-oriented lines. Data were downloaded from the Polycorder and written to a .xyz data file using Geonics DAT31.exe. Corrections of position errors during data collection (if any) are made in standard spreadsheet software such as Microsoft Excel [2]. Data were gridded and plotted using Surfer [3]. Cell size for data plots is nominally 3 m (cross line) x 1.5 m (down line). --- [2] Excel is a trademark of Microsoft Corporation, Redmond, Washington. [3] Surfer is a trademark of Golden Software, Inc., Golden, Colorado.
G-858/G	Data were collected with sensors 0.5 and 1.5 m above the ground in continuous sampling mode, with samples recorded every 0.5 seconds (nominal 0.5 m data spacing), and fiducial positioning marks placed every 30 m, on lines spaced 3 m apart. Data were collected in East-West direction with the sensors oriented East-West at a 45-degree angle to the horizon. Data were downloaded from the field instrument, filtered for spikes and dropouts (if any), corrected for position errors (if any), and written to a .xyz file using Geometrics, Inc., MagMapper2000.exe. Data were gridded and plotted using Surfer. Grid cell size for the data plots is nominally 3 m (cross line) x 0.5 m (down line).
Results	
Data Discussion	Refer to data plots A4-1 through A4-4 and Table A4-1 for the following discussion. The magnetic data produced anomalies that appear to be from ferrous metallic debris buried in the trenches, as well as basalt-rich fill material that was used to fill the trenches, or perhaps as added generic fill material to parts of the burial ground. Experience at other Hanford sites shows that the Columbia River Basalt that dominates the region often is high in iron and often causes anomalies in the magnetic data when the surface material is rich in basalt, especially when compacted. The EMI data mapped pockets of metallic debris as well as changes in the conductivity of the soil. The in-phase data were effective in mapping where the metallic debris is buried in the trenches. The conductivity data show that the soil conditions vary across the site and show where the largest pockets of conductive (most often metallic) debris are located. The GPR data were effective at mapping the trench boundaries in the western half of the site where the dry waste trenches are located but were not effective at mapping the thinner, acid waste trenches that are located in the eastern half of the site. The GPR data also indicate that most of the debris is covered by at least 2 m of fill. However, because of the reconnaissance nature of the investigations, there may be some shallower debris between the GPR profiles. Three linear anomalies, clearly depicted in the data, are known buried pipelines. The East-West linear that crosses the middle of the site is from a combination of a surface cable and the metal T-posts that protect it.

Geophysical Investigation Summary Sheet	
Interpretation	**Dry Waste Trenches (1, 2, 3, 12, 13, 14, 17, 18, 19, 20, 21, 22, 23, 24, and 25)** Pockets of debris were located and mapped in each of the dry waste trenches. In all of the dry waste trenches, concentrations of metallic waste were identified. Some apparent nonmetallic waste appears to be mixed with the metallic waste. Most of the waste is at least 1.5 to 2.0 m deep or deeper. It appears that the thickness of the fill over the waste and the soil conditions at the site resulted in the EMI and magnetic data being the most effective tools, while limiting the effectiveness of GPR. Because of the depth of burial of the debris in trenches and the marginally favorable soil conditions, it is assumed that there is more debris in the trenches than was detected in the data. **Acid-Soaked Material Trenches (4, 5, 6, 7, 8, 9, 10, 11, 15, 16, 26, 27, and 28),** All of the acid trenches are documented as being in the eastern half of the burial ground where the soil conditions are least favorable to GPR. The widths of the acid trenches are documented as being either 1.5 or 3.7 m (5 or 12 ft) wide; thus they are most likely relatively shallow. There were no geophysical features identified in the data (i.e. excavation boundaries or notable changes in the characteristics of the soil) that are often associated with a trench. There are a few pockets of anomalies in the eastern half of the site; they may fall within a trench but might also be scattered surface debris that is unrelated to a trench. If there were concentrations of metallic debris in these trenches, they should have been identified in the geophysical data. This suggests that most of the debris in these apparently narrow, shallow trenches is nonmetallic.
Lessons learned	The easternmost third of the site was not very conducive to GPR, because of the homogeneity of the natural soil before it was disturbed by the excavations for the trenches. GPR often is the best tool at the Hanford Site for mapping trenches and nonmetallic waste. A very detailed GPR survey (tightly spaced profiles) might improve the detection of some of the boundaries of the trenches, especially if coupled with a test trench to help understand the subtle geophysical signatures.

Table A4-1. Summary of Results from Burial Ground 218-E-12A, 200 East Area. (4 Pages)

Approx. Center of Trench, Based on Geo-physical Data	Best Trench Corre-lation, Based on Drawing H-2-32560	Documented Waste Type	Approx. Center of Trench, Based on Drawing H-2-32560	Comments
E232	17	Dry Waste	E230	Good correlation between the geophysical data and the documented location, width, and length of the trench. Geophysical data suggest a mix of metallic and nonmetallic waste.
E220	18	Dry Waste	E218	Good correlation between the geophysical data and the documented location, width, and length of the trench. Geophysical data suggest a mix of metallic and nonmetallic waste.
E208	19	Dry Waste	E206	Good correlation between the geophysical data and the documented location, width, and length of the trench. Geophysical data suggest a mix of metallic and nonmetallic waste.
E196	20	Dry Waste	E194	Good correlation between the geophysical data and the documented location, width, and length of the trench. Geophysical data suggest a mix of metallic and nonmetallic waste.
E183	21	Dry Waste	E182	Good correlation between the geophysical data and the documented location, width, and length of the trench. Geophysical data suggest a mix of metallic and nonmetallic waste.
E169	22	Dry Waste	E169	Good correlation between the geophysical data and the documented location, width, and length of the trench. Geophysical data suggest a mix of metallic and nonmetallic waste.
E156	23	Dry Waste	E157	Good correlation between the geophysical data and the documented location, width, and length of the trench. Geophysical data suggest a mix of metallic and nonmetallic waste.
E145	24	Dry Waste	E145	Good correlation between the geophysical data and the documented location, width, and length of the trench. Geophysical data suggest a mix of metallic and nonmetallic waste.
E132	25	Dry Waste	E132	Good correlation between the geophysical data and the documented location, width, and length of the trench. Geophysical data suggest a mix of metallic and nonmetallic waste.
E244	14	Dry Waste	E242	Good correlation between the geophysical data and the documented location, length, and width of the trench. The geophysical data suggest that the trench isn't completely full. Alternately, there could more nonmetallic than metallic debris, or the debris is deeper than the effective detection limits of the geophysical tools, thus giving the appearance of less debris.
E256	13	Dry Waste	E254	Good correlation between the geophysical data and the documented location and width of the trench. The geophysical data suggest that the trench is not as long as documented and isn't completely full. Alternately, there could more nonmetallic than metallic debris, or the debris is deeper than the effective detection limits of the geophysical tools, thus giving the appearance of a smaller trench with less debris.
E267	12	Dry Waste	E267	Good correlation between the geophysical data and the documented location, length, and width of the trench. The geophysical data suggest that the trench isn't completely full. Alternately, there could more nonmetallic than metallic debris, or the debris is deeper than the effective detection limits of the geophysical tools, thus giving the appearance of less debris.

Table A4-1. Summary of Results from Burial Ground 218-E-12A, 200 East Area. (4 Pages)

Approx. Center of Trench, Based on Geo-physical Data	Best Trench Corre-lation, Based on Drawing H-2-32560	Documented Waste Type	Approx. Center of Trench, Based on Drawing H-2-32560	Comments
E282-E288	3	Dry Waste	E283	The trench boundaries or center of the trench is not well delineated in the geophysical data. However, there are detectable concentrations of both metallic and nonmetallic debris. Likewise, the debris could be deeper than the effective detection limits of the geophysical tools, thus giving the appearance of less debris
E310	1	Dry Waste	E300	The trench boundaries or center of the trench is not well delineated in the geophysical data. However, there are detectable concentrations of both metallic and nonmetallic debris that fall in the approximate documented location of the trench. Additional debris could be in the trench that is deeper than the effective detection limits of the geophysical tools, thus giving the appearance of less debris.
E328	2	Dry Waste	E324	The trench boundaries or center of the trench is not well delineated in the geophysical data. However, there are detectable concentrations of both metallic and non–metallic debris that fall in the approximate documented location of the trench. Additional debris could be in the trench that is deeper than the effective detection limits of the geophysical tools, thus giving the appearance of less debris.
None	16	Acid Soaked	E276	There is no indication of trench boundaries (i.e., excavation boundaries) or debris in the documented location of the trench. This is consistent with all of the trenches that are documented as containing acid-soaked material, suggesting that these trenches are relatively shallow with primarily nonmetallic waste. It does not appear that the waste is deeper than the detection limits of the geophysical methods, because the trenches are documented as being only 1.5 or 3.7 m (5 or 12 ft) wide.
None	15	Acid Soaked	E290	There is no indication of trench boundaries (i.e. excavation boundaries) or debris in the documented location of the trench. This is consistent with all of the trenches that are documented as containing acid-soaked material, suggesting that these trenches are relatively shallow with primarily nonmetallic waste. However, because of the proximity of trench 15 to trench 3, they may blend together, thus giving the appearance of a single trench.
None	28	Acid Soaked	E337	There is no indication of trench boundaries (i.e., excavation boundaries) or debris in the documented location of the trench. This is consistent with all of the trenches that are documented as containing acid-soaked material, suggesting that these trenches are relatively shallow with primarily nonmetallic waste. It does not appear that the waste is deeper than the detection limits of the geophysical methods, because the trenches are documented as being only 1.5 or 3.7 m (5 or 12 ft) wide.
None	5	Acid Soaked	E346	There is no indication of trench boundaries (i.e., excavation boundaries) or debris in the documented location of the trench. This is consistent with all of the trenches that are documented as containing acid-soaked material, suggesting that these trenches are relatively shallow with primarily nonmetallic waste. It does not appear that the waste is deeper than the detection limits of the geophysical methods, because the trenches are documented as being only 1.5 m (5 ft) wide.

Table A4-1. Summary of Results from Burial Ground 218-E-12A, 200 East Area. (4 Pages)

Approx. Center of Trench, Based on Geo-physical Data	Best Trench Corre-lation, Based on Drawing H-2-32560	Documented Waste Type	Approx. Center of Trench, Based on Drawing H-2-32560	Comments
None	4	Acid Soaked	E349	There is no indication of trench boundaries (i.e., excavation boundaries) or debris in the documented location of the trench. This is consistent with all of the trenches that are documented as containing acid-soaked material, suggesting that these trenches are relatively shallow with primarily nonmetallic waste. It does not appear that the waste is deeper than the detection limits of the geophysical methods, because the trenches are documented as being only 1.5 m (5 ft) wide.
None	6	Acid Soaked	E352	There is no indication of trench boundaries (i.e., excavation boundaries) or debris in the documented location of the trench. This is consistent with all of the trenches that are documented as containing acid-soaked material, suggesting that these trenches are relatively shallow with primarily nonmetallic waste. It does not appear that the waste is deeper than the detection limits of the geophysical methods, because the trenches are documented as being only 1.5 m (5 ft) wide.
None	7	Acid Soaked	E362	There is no indication of trench boundaries (i.e., excavation boundaries) or debris in the documented location of the trench. This is consistent with all of the trenches that are documented as containing acid-soaked material, suggesting that these trenches are relatively shallow with primarily nonmetallic waste. It does not appear that the waste is deeper than the detection limits of the geophysical methods, because the trenches are documented as being only 3.7 m (12 ft) wide.
None	8	Acid Soaked	E368	There is no indication of trench boundaries (i.e., excavation boundaries) or debris in the documented location of the trench. This is consistent with all of the trenches that are documented as containing acid-soaked material, suggesting that these trenches are relatively shallow with primarily nonmetallic waste. It does not appear that the waste is deeper than the detection limits of the geophysical methods, because the trenches are documented as being only 3.7 m (12 ft) wide.
None	9	Acid Soaked	E375	There is no indication of trench boundaries (i.e., excavation boundaries) or debris in the documented location of the trench. This is consistent with all of the trenches that are documented as containing acid-soaked material, suggesting that these trenches are relatively shallow with primarily nonmetallic waste. It does not appear that the waste is deeper than the detection limits of the geophysical methods, because the trenches are documented as being only 3.7 m (12 ft) wide.
None	10	Acid Soaked	E380	There is no indication of trench boundaries (i.e., excavation boundaries) or debris in the documented location of the trench. This is consistent with all of the trenches that are documented as containing acid-soaked material, suggesting that these trenches are relatively shallow with primarily nonmetallic waste. It does not appear that the waste is deeper than the detection limits of the geophysical methods, because the trenches are documented as being only 3.7 m (12 ft) wide.

Table A4-1. Summary of Results from Burial Ground 218-E-12A, 200 East Area. (4 Pages)

Approx. Center of Trench, Based on Geo-physical Data	Best Trench Corre-lation, Based on Drawing H-2-32560	Documented Waste Type	Approx. Center of Trench, Based on Drawing H-2-32560	Comments
None	26	Acid Soaked	E388	There is no indication of trench boundaries (i.e., excavation boundaries) or debris in the documented location of the trench. This is consistent with all of the trenches that are documented as containing acid-soaked material, suggesting that these trenches are relatively shallow with primarily nonmetallic waste. It does not appear that the waste is deeper than the detection limits of the geophysical methods, because the trenches are documented as being only 3.7 m (12 ft) wide.
None	11	Acid Soaked	E394	There is no indication of trench boundaries (i.e., excavation boundaries) or debris in the documented location of the trench. This is consistent with all of the trenches that are documented as containing acid-soaked material, suggesting that these trenches are relatively shallow with primarily nonmetallic waste. It does not appear that the waste is deeper than the detection limits of the geophysical methods, because the trenches are documented as being only 3.7 m (12 ft) wide.
v	27	Acid Soaked	E405	There is no indication of trench boundaries (i.e., excavation boundaries) or debris in the documented location of the trench. This is consistent with all of the trenches that are documented as containing acid-soaked material, suggesting that these trenches are relatively shallow with primarily nonmetallic waste. It does not appear that the waste is deeper than the detection limits of the geophysical methods, because the trenches are documented as being only 3.7 m (12 ft) wide.

Figure A4-1. Geophysical Investigation Results, 218-E-12A Burial Ground, 200 East Area, June 2006.

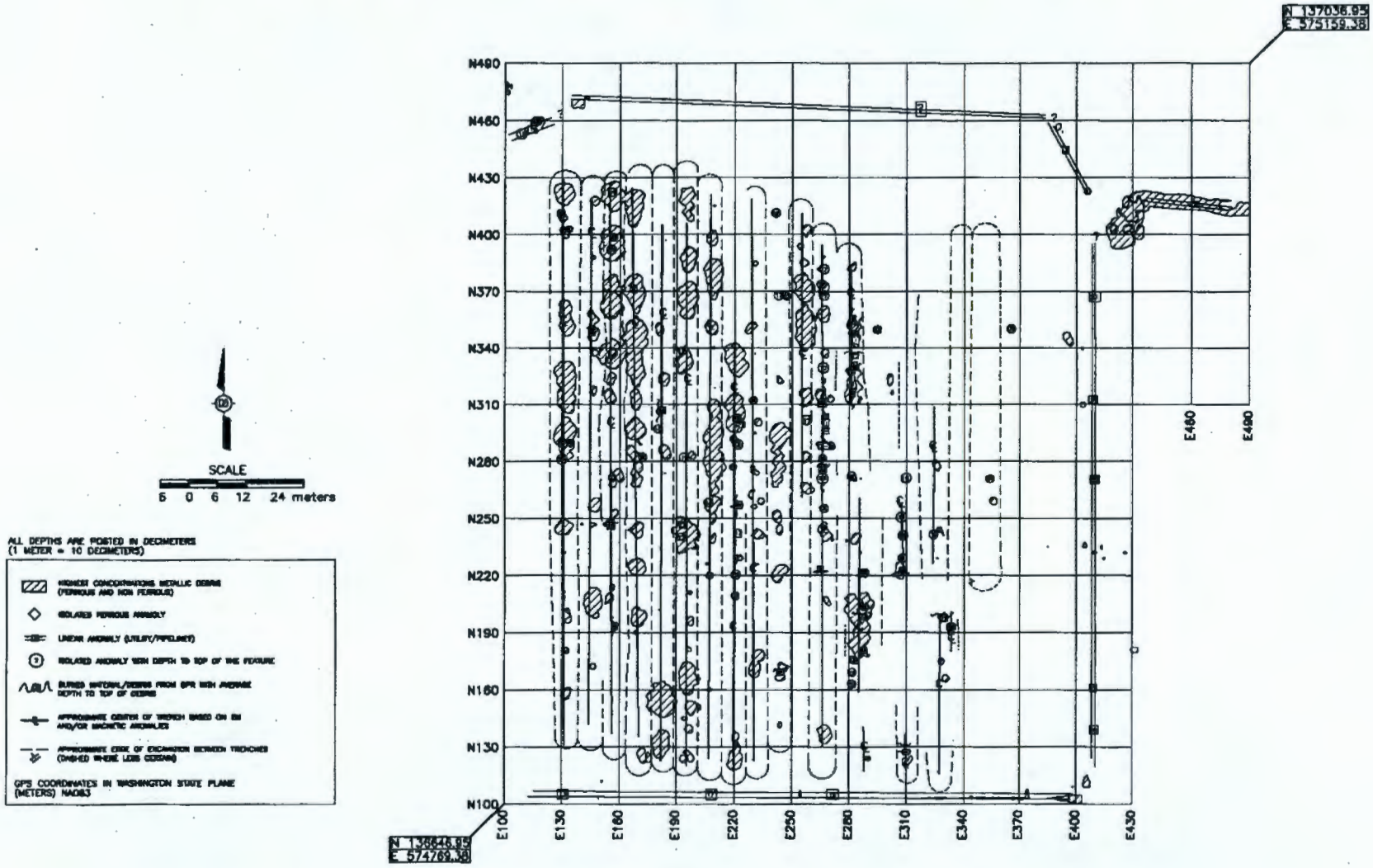


Figure A4-2. Electromagnetic Induction (EM31) Ground Conductivity Data, 218-E-12A Burial Ground, 200 East Area, June 11, 2006.

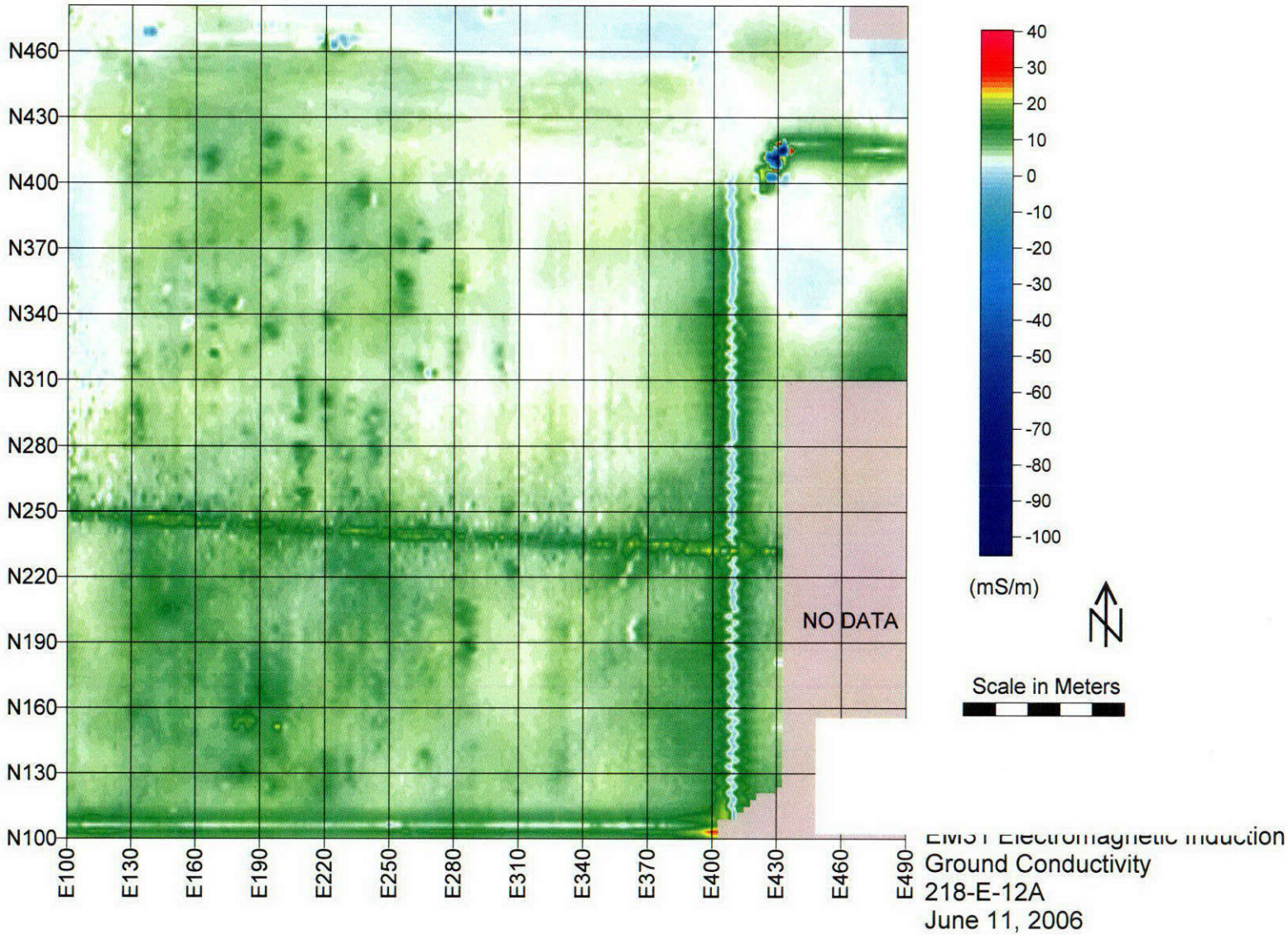


Figure A4-3. Electromagnetic Induction (EM31) In-Phase Data, 218-E-12A Burial Ground, 200 East Area, June 11, 2006.

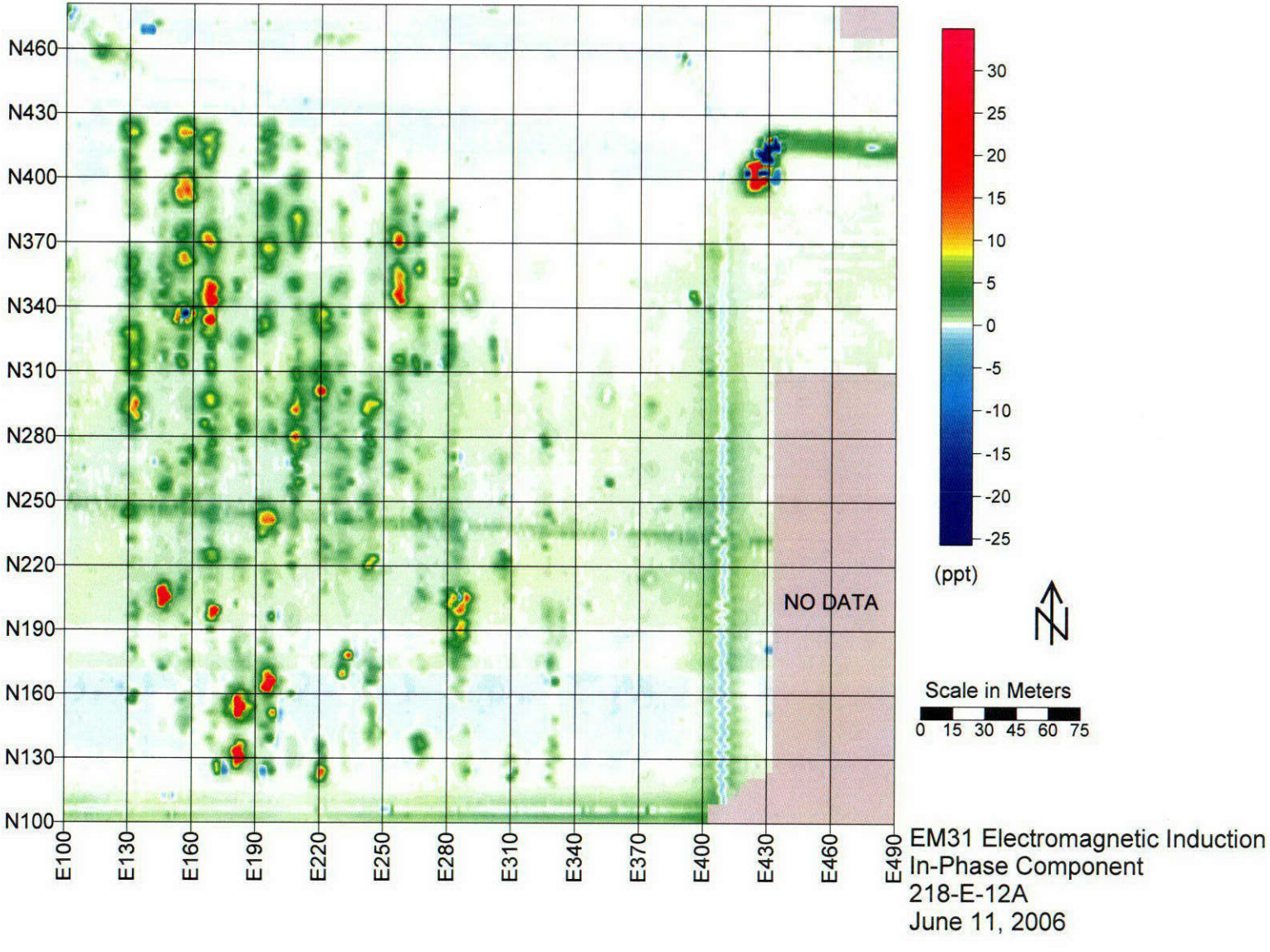
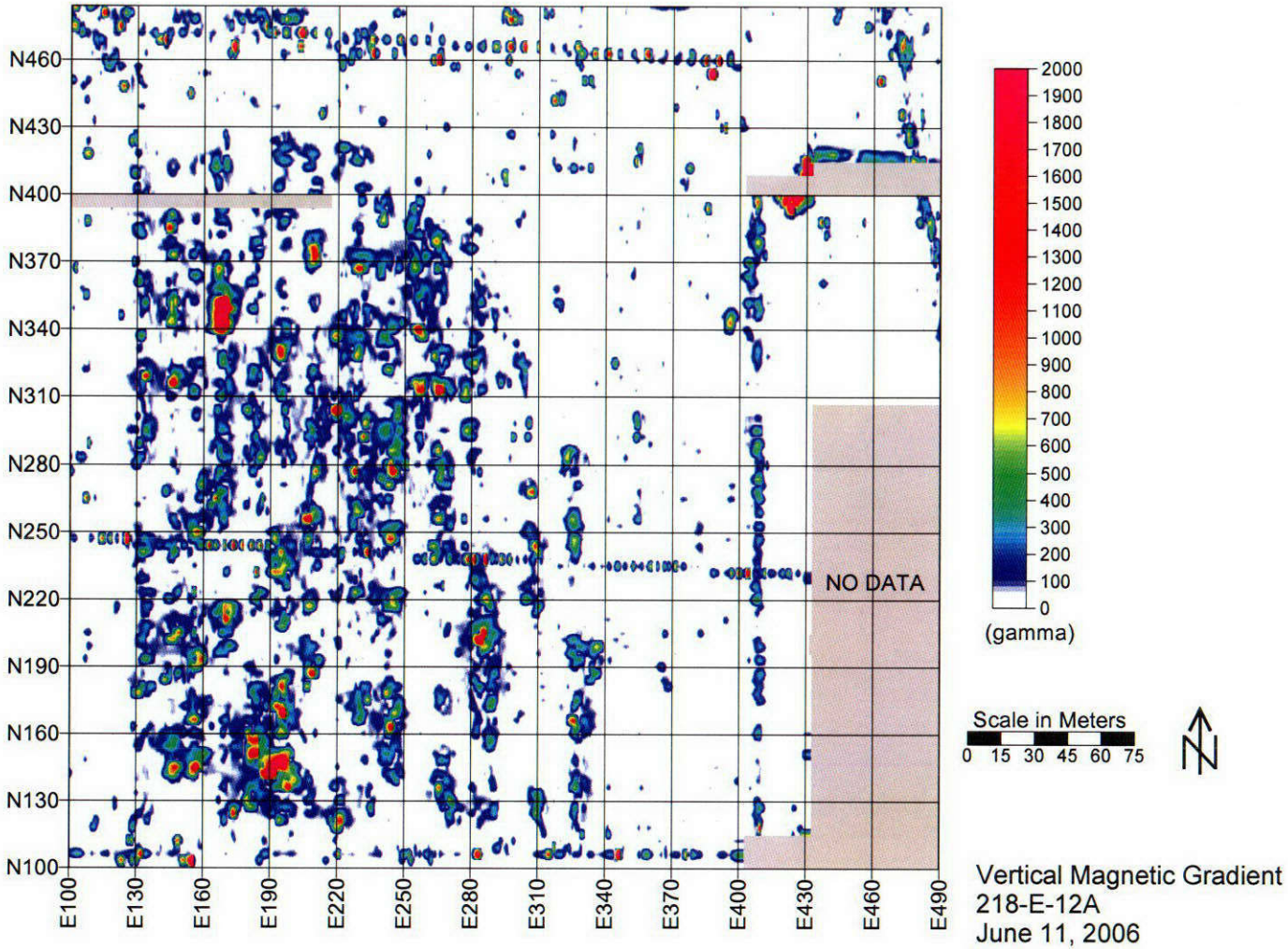


Figure A4-4. Total Magnetic Field (G-858/G) Data, 218-E-12A Burial Ground, 200 East Area, June 11, 2006.



A5.0 218-W-1 BURIAL GROUND GEOPHYSICAL INVESTIGATION SUMMARY AND DATA PLOTS

Geophysical Investigation Summary Sheet	
Site Name	218-W-1 Burial Ground
Location	200 West Area
Approximate size	150 m x 180 m (~5.5 acres)
Burial Ground Information	Per Hanford Site Drawing H-2-75149, this burial ground contains 15 East-West trenches of various lengths and widths.
Terrain	Generally flat throughout the site.
Vegetation/ground cover	Relatively vegetation free with scattered bunch grass and cheat grass. Gravelly sand.
Hydrological properties	Surface relatively dry at time of data collection, although heavy rains fell a few days before data collection.
Limitations/obstacles	None
Overall assessment for geophysical investigation	Electromagnetic induction and magnetic methods were the most effective at meeting project objectives. GPR data quality varied from average to good.
Equipment	
Ground Penetrating Radar (GPR)	Geophysical Survey Systems, Inc., SIR-10A GPR system with 200 MHz antenna
Electromagnetic Induction (EMI)	Frequency domain EMI: Geonics Limited, EM31 Ground Conductivity Meter with Wescor, Inc., Polycorder 720.
Total Magnetic Field	Geometrics, Inc., G-858/G Cesium Vapor Magnetometer/Gradiometer
Data Collection and Processing Parameters	
Grid location control and data collection lines	Base grid staked at 30 m centers by Fluor personnel using Global Positioning System instruments and coordinates supplied by North Wind, which were based on Hanford Site Drawing H-2-75149. The overall base grid is combined with the 218-W-2 Burial Ground site. The dimensions for the 218-W-1 Burial Ground extended 150 m N-S, 180 m E-W, from geophysical coordinates N250 to N400 and from E100 to E280; data collection lines were flagged at 6 m centers in East-West and North-South direction along base grid nodes.
SIR-10A	Data were collected with the antenna towed behind a 4 x 6 all-terrain vehicle (Gator Utility Vehicle [1]). Marks were placed in the data as the instrument passed position flags or stakes. Data were stacked (2 signals), recording window 108 ns, gains and filters set in field to match soil conditions. Hard copy plots of data were printed in the office on a thermal printer for interpretation. Two East-West profiles and two North-South profiles were collected along each 30 m baseline. Additional North-South profiles were collected roughly every 6-12 m between the bases. Numerous East-West profiles were collected down the estimated center line of trenches depicted from the EM31 and/or magnetic data.

[1] Gator Utility Vehicle is a trademark of John Deere & Company, Moline, Illinois.

Geophysical Investigation Summary Sheet	
EM31	Data were collected at hip height in the vertical dipole mode on 1.5 m station spacing and 3 m line spacing on North-South oriented lines. Data were downloaded from the Polycorder and written to a .xyz data file using Geonics DAT31.exe. Corrections of position errors during data collection (if any) are made in standard spreadsheet software such as Microsoft Excel [2]. Data were gridded and plotted using Surfer [3]. Cell size for data plots is nominally 3 m (cross line) x 1.5 m (down line). --- [2] Excel is a trademark of Microsoft Corporation, Redmond, Washington. [3] Surfer is a trademark of Golden Software, Inc., Golden, Colorado.
G-858/G	Data were collected with sensors 0.5 and 1.5 m above the ground in continuous sampling mode, with samples recorded every 0.5 seconds (nominal 0.5 m data spacing), and fiducial positioning marks placed every 30 m, on lines spaced 3 m apart. Data were collected in the North-South direction with the sensors oriented East-West at a 45-degree angle to the horizon. Data were downloaded from the field instrument, filtered for spikes and dropouts (if any), corrected for position errors (if any), and written to a .xyz file using Geometrics, Inc., MagMapper2000.exe. Data were gridded and plotted using Surfer. Grid cell size for the data plots is nominally 3 m (cross line) x 0.5 m (down line).
Results	
Data Discussion	Refer to data plots A5-1 through A5-4 and Table A5-1 for the following discussion. The magnetic data produced anomalies that appear to be from ferrous metallic debris buried in the trenches, as well as basalt rich fill material that was used to fill in the trenches, or perhaps as added fill to parts of the burial ground. The Columbia River Basalt that dominates the region often is high in iron and influences magnetic data when the soil is rich in basalt, and more so when the soils are compacted. The EMI data mapped pockets of metallic debris as well as changes in the conductivity of the soil. The in-phase data best reflected where the metallic debris is buried in the trenches. The conductivity data show the variable soil conditions across the site and show where the largest pockets of conductive (most often metallic) debris are located. The GPR data were effective at mapping the trench boundaries when the trenches had space between them. The GPR data also indicate that much of the debris was buried 2 m or more below the surface, although in several areas the debris anomalies are much shallower. Because of the reconnaissance nature of the investigations, and space between profiles, many of the debris anomalies have not been discretely mapped.

Geophysical Investigation Summary Sheet	
Interpretation	Interpretation of the geophysical data indicates pockets of debris in each of the identified trenches. Discrete concentrations of metallic waste were identified in most of the trenches. Nonmetallic waste is interpreted to be mixed with the metallic waste. Most of the waste is at least 1 to 2 m deep and occasionally deeper. It is possible that there is more debris in the trenches than was detected in the data and plotted on the interpretation map. Most of the trenches were clearly evident in the data, with the exception of Trenches 1, 1A, 4A, and 6. These four trenches lack even subtle anomalies; therefore, their existence cannot be confirmed. Based on Hanford Site Drawing H-2-75149, trench series 1 through 6 were designed to be about 2.5 m deep with about 1.3 m separation. Given the proximity of the trenches in the 1 through 6 series, it is quite possible that trenches may have been constructed and may not be apparent in the geophysical data. They may have been opened and backfilled with similar soils or never opened. According to the drawing, trenches 7 and 8 are separated by 1 m. These trenches were mapped, although the boundary between them could not be distinguished. Three East-West-oriented trenches were identified that are not shown on drawing H-2-75149. They are north of the northernmost trench shown on the drawing (Trench 9) and south of the 218-W-11 Burial Ground. They have characteristics similar to those in the other trenches in the 218-W-1 Burial Ground. Additionally, two pit-like areas not shown on the drawing also were identified in this northern area; one of these has significant metallic content (N360/E241).
Lessons learned	The site is sufficiently large that local variability in soil/geologic conditions affected the background character of the data. GPR often is the best tool at the Hanford Site for mapping trenches and nonmetallic waste. A very detailed GPR survey, using more closely spaced profiles, likely would have enhanced the detection of some of the boundaries of the trenches. An approach that would improve the success in locating and mapping the trenches and contained debris would be to supplement the geophysics with test pits/trenches. The pits would help in understanding the geophysical signature that these subtle features produce, thus making it easier to identify and map.

Table A5-1. Summary of Results from Burial Ground 218-W-1, 200 West Area. (3 Pages)

Best Trench Correlation, Based on Drawing H-2-75149, Rev. 1	Approx. Center of Trench, Based on Geophysical Data	Approx. Ends of Trench, Based on Geophysical Data	Documented Waste Type	Approx. Center of Trench, Based on Drawing H-2-75149, Rev. 1	Approx. Ends of the Trench, Based on Drawing H-2-75149, Rev. 1	Comments
1	Not Determined	Not Determined	Dry Waste	N268	E132 – E206	No clear evidence of the trench. Subtle indications of disturbed ground might indicate some nonmetallic debris if the trench were opened.
1A	Not Determined	Not Determined	Dry Waste	N268	E210 – E282	No clear evidence of the trench. Subtle indications of disturbed ground might indicate some nonmetallic debris if the trench were opened.
3	N274	E133 – E208	Dry Waste	N274	E132 – E206	Good correlation between the geophysical data and the documented location and length of the trench. Geophysical data suggest a mix of metallic and nonmetallic waste. Center of anomalies corresponds with documented trench dimensions. Clear break between Trench 3 and 3A.
3A	Not Determined	Not Determined	Dry Waste	N274	E210 – E282	Only subtle indications of disturbed ground in the documented trench location. No notable metallic anomalies. Ground-penetrating radar indicates some "soft" debris at about 1.5 to 2 m depth. The western third of the trench is void of anomalies.
5	N280	E142 – E205	Dry Waste	N280	E132 – E206	Good correlation between the geophysical data and the documented location and length of the trench. Geophysical data suggest a mix of metallic and nonmetallic waste, with several strong metallic anomalies.
5A	Not Determined	Not Determined	Dry Waste	N280	E210 – E282	Only subtle indications of disturbed ground in the documented trench location. No notable metallic anomalies. Ground-penetrating radar indicates some "soft" debris at about 1.5 to 2 m depth. The western third of the trench is void of anomalies.
6	Not Determined	Not Determined	Dry Waste	N292	E132 – E206	No geophysical indication of excavation boundaries or buried debris.
6A	N292	E214 – E282	Dry Waste	N292	E210 – E282	Good correlation between the geophysical data and the documented location and length of the trench. The only recognizable anomalies are at the ends of the trench and indicate strong metallic/ferrous material. The anomaly centered at N291/E277 appears rectangular/square in shape.
4	N300	Not Determined	Dry Waste	N298	E157 – E206	The trench boundaries cannot be identified readily in the geophysical data. The only observed anomalies, ferrous in character with ground-penetrating radar depths on the order of 2 m, are at/near the ends of the documented trench. Therefore, the trench ends are inferred. A shallow, 0.8 m disturbed zone is noted west of the inferred trench end and may correlate with a ramp into the trench?

Table A5-1. Summary of Results from Burial Ground 218-W-1, 200 West Area. (3 Pages)

Best Trench Correlation, Based on Drawing H-2-75149, Rev. 1	Approx. Center of Trench, Based on Geophysical Data	Approx. Ends of Trench, Based on Geophysical Data	Documented Waste Type	Approx. Center of Trench, Based on Drawing H-2-75149, Rev. 1	Approx. Ends of the Trench, Based on Drawing H-2-75149, Rev. 1	Comments
4A	Not Determined	Not Determined	Dry Waste	N298	E210 – E282	Minimal geophysical evidence for this trench. No clear excavation boundaries are observed, although the adjacent trenches easily can overlap because of the minimal spacing between trenches.
2	N294	E157 – E202	Dry Waste	N304	E157 – E206	Good correlation between the geophysical data and the documented location and length of the trench. Geophysical data suggest a mix of metallic and nonmetallic waste, with several strong metallic anomalies. Most anomalies are on the order of 2 m below the surface.
2A	N304	E210 – E280	Dry Waste	N304	E210 – E282	Good correlation between the geophysical data and the documented location and length of the trench. Geophysical data suggest a mix of metallic and nonmetallic waste, with several strong metallic anomalies. Depth to anomalies varies from 1 to 2 m below the surface.
7	N314	E133 – E274	Dry Waste	N314	E132 – E282	Good correlation between the geophysical data and the documented location, width, and length of the trench. Geophysical data suggest a mix of metallic and nonmetallic waste.
8	N322	E136 - E271	Dry Waste	N322	E132 – E282	Good correlation between the geophysical data and the documented location, width, and length of the trench. Geophysical data suggest a mix of metallic and nonmetallic waste. A strong metallic anomaly(s) was detected about 2.5 m below the surface, centered at E200.
9	N350	E133 – ~E280	Dry Waste	N350	E132 – E282	Good correlation between the geophysical data and the documented location, width, and length of the trench. Geophysical data suggest a mix of metallic and nonmetallic waste. The western half of the trench is dominated by metallic features, and the eastern half appears to be dominated more by nonmetallic waste.
Undocumented	N360	E142 – E205	Unknown	Unknown	Unknown	Geophysical data suggest a mix of metallic and nonmetallic waste, although most of the anomalies are subtle, with minimal ground-penetrating radar debris character.
Undocumented	N372	E136 – ~E250	Unknown	Unknown	Unknown	Trench boundaries are relatively well defined from E136 to E250. Geophysical data suggest a mix of metallic and nonmetallic waste. Minimal ferrous/metallic debris is noted from E196 to E250.
Undocumented	N384	E133 – E226	Unknown	Unknown	Unknown	Trench boundaries are relatively well defined from E142 to E220. Geophysical data suggest a mix of metallic and nonmetallic waste.

Table A5-1. Summary of Results from Burial Ground 218-W-1, 200 West Area. (3 Pages)

Best Trench Correlation, Based on Drawing H-2-75149, Rev. 1	Approx. Center of Trench, Based on Geophysical Data	Approx. Ends of Trench, Based on Geophysical Data	Documented Waste Type	Approx. Center of Trench, Based on Drawing H-2-75149, Rev. 1	Approx. Ends of the Trench, Based on Drawing H-2-75149, Rev. 1	Comments
Undocumented	Pit centered at N360/E241	NA	Unknown	Unknown	Unknown	Pit-like anomaly, about 12 m in diameter. The anomaly is dominated by metallic/ferrous material. Depths vary from 0.5 to over 2 m below the surface. This feature could be associated with the trench mapped along N360, but likely is a standalone feature caused by interpreted excavation boundaries on the west side of the feature.
Undocumented	Pit centered at N388/E254	NA	Unknown	Unknown	Unknown	Pit-like anomaly, irregularly shaped. This anomaly could be related to the trench mapped along N384, or could be a separate burial feature.

Figure A5-1. Geophysical Investigation Results, 218-W-1 Burial Ground, 200 West Area, June 2006.

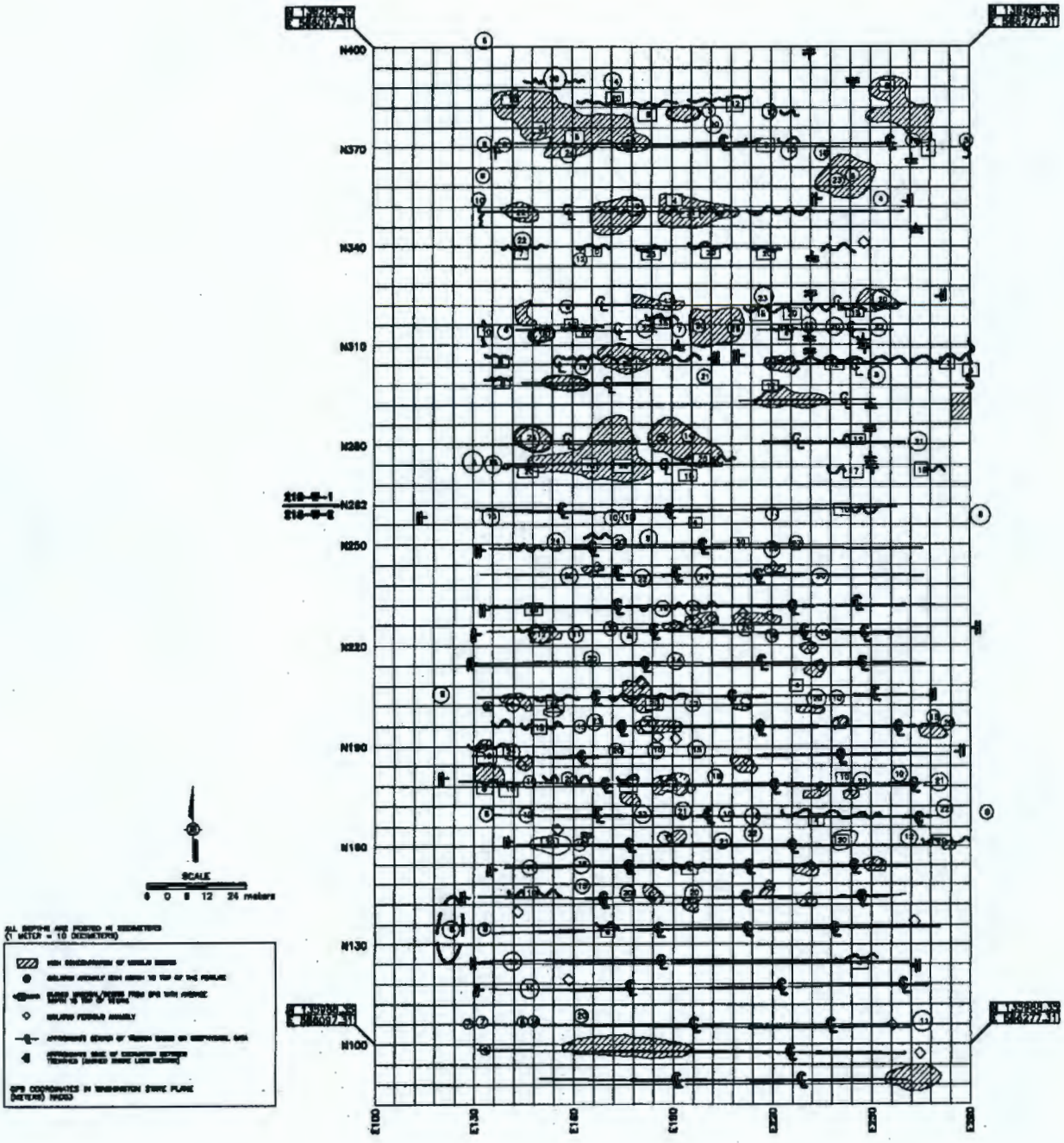


Figure A5-2. Electromagnetic Induction (EM31) Ground Conductivity Data, 218-W-1 Burial Ground, 200 West Area, June 6, 2006.

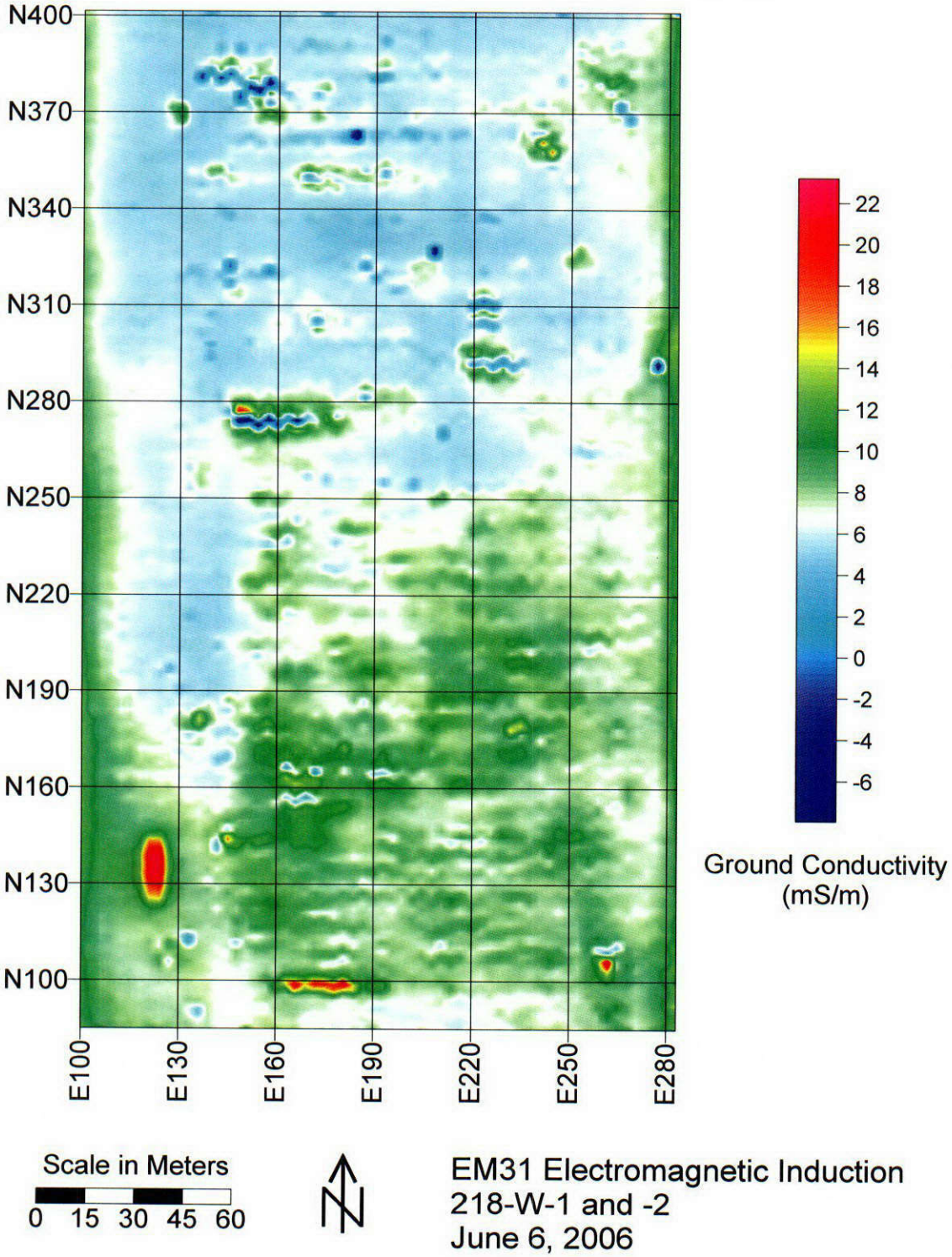


Figure A5-3. Electromagnetic Induction (EM31) In-Phase Data, 218-W-1 Burial Ground, 200 West Area, June 6, 2006.

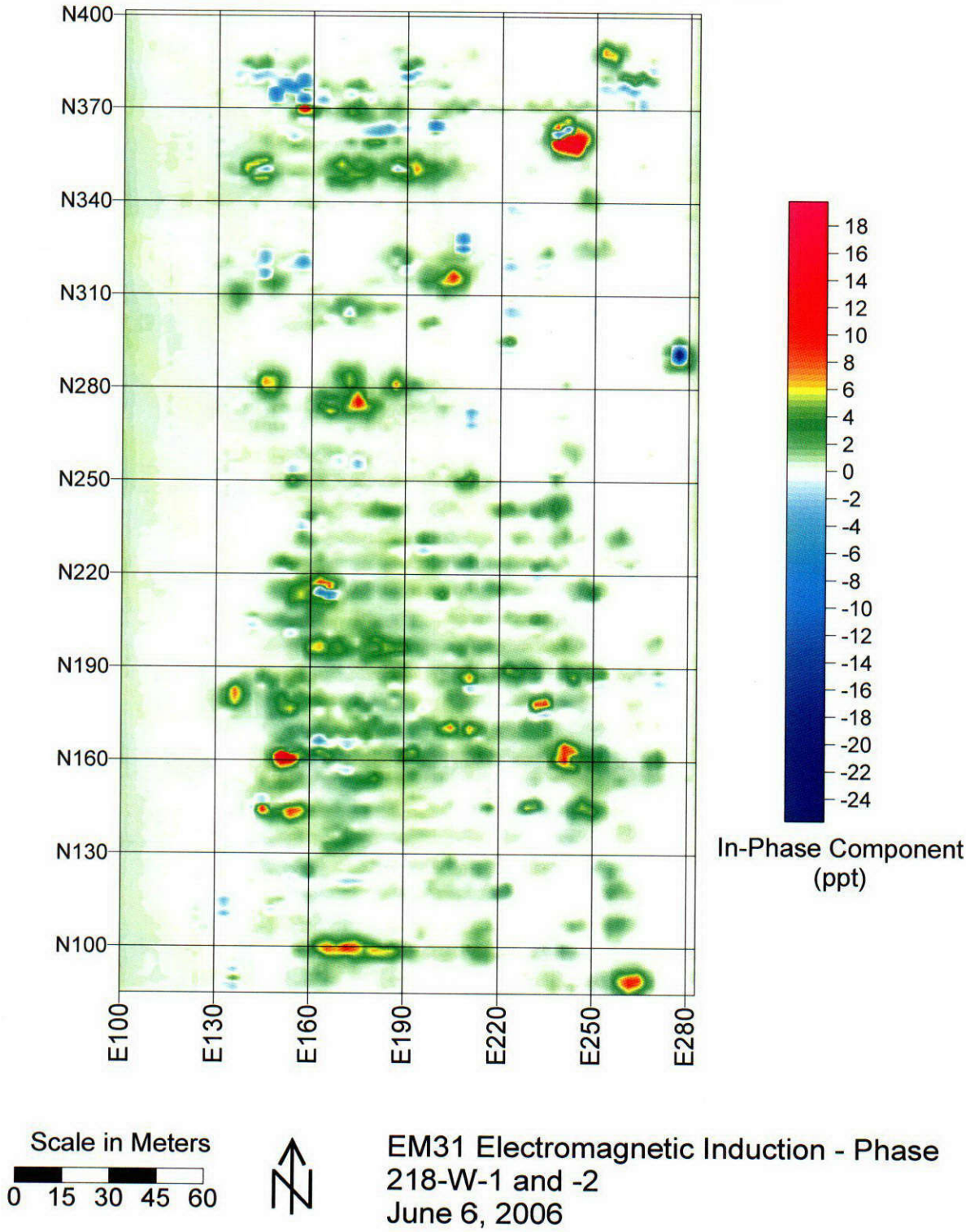
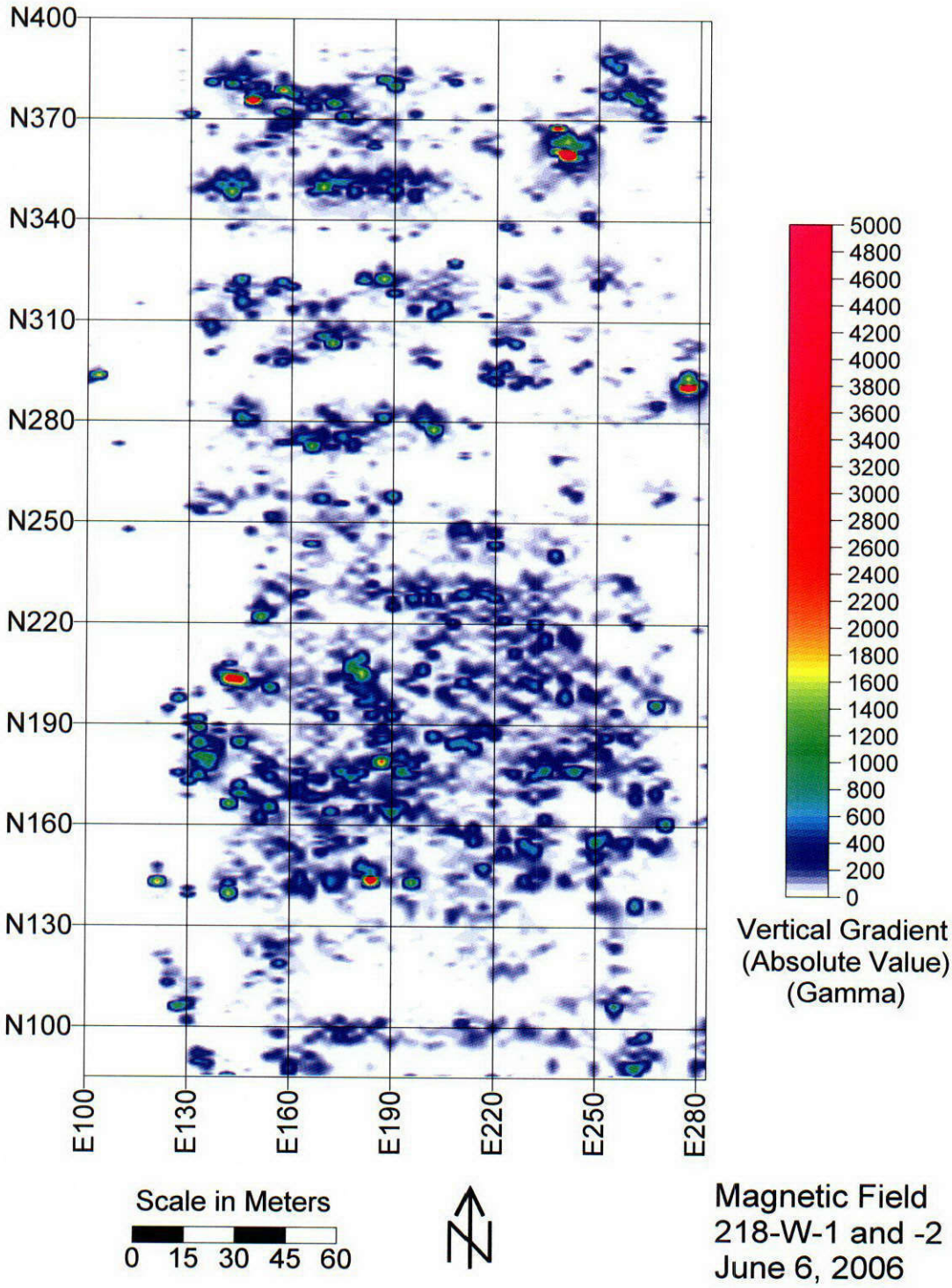


Figure A5-4. Total Magnetic Field (G-858/G) Data, 218-W-1 Burial Ground, 200 West Area, June 6, 2006.



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A6.0 218-W-2 BURIAL GROUNDS GEOPHYSICAL INVESTIGATION SUMMARY AND DATA PLOTS

Geophysical Investigation Summary Sheet	
Site Name	218-W-2 Burial Ground
Location	200 West Area
Approximate size	180 m x 180 m (~7 acres)
Burial Ground Information	Per Hanford Site Drawing H-2-2503, this burial ground contains 20 documented East-West trenches of similar length and width.
Terrain	Generally flat throughout the site.
Vegetation/ground cover	Variable vegetation, ranging from little to immature thick Russian thistle to scattered bunch grass and cheat grass. The soil typically was gravelly sand.
Hydrological properties	Surface relatively dry at time of data collection, although heavy rains fell a few days before data collection.
Limitations/obstacles	None
Overall assessment for geophysical investigation	Electromagnetic induction and magnetic methods were the most effective at meeting project objectives. GPR data quality varied from average to good.
Equipment	
Ground Penetrating Radar (GPR)	Geophysical Survey Systems, Inc., SIR-10A GPR system with 200 MHz antenna
Electromagnetic Induction (EMI)	Frequency domain EMI: Geonics Limited, EM31 Ground Conductivity Meter with Wescor, Inc., Polycorder 720.
Total Magnetic Field	Geometrics, Inc., G-858/G Cesium Vapor Magnetometer/Gradiometer
Data Collection and Processing Parameters	
Grid location control and data collection lines	Base grid staked at 30 m centers by Fluor personnel using Global Positioning System instruments with coordinates supplied by North Wind, which were based on Hanford Site Drawing H-2-2503. The overall base grid is combined with the 218-W-1 Burial Ground site. The dimensions for the 218-W-2 Burial Ground extended 180 m N-S, 180 m E-W, from geophysical coordinates ~N83 to N263 and from E100 to E280; data collection lines were flagged at 6 m centers in East-West and North-South direction along base grid nodes.
SIR-10A	Data were collected with the antenna towed behind a 4 x 6 all-terrain vehicle (Gator Utility Vehicle [1]). Marks were placed in the data as the instrument passed position flags or stakes. Data were stacked (2 signals), recording window 108 ns, gains and filters set in field to match soil conditions. Hard copy plots of data were printed in the office on a thermal printer for interpretation. Two East-West profiles and two North-South profiles were collected along each 30 m baseline. Additional North-South profiles were collected roughly every 6-12 m between the bases. Numerous East-West profiles were collected down the estimated center line of trenches depicted from the EM31 and/or magnetic data. [1] Gator Utility Vehicle is a trademark of John Deere & Company, Moline, Illinois.

Geophysical Investigation Summary Sheet	
EM31	Data were collected at hip height in the vertical dipole mode on 1.5 m station spacing and 3 m line spacing on North-South oriented lines. Data were downloaded from the Polycorder and written to a .xyz data file using Geonics DAT31.exe. Corrections of position errors during data collection (if any) are made in standard spreadsheet software such as Microsoft Excel [2]. Data were gridded and plotted using Surfer [3]. Cell size for data plots is nominally 3 m (cross line) x 1.5 m (down line). ---------- [2] Excel is a trademark of Microsoft Corporation, Redmond, Washington. [3] Surfer is a trademark of Golden Software, Inc., Golden, Colorado.
G-858/G	Data were collected with sensors 0.5 and 1.5 m above the ground in continuous sampling mode, with samples recorded every 0.5 seconds (nominal 0.5 m data spacing), and fiducial positioning marks placed every 30 m, on lines spaced 3 m apart. Data were collected in the North-South direction with the sensors oriented East-West at a 45-degree angle to the horizon. Data were downloaded from the field instrument, filtered for spikes and dropouts (if any), corrected for position errors (if any), and written to a .xyz file using Geometrics, Inc., MagMapper2000.exe. Data were gridded and plotted using Surfer. Grid cell size for the data plots is nominally 3 m (cross line) x 0.5 m (down line).
Results	
Data Discussion	Refer to data plots A6-1 through A6-4 and Table A6-1 for the following discussion. The magnetic data produced anomalies that appear to be from ferrous metallic debris buried in the trenches, as well as basalt-rich fill material that was used to fill in the trenches, or perhaps as added fill to parts of the burial ground. The Columbia River Basalt that dominates the region often is high in iron and influences magnetic data when the soil is rich in basalt, and more so when the soils are compacted. The EMI data mapped pockets of metallic debris as well as changes in the conductivity of the soil. The in-phase data best reflected where the metallic debris is buried in the trenches. The conductivity data show the variable soil conditions across the site and show where the largest pockets of conductive (most often metallic) debris are located. The GPR data were effective at mapping the trench boundaries when the trenches had space between them. The GPR data also indicate that much of the debris was buried 2 m or more below the surface, although in several areas the anomalies from debris are much shallower. Because of the reconnaissance nature of the investigations, and space between profiles, many of the anomalies have not been discretely mapped.

Geophysical Investigation Summary Sheet	
Interpretation	Interpretation of the geophysical data indicates that pockets/zones of debris are located and mapped in each of the identified trenches. Discrete concentrations of metallic waste were identified in most of the trenches. Nonmetallic waste is interpreted to be mixed with the metallic waste. The vast majority of the anomalies are greater that 1 m below the surface and more typically 1.5 to 2+ m deep. It is possible that there is more debris in the trenches than was detected in the data and plotted on the interpretation map. All twenty of the trenches shown on Hanford Site Drawing H-2 2503 were clearly evident in the data. They all are generally the same length and width as shown on the drawing. Some of the trench centerlines, from the geophysics, are a few meters different than the drawing indicates, but the geophysics centerlines are based on debris concentrations and not necessarily on the actual trench opening. Individual discussions for each trench are included in Table A6-1.
Lessons learned	The site is sufficiently large that local variability in soil/geologic conditions affected the background character of the data. GPR often is the best tool at the Hanford Site for mapping trenches and nonmetallic waste. A very detailed GPR survey, using more closely spaced profiles, might enhance the detection of some of the boundaries of the trenches.

Table A6-1. Summary of Results from Burial Ground 218-W-2, 200 West Area. (3 Pages)

Best Trench Correlation, Based on Drawing H-2-2503, Rev. 3	Approx. Center of Trench, Based on Geophysical Data	Approx. Ends of Trench, Based on Geophysical Data	Documented Waste Type	Approx. Center of Trench, Based on Drawing H-2-2503, Rev. 3	Approx. Ends of Trench from Drawing H-2-2503, Rev. 3	Comments
1	N260	~E130 – E283	Dry Waste	N258	E136 – E283	Good correlation between the geophysical data and the documented location, width, and length of the trench. Geophysical data suggest a mix of metallic and nonmetallic waste. Minimal recognizable debris from E190 to E280.
4	N249	E130 – E280	Dry Waste	N249	E136 – E283	Good correlation between the geophysical data and the documented location, width, and length of the trench. Geophysical data suggests a mix of metallic and nonmetallic waste, with the primary concentration from E154 to E220. Minimal recognizable debris east of E220.
6	N241	E130 – ~E283	Dry Waste	N240	E136 – E283	Good correlation between the geophysical data and the documented location, width, and length of the trench. Geophysical data suggest a mix of metallic and nonmetallic waste, with the primary concentration from E154 to E244.
7	N232	E133 – ~E277	Dry Waste	N231	E136 – E283	Good correlation between the geophysical data and the documented location, width, and length of the trench. Geophysical data suggest a mix of metallic and nonmetallic waste, with the primary concentration from E142 to E262.
8	N224	E130 – E280	Dry Waste	N222	E136 – E283	Good correlation between the geophysical data and the documented location, width, and length of the trench. Geophysical data suggest a mix of metallic and nonmetallic waste, with the primary concentration from E142 to E262.
9	N211	E127 – E270	Dry Waste	N213	E136 – E283	Good correlation between the geophysical data and the documented location, width, and length of the trench. Geophysical data suggest a mix of metallic and nonmetallic waste, with the primary concentration from E145 to E250.
10	N205	E130 – Unknown	Dry Waste	N204	E136 – E283	Good correlation between the geophysical data and the documented location, width, and length of the trench. Geophysical data suggest a mix of metallic and nonmetallic waste, with the primary concentration from E136 to E268.
11	N196	E127 – E283	Dry Waste	N195	E136 – E283	Good correlation between the geophysical data and the documented location, width, and length of the trench. Geophysical data suggest a mix of metallic and nonmetallic waste, with the primary concentration from E127 to E273.
12	N186	E122 – E280	Dry Waste	N186	E136 – E283	Good correlation between the geophysical data and the documented location, width, and length of the trench. Geophysical data suggest a mix of metallic and nonmetallic waste, with the primary concentration from E130 to E274.

Table A6-1. Summary of Results from Burial Ground 218-W-2, 200 West Area. (3 Pages)

Best Trench Correlation, Based on Drawing H-2-2503, Rev. 3	Approx. Center of Trench, Based on Geophysical Data	Approx. Ends of Trench, Based on Geophysical Data	Documented Waste Type	Approx. Center of Trench, Based on Drawing H-2-2503, Rev. 3	Approx. Ends of Trench from Drawing H-2-2503, Rev. 3	Comments
13	N178	E130 – E280	Dry Waste	N177	E136 – E283	Good correlation between the geophysical data and the documented location, width, and length of the trench. Geophysical data suggest a mix of metallic and nonmetallic waste, with the primary concentration from E130 to E268.
14	N169	E133 – Unknown	Dry Waste	N168	E136 – E283	Good correlation between the geophysical data and the documented location, width, and length of the trench. Geophysical data suggest a mix of metallic and nonmetallic waste, with the primary concentration from E142 to E272.
15	N161	E135 – ~E280	Dry Waste	N159	E136 – E283	Good correlation between the geophysical data and the documented location width, and length of the trench. Geophysical data suggest a mix of metallic and nonmetallic waste, with the primary concentration from E145 to E274.
16	N153	E133 – ~E283	Dry Waste	N150	E136 – E283	Good correlation between the geophysical data and the documented location width, and length of the trench. Geophysical data suggest a mix of metallic and nonmetallic waste, with the primary concentration from E139 to E271.
17	N144	E127 – E280	Dry Waste	N141	E136 – E283	Good correlation between the geophysical data and the documented location width, and length of the trench. Geophysical data suggest a mix of metallic and nonmetallic waste, with the primary concentration from E139 to E256.
Anomaly outside of the trench design	E122	N124 – N145	NA	NA	NA	North-south pit/trench west of the designed trenches. The geophysical data do not indicate significant metallic material in the anomalous zone. Ground-penetrating radar indicates a feature at about 0.8 to 1 m below the surface at N135/E123.
18	N135	E133 – E283	Dry Waste	N133	E136 – E283	Good correlation between the geophysical data and the documented location, width, and length of the trench. Minimal metallic and ferrous debris throughout the trench.
19	N126	E130 – E280	Dry Waste	N124	E136 – E283	Good correlation between the geophysical data and the documented location, width, and length of the trench. Minimal metallic and ferrous debris throughout the trench.
20	N116	E130 – E283	Dry Waste	N114	E136 – E283	Good correlation between the geophysical data and the documented location, width, and length of the trench. Geophysical data suggest a mix of metallic and nonmetallic waste, with the primary concentration from E130 to E274.
3	N106	Not Determined	Dry Waste	N106	E136 – E283	Good correlation between the geophysical data and the documented location, width, and length of the trench. Metallic and ferrous debris are concentrated near the ends of the trench. No clear evidence of debris from ~E175 to E240.

Table A6-1. Summary of Results from Burial Ground 218-W-2, 200 West Area. (3 Pages)

Best Trench Correlation, Based on Drawing H-2-2503, Rev. 3	Approx. Center of Trench, Based on Geophysical Data	Approx. Ends of Trench, Based on Geophysical Data	Documented Waste Type	Approx. Center of Trench, Based on Drawing H-2-2503, Rev. 3	Approx. Ends of Trench from Drawing H-2-2503, Rev. 3	Comments
5	N98	Not Determined	Dry Waste	N97	E136 – E283	Good correlation between the geophysical data and the documented location, width, and length of the trench. Multiple, large metallic anomalies between E160 and E185.
2	N90	Not Determined	Dry Waste	N87	E136 – E283	Good correlation between the geophysical data and the documented location, width, and length of the trench. The central portion of the trench has minimal anomalies. A large metallic/ferrous anomaly at ~E272 near the eastern end of the trench.

Figure A6-1. Geophysical Investigation Results, 218-W-2 Burial Grounds, 200 West Area, June 2006.

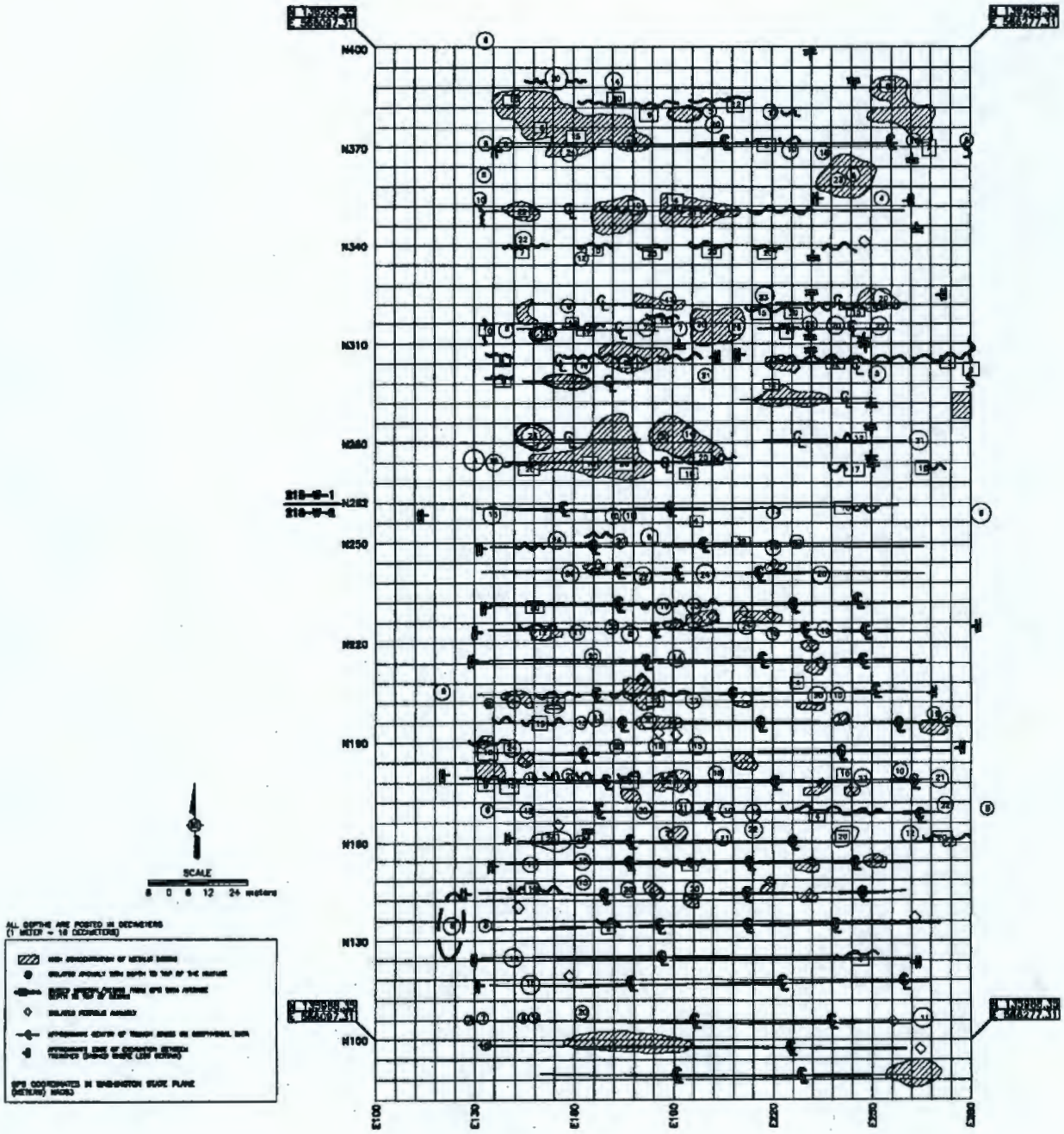


Figure A6-2. Electromagnetic Induction (EM31) Ground Conductivity Data, 218-W-2 Burial Grounds, 200 West Area, June 6, 2006.

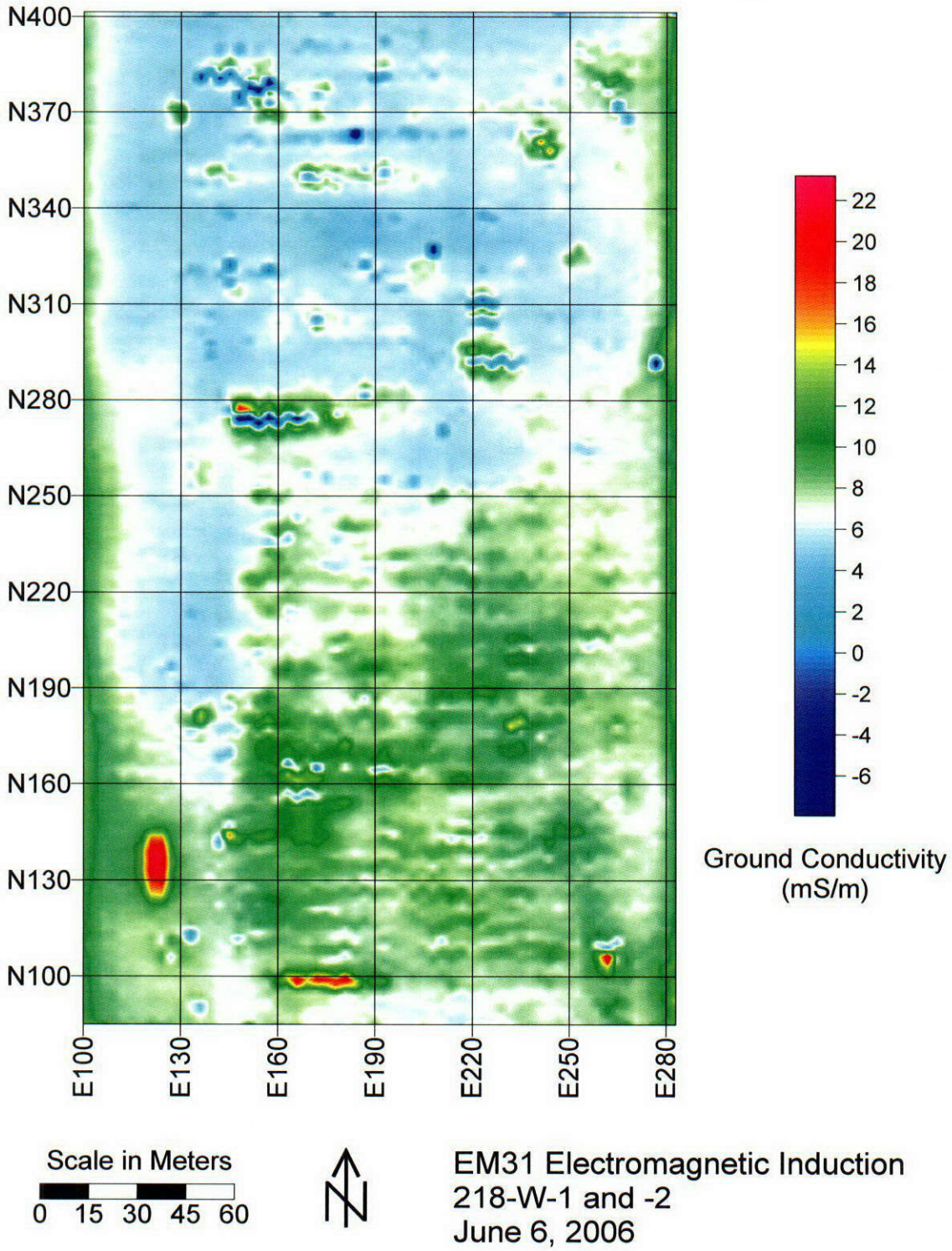


Figure A6-3. Electromagnetic Induction (EM31) In-Phase Data, 218-W-2 Burial Grounds, 200 West Area, June 6, 2006.

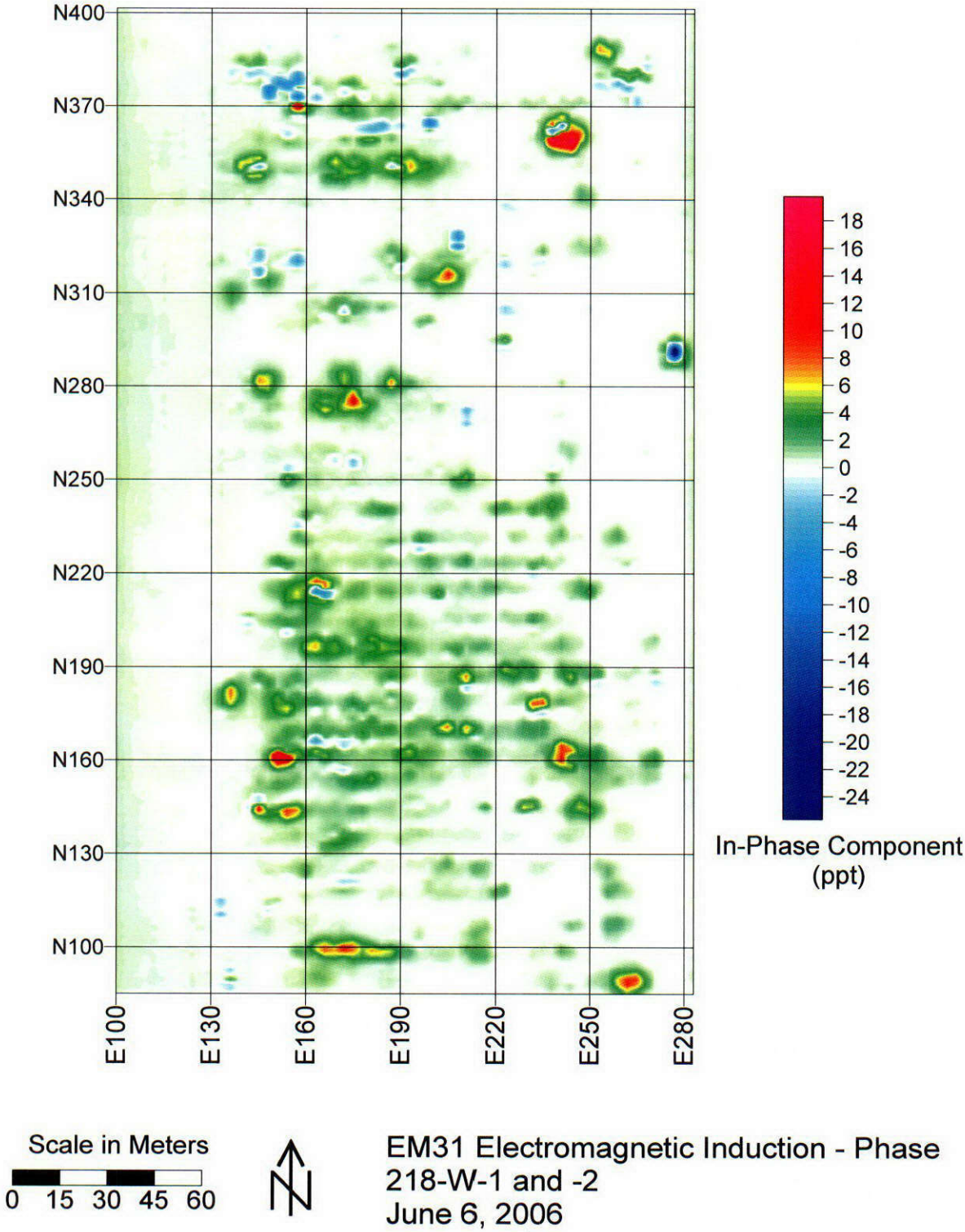
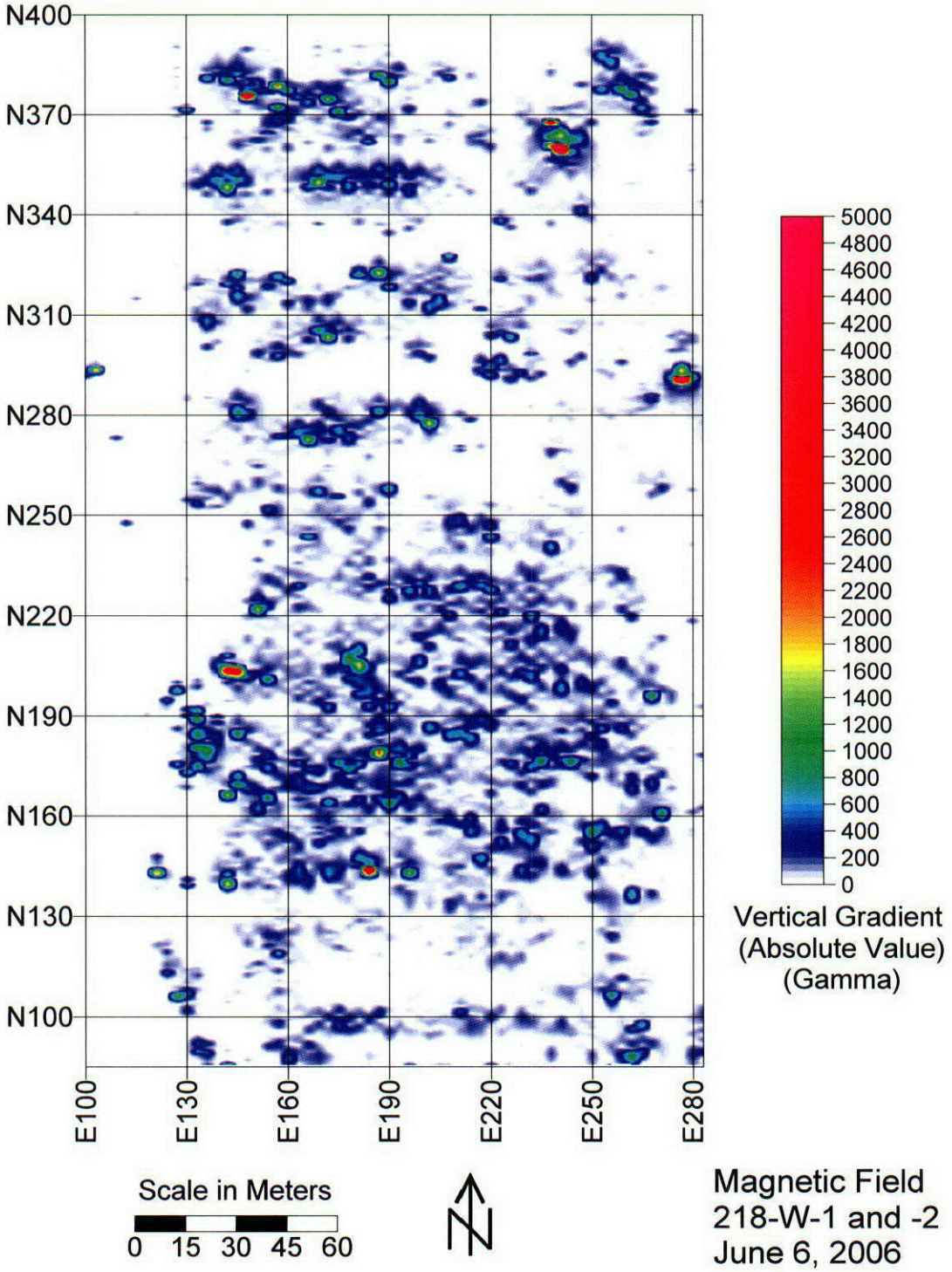


Figure A6-4. Total Magnetic Field (G-858/G) Data,
218-W-2 Burial Grounds, 200 West Area, June 6, 2006.



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A7.0 218-W-3 BURIAL GROUND GEOPHYSICAL INVESTIGATION SUMMARY AND DATA PLOTS

Geophysical Investigation Summary Sheet	
Site Name	218-W-3 Burial Ground
Location	200 West Area
Approximate size	210 m x 180 m (~8.2 acres)
Burial Ground Information	Per Hanford Site Drawing H-2-32095, this burial ground contains 20 East-West-oriented trenches approximately 153 m (500 ft) long.
Terrain	Generally flat, some low (<1 m) surface undulations in places
Vegetation/ground cover	No vegetation. Silty gravel surface material, with some sand.
Hydrological properties	Surface dry at time of data collection. Rain event approximately 1 week before data collection.
Limitations/obstacles	No significant limitations or obstacles.
Overall assessment for geophysical investigation	Data were adequate to meet project objectives.
Equipment	
Ground Penetrating Radar (GPR)	Geophysical Survey Systems, Inc., SIR-10A GPR system with 200 MHz antenna
Electromagnetic Induction (EMI)	Frequency domain EMI: Geonics Limited, EM31 Ground Conductivity Meter with Wescor, Inc., Polycorder 720.
Total Magnetic Field	Geometrics, Inc., G-858/G Cesium Vapor Magnetometer/Gradiometer
Data Collection and Processing Parameters	
Grid location control and data collection lines	Base grid staked at 30 m centers by Fluor personnel using Global Positioning System instruments and coordinates supplied by North Wind, which were based on Hanford Site Drawing H-2-32095. Data collection lines were flagged at 6 m centers in East-West direction along base grid.
SIR-10A	Data were collected with the antenna towed behind a 4 x 6 all-terrain vehicle (Gator Utility Vehicle [1]). Marks were placed in the data as the instrument passed position flags or stakes. Data were stacked (2 signals), recording window 108 ns, gains and filters set in field to match soil conditions. Hard copy plots of data were printed in the office on a thermal printer for interpretation. [1] Gator Utility Vehicle is a trademark of John Deere & Company, Moline, Illinois.
EM31	Data were collected at hip height in the vertical dipole mode on 1.5 m station spacing and 3 m line spacing on North-South-oriented lines. Data were downloaded from the Polycorder and written to a .xyz data file using Geonics DAT31.exe. Corrections of position errors during data collection (if any) are made in standard spreadsheet software such as Microsoft Excel [2]. Data were gridded and plotted using Surfer [3]. Cell size for data plots is nominally 3 m (cross line) x 1.5 m (down line). [2] Excel is a trademark of Microsoft Corporation, Redmond, Washington. [3] Surfer is a trademark of Golden Software, Inc., Golden, Colorado.

Geophysical Investigation Summary Sheet	
G-858/G	Data were collected with sensors 0.5 and 1.5 m above the ground in continuous sampling mode with samples recorded every 0.5 seconds (nominal 0.5 m data spacing), and fiducial positioning marks placed every 30 m, on lines spaced 3 m apart. Data were collected in North-South direction with the sensors oriented East-West at a 45-degree angle to the horizon. Data were downloaded from the field instrument, filtered for spikes and dropouts (if any), corrected for position errors (if any), and written to a .xyz file using Geometrics, Inc., MagMapper2000.exe. Data were gridded and plotted using Surfer. Grid cell size for the data plots is nominally 3 m (cross line) x 0.5 m (down line).
Results	
Data Discussion	Refer to data plots A7-1 through A7-4 and Table A7-1 for the following discussion. EMI and magnetic data show low-to-moderate amplitude anomalies aligned generally in an East-West trend across the site. Relatively few high-amplitude EMI and magnetic anomalies are scattered throughout the site. Large areas of the site show no EMI and/or magnetic anomalies. Along the eastern edge of the site, the EMI and magnetic data depict a North-South alignment of anomalies. It is possible that this trend of anomalies is an artifact in the data caused by a geophysical response to a gravel road that is located near the ends of the East-West trenches. The anomalies in the GPR data are typically in groups, approximately greater than 1 m deep and aligned with the East-West EMI and magnetic anomalies. The GPR data also show a North-South trend of anomalies along the eastern edge of the investigation area, which correlates with the other methods.
Interpretation	Fourteen East-West-oriented trenches were identified in the geophysical data. This number could be slightly greater or smaller, depending on the subtle identification of the boundaries. All of the trenches have varying amounts of metallic debris. The trenches appear to be in groups of 2 to 3, with very little space between them, making the distinction of individual trenches within the groups difficult. One North-South-oriented trench is interpreted along the eastern edge of the site, although this may be an artifact in the data caused by the gravel road located here. All of the debris within the trenches appears to be buried greater than 1 m, some up to 2 m deep. The southeastern corner of this survey extended into the 218-W-2A Burial Ground. A portion of Trench 1 of the 218-W-2A Burial Ground was detected and plotted.

Table A7-1. Summary of Results from Burial Ground 218-W-3, 200 West Area. (3 Pages)

Trench Number as Shown on Figure A7-1	Approx. Center of Trench, based on Geo-physical Data	Approx. Ends of Trench, Based on Geo-physical Data	Documented Waste Type	Approx. Center of Trench, Based on Drawing H-2-32095	Approx. Ends of the Trench, Based on Drawing H-2-32095	Comments
A	N107	E148 – E250	Dry Waste	NA	NA	Reasonable correlation between the geophysical data and the documented centerline of Trench 1 from the drawing. Geophysical data suggest a mix of metallic and nonmetallic waste. Large ferrous metal object(s) at E196, E210, and E235.
B	N118	E154 – E250	Dry Waste	NA	NA	The trench interpreted from the geophysical data appears to have an irregular centerline. It may be that there are two closely spaced trenches that could not be distinguished in the data. Geophysical data suggest a mix of metallic and nonmetallic waste. Large ferrous metal object(s) at E178 and E214.
C	N150	E118 – E250	Dry Waste	NA	NA	Trenches C through N interpreted from the geophysical data do not have regular spacing and therefore cannot be directly correlated with trench locations as shown on Hanford Site Drawing H-2-32095. Geophysical data suggest a mix of metallic and nonmetallic waste. Large ferrous metal object(s) at E122 and E232; otherwise very little ferrous material in this trench.
D	N164	E118 – E250	Dry Waste	NA	NA	Trenches C through N interpreted from the geophysical data do not have regular spacing and therefore cannot be directly correlated with trench locations as shown on Hanford Site Drawing H-2-32095. Geophysical data suggest a mix of metallic and nonmetallic waste. Ferrous metal objects located throughout the length of this trench.
E	N175	E118 – E250	Dry Waste	NA	NA	Trenches C through N interpreted from the geophysical data do not have regular spacing and therefore cannot be directly correlated with trench locations as shown on Hanford Site Drawing H-2-32095. Geophysical data suggest a mix of metallic and nonmetallic waste. Large ferrous metal objects west of E136 and at E154. Based on a lack of geophysical anomalies in some areas, significant portions of this trench contain either no waste or soft (nonmetallic) waste.
F	N196 on west end, N190 on east end	E124 – E250	Dry Waste	NA	NA	Trenches C through N interpreted from the geophysical data do not have regular spacing and therefore cannot be directly correlated with trench locations as shown on Hanford Site Drawing H-2-32095. This trench has a diagonal centerline relative to others in this burial ground. Geophysical data suggest a mix of metallic and nonmetallic waste. Large ferrous metal objects at E128, E150, E193, E228, and E240. Based on a lack of geophysical anomalies in some areas, significant portions of this trench contain either no waste or soft (nonmetallic) waste.

Table A7-1. Summary of Results from Burial Ground 218-W-3, 200 West Area. (3 Pages)

Trench Number as Shown on Figure A7-1	Approx. Center of Trench, based on Geo-physical Data	Approx. Ends of Trench, Based on Geo-physical Data	Documented Waste Type	Approx. Center of Trench, Based on Drawing H-2-32095	Approx. Ends of the Trench, Based on Drawing H-2-32095	Comments
G	N213	E124 – E250	Dry Waste	NA	NA	Trenches C through N interpreted from the geophysical data do not have regular spacing and therefore cannot be directly correlated with trench locations as shown on Hanford Site Drawing H-2-32095. Geophysical data suggest a mix of metallic and nonmetallic waste. Based on a lack of geophysical anomalies in some areas, significant portions of this trench contain either no waste or soft (nonmetallic) waste.
H	N234 on west end, N228 on east end	E124 – E250	Dry Waste	NA	NA	Trenches C through N interpreted from the geophysical data do not have regular spacing and therefore cannot be directly correlated with trench locations as shown on Hanford Site Drawing H-2-32095. This trench has a diagonal centerline relative to others in this burial ground. Geophysical data suggest a mix of metallic and nonmetallic waste. Large ferrous metal objects at E128 - E133 and E184. Based on a lack of geophysical anomalies in some areas, significant portions of this trench contain either no waste or soft (nonmetallic) waste.
I	N247	E118 – E214	Dry Waste	NA	NA	Trenches C through N interpreted from the geophysical data do not have regular spacing and therefore cannot be directly correlated with trench locations as shown on Hanford Site Drawing H-2-32095. Geophysical data suggest a mix of metallic and nonmetallic waste. Large ferrous metal objects at E128 – E133. Based on a lack of geophysical anomalies in some areas, portions of this trench contain either no waste or soft (nonmetallic) waste.
J	N253	E214 - 238	Dry Waste	NA	NA	Trenches C through N interpreted from the geophysical data do not have regular spacing and therefore cannot be directly correlated with trench locations as shown on Hanford Site Drawing H-2-32095. This trench is interpreted from a short section of buried waste that does not appear to align with Trenches 9 or 11, which are on either side of it. Geophysical data indicate metallic debris.
K	N258	E112 – E190	Dry Waste	NA	NA	Trenches C through N interpreted from the geophysical data do not have regular spacing and therefore cannot be directly correlated with trench locations as shown on Hanford Site Drawing H-2-32095. Geophysical data suggest a mix of metallic and nonmetallic waste. Based on a lack of geophysical anomalies in some areas, portions of this trench contain either no waste or soft (nonmetallic) waste.

Table A7-1. Summary of Results from Burial Ground 218-W-3, 200 West Area. (3 Pages)

Trench Number as Shown on Figure A7-1	Approx. Center of Trench, based on Geo-physical Data	Approx. Ends of Trench, Based on Geo-physical Data	Documented Waste Type	Approx. Center of Trench, Based on Drawing H-2-32095	Approx. Ends of the Trench, Based on Drawing H-2-32095	Comments
L	N268	E184 – E250	Dry Waste	NA	NA	Trenches C through N interpreted from the geophysical data do not have regular spacing and therefore cannot be directly correlated with trench locations as shown on Hanford Site Drawing H-2-32095. This trench is interpreted from a short section of buried waste that does not appear to align with Trenches 11 or 13, which are on either side of it. Geophysical data indicate metallic debris.
M	N283 on west end, N275 on east end	E124 – E250	Dry Waste	NA	NA	Trenches C through N interpreted from the geophysical data do not have regular spacing and therefore cannot be directly correlated with trench locations as shown on Hanford Site Drawing H-2-32095. This trench has a diagonal centerline relative to others in this burial ground. Geophysical data suggest a mix of metallic and nonmetallic waste. Large ferrous metal objects at E136 and E154.
N	E250	N100 – N280	NA	NA	NA	This trench does not correlate with any feature on Hanford Site Drawing H-2-32095. It is interpreted based on a North-South linear pattern of anomalies along the east edge of the burial ground. Confidence in this interpretation is not high. It is possible that this pattern is a combination of anomalies caused by waste material at the ends of the East-West trenches and anomalies caused by the North-South roadway at approximately this location.

Figure A7-1. Geophysical Investigation Results, 218-W-3 Burial Ground, 200 West Area, June 2006.

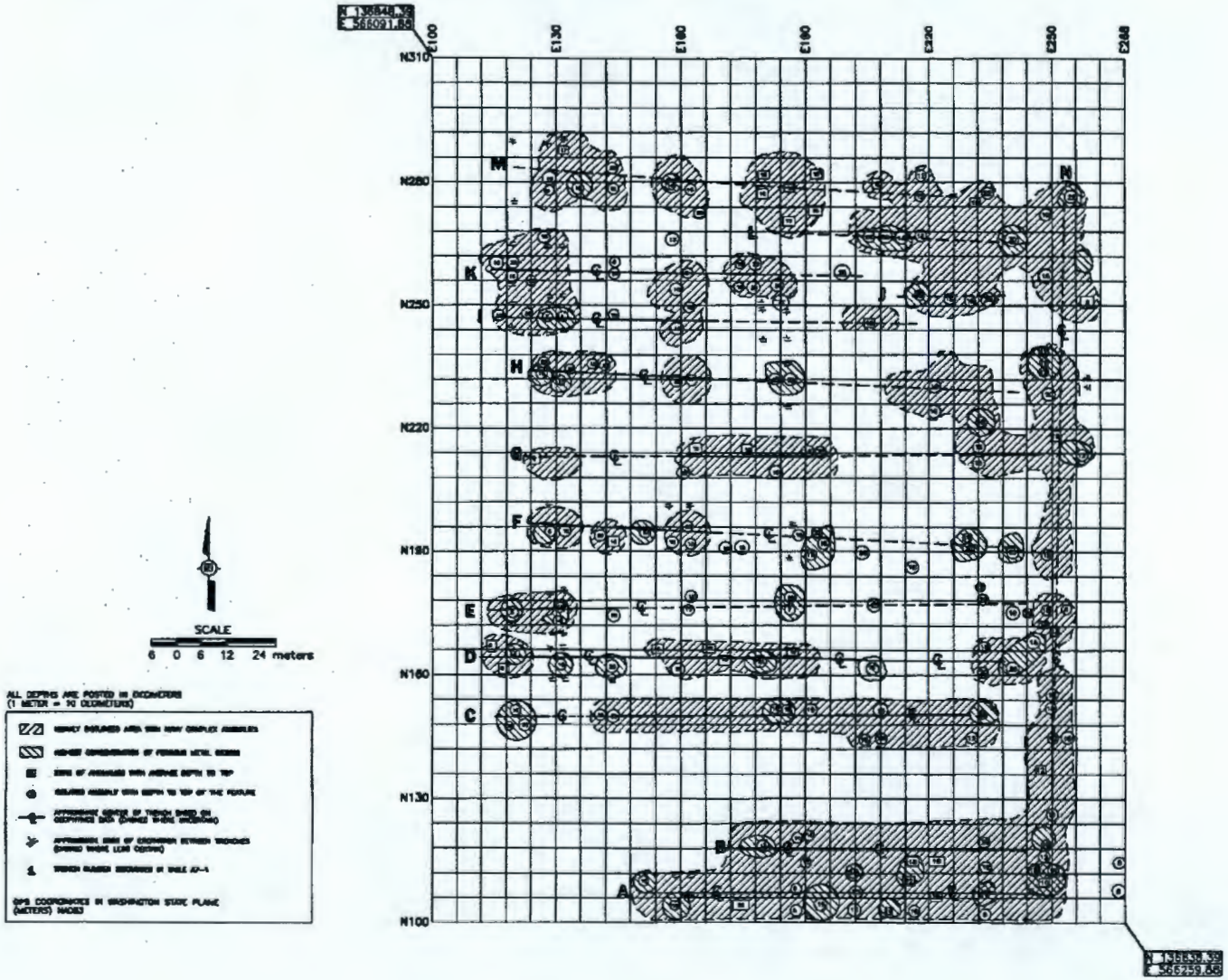


Figure A7-2. Electromagnetic Induction (EM31) Ground Conductivity Data, 218-W-3 Burial Ground, 200 West Area, June 3, 2006.

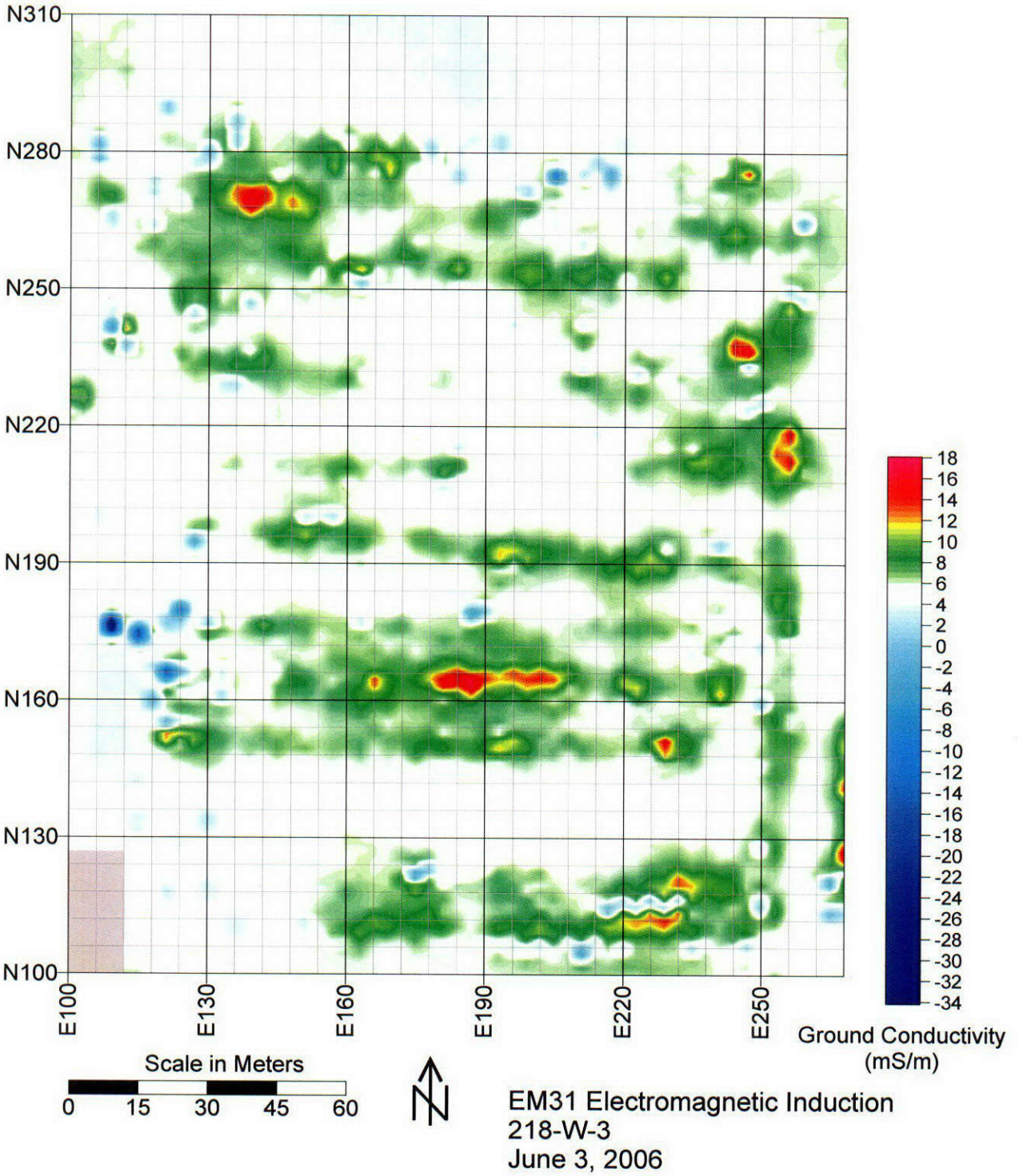


Figure A7-3. Electromagnetic Induction (EM31) In-Phase Data, 218-W-3 Burial Ground, 200 West Area, June 3, 2006.

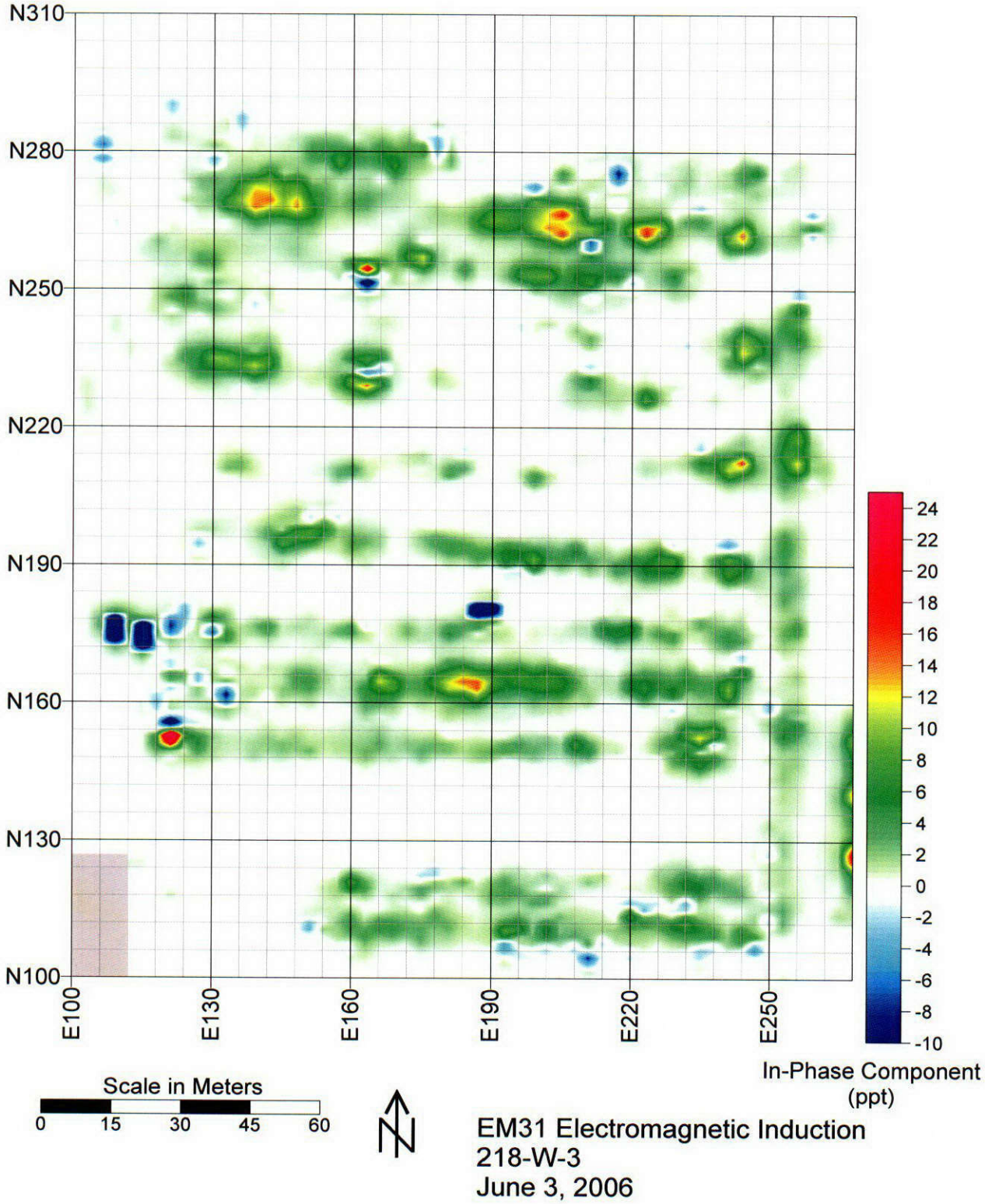
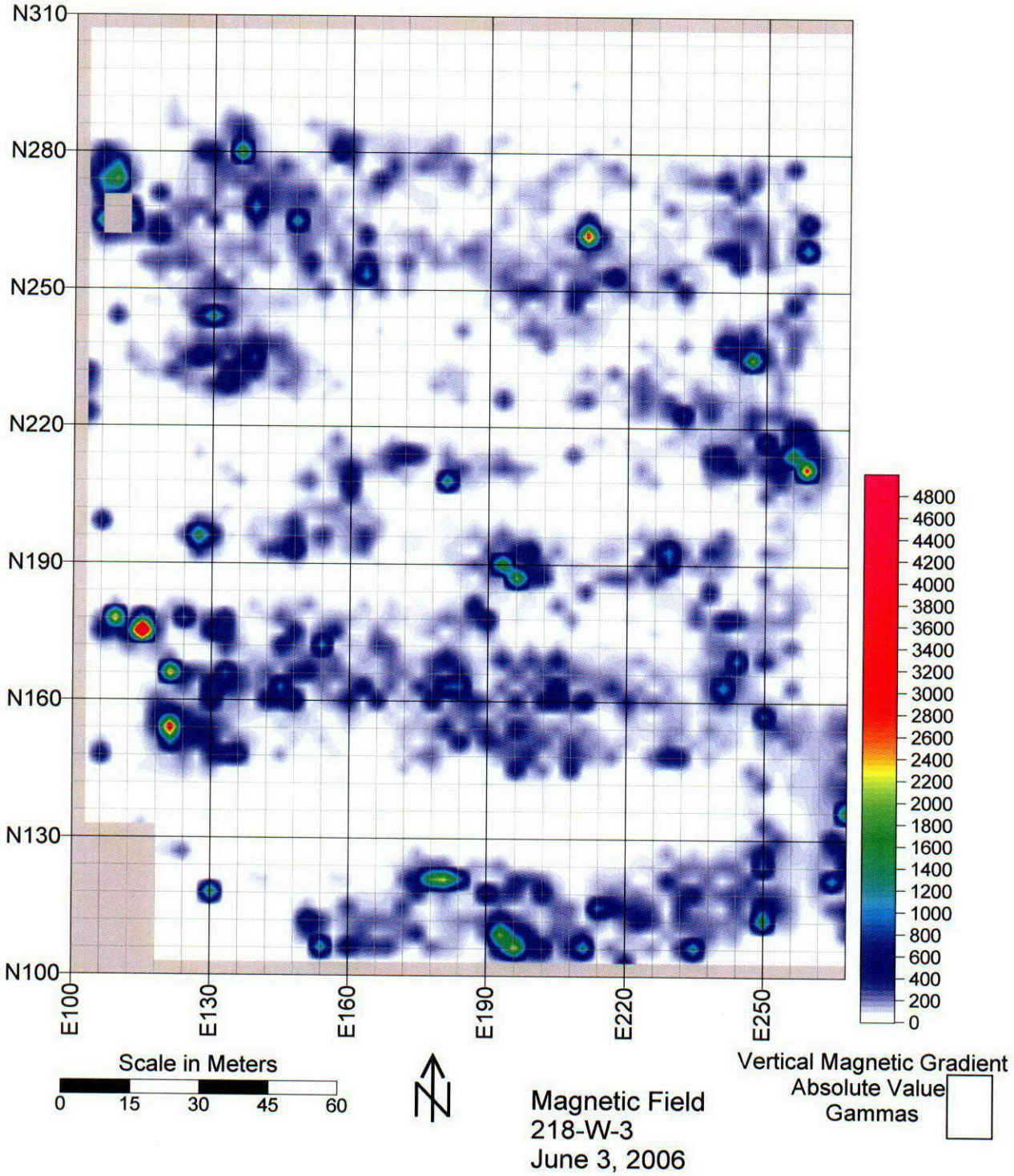


Figure A7-4. Total Magnetic Field (G858/G) Data, 218-W-3 Burial Ground, 200 West Area, June 3, 2006.



A8.0 218-W-11 BURIAL GROUND GEOPHYSICAL INVESTIGATION SUMMARY AND DATA PLOTS

Geophysical Investigation Summary Sheet	
Site Name	218-W-11 Burial Ground
Location	200 West Area
Approximate size	(Expansion area) 60 m x 180 m
Burial Ground Information	2 documented East-West trenches/regulated storage areas.
Terrain	Generally flat throughout the site.
Vegetation/ground cover	Relatively vegetation free. The soil typically was gravelly sand.
Hydrological properties	Surface relatively dry at time of data collection, although heavy rains fell a few days before data collection.
Limitations/obstacles	None
Overall assessment for geophysical investigation	Electromagnetic induction and magnetic methods were the most effective at meeting project objectives. GPR data quality varied from average to good.
Equipment	
Ground Penetrating Radar (GPR)	Geophysical Survey Systems. Inc., SIR-10A GPR system with 200 MHz antenna
Electromagnetic Induction (EMI)	Frequency domain EMI: Geonics Limited, EM31 Ground Conductivity Meter with Wescor, Inc., Polycorder 720.
Total Magnetic Field	Geometrics, Inc., G-858/G Cesium Vapor Magnetometer/Gradiometer
Data Collection and Processing Parameters	
Grid location control and data collection lines	Base grid staked at 30 m centers by Fluor personnel using Global Positioning System instruments and coordinates supplied by North Wind, which were based on Hanford Site Drawing H-2-94250, Rev. 1. The overall base grid is coupled with the 218-W-1 and -2 Burial Ground sites, maintaining a consistent 30 m grid node spacing. The dimensions for the 218-W-11 Burial Ground extended 120 m N-S, 202 m E-W, from geophysical coordinates N100 to N220 and from E100 to E302; data collection lines were flagged at 6 m centers in East-West and North-South directions along base grid nodes. The geophysical grid node N100/E100 corresponds with node N400/E100 of the 218-W-1 Burial Ground survey area. Additionally, the area from N100 to N160 was previously surveyed in 2005.
SIR-10A	Data were collected with the antenna towed behind a 4 x 6 all-terrain vehicle (Gator Utility Vehicle [1]). Marks were placed in the data as the instrument passed position flags or stakes. Data were stacked (2 signals), recording window 108 ns, gains and filters set in field to match soil conditions. Hard copy plots of data were printed in the office on a thermal printer for interpretation. Two East-West profiles and two North-South profiles typically were collected along each 30 m baseline. Additional North-South profiles were collected, roughly every 6-12 m between the bases. Additional East-West profiles also were collected every 6 m. [1] Gator Utility Vehicle is a trademark of John Deere & Company, Moline, Illinois.

Geophysical Investigation Summary Sheet	
EM31	Data were collected at hip height in the vertical dipole mode on 1.5 m station spacing and 3 m line spacing on North-South-oriented lines. Data were downloaded from the Polycorder and written to a .xyz data file using Geonics DAT31.exe. Corrections of position errors during data collection (if any) are made in standard spreadsheet software such as Microsoft Excel [2]. Data were gridded and plotted using Surfer [3]. Cell size for data plots is nominally 3 m (cross line) x 1.5 m (down line). ---------- [2] Excel is a trademark of Microsoft Corporation, Redmond, Washington. [3] Surfer is a trademark of Golden Software, Inc., Golden, Colorado.
G-858/G	Data were collected with sensors 0.5 and 1.5 m above the ground in continuous sampling mode with samples recorded every 0.5 seconds (nominal 0.5 m data spacing), and fiducial positioning marks placed every 30 m, on lines spaced 3 m apart. Data were collected in the North-South direction with the sensors oriented East-West at a 45-degree angle to the horizon. Data were downloaded from the field instrument, filtered for spikes and dropouts (if any), corrected for position errors (if any), and written to a .xyz file using Geometrics, Inc., MagMapper2000.exe. Data were gridded and plotted using Surfer. Grid cell size for the data plots is nominally 3 m (cross line) x 0.5 m (down line).
Results	
Data Discussion	Refer to data plots A8-1 through A8-4 and Table A8-1 for the following discussion. The intent of this data set was to expand to the north the initial geophysical data set (D&D-28379), collected in 2005, another 60 m to resolve uncertainties in the configuration of the 218-W-11 Burial Ground. The EMI, magnetic, and GPR data show numerous small, isolated anomalies scattered throughout the investigation area. South of N160, two concentrated areas of anomalies are contained within two separate interpreted excavation areas. The top of the buried debris/anomalies varies from 0.5 to 2.2 m below the surface in these two trenches/pits. The magnetic data show anomalies that appear to be from ferrous metallic debris buried in the trenches, as well as basalt-rich fill material that was used to fill in the trenches, or perhaps as added fill to parts of the burial ground. The Columbia River Basalt that dominates the region is often high in iron and often causes magnetic anomalies when the soil is rich in basalt, especially when the soils are compacted. The EMI data mapped pockets of metallic debris as well as changes in the conductivity of the soil. The in-phase data best reflected where the metallic debris is buried in the trenches. The conductivity data show the variable soil conditions across the site and show where the largest pockets of conductive (most often metallic) debris are located. The GPR data were effective at mapping the trench boundaries when the trenches had space between them. The GPR data also indicate that much of the debris was buried greater the 1 m below the surface, although a few anomalies were shallower than 1 m. Because of the reconnaissance nature of the investigations, and space between profiles, many of the anomalies have not been discretely mapped.

Geophysical Investigation Summary Sheet	
Interpretation	Two Hanford Site engineering drawings are available for reference for this site. The older drawing (H-2-31268) shows only one trench at this burial ground. A newer, revised drawing (H-2-94250) shows two East-West-oriented trenches, the northern of which correlates with that shown on the older drawing, but extended further to the west. Investigation continued to the area just north of the 218-W-11 Burial Ground. As reported in the previous investigation report (D&D-28379), one trench and one "pit" make up the 218-W-11 Burial Ground/Regulated Storage Site. The trench location correlates very well with the trench documented in Hanford Site Drawing H-2-31268, Rev. 8. The discrete pit is about 18 m east of this trench and is not depicted on any available drawings. Given the quality of the geophysical data at this site, the interpreters are confident that the southern trench shown in Hanford Site Drawing H-2-94250 does not exist. Five trenches were identified north of N160, which is in the southern part of the 218-W-4A Burial Ground. There is a clear data character change at about N160. This correlates with the documented location of the southern boundary of the 218-W-4A Burial Ground, which was not specifically part of this investigation. The mapped trenches extend from about E115 to E295. Pockets/zones of debris were located and mapped in each of the identified trenches in the 218-W-4A Burial Ground. Discrete concentrations of metallic waste were identified in most of the trenches. Nonmetallic waste is interpreted to be mixed with the metallic waste. The vast majority of the anomalies are greater that 1 m below the surface. It is possible that there is more debris in the trenches than was detected in the data and plotted on the interpretation map.

Table A8-1. Summary of Results from Burial Ground 218-W-11 (Includes the Southern Part of Burial Ground 218-W-4A), 200 West Area. (2 Pages)

Best Trench Correlation, Based on Drawing H-2-31268, Rev. 8	Approx. Center of Trench, Based on Geo-physical Data	Approx. Ends of Trench, Based on Geo-physical Data	Documented Waste Type	Approx. Center of Trench, Based on Drawing H-2-31268, Rev. 8	Approx. Ends of Trench, Based on Drawing H-2-31268, Rev. 8	Comments
218-W-11 Burial Ground						
Unnumbered single east-west burial trench	N140	E166 – E215	Dry Waste	N135	E170 – E215 (E135 – E215 from DWG H-2-94250)	Hanford Site Drawing H-2-94250, Rev. 1 (1993), depicts two areas/trenches in this dry waste burial ground. Older Hanford Site Drawing H-2-31268, Rev. 8 (1977), depicts only one trench, which correlates with the eastern half of the northern trench shown on H-2-94250. Only the eastern "half" of the northern trench, as shown on H-2-31268, contains subsurface debris/waste and evidence of excavation boundaries.
Unnumbered single east-west burial trench	Not detected	Not detected	Dry Waste	N121		No indication of subsurface disturbance in this area.
No documented pit/trench	N145	E232 – E273	Unknown	NA	NA	Irregularly shaped excavation/pit with all the debris concentrated in the center at about N145/E250, typically at about 2 m below the surface. Good evidence of excavation boundaries in the data.
Widely scattered, near surface metallic debris	NA	NA	NA	NA	NA	Widely scattered, shallow, small metallic debris covers much of the site. The debris appears to be within 0.5 m of the surface and likely within the "stabilization" layer. This type of anomaly/debris is very typical of many waste sites at the Hanford Site.
218-W-4A Burial Ground						
1	N169	- E289	Unknown	N169	E105 – E290	Hanford Site drawings for the 218-W-4A Burial Ground show this trench as number 1. The trench contains both metallic and nonmetallic material, all within the documented East-West boundaries. The metallic material tends to be concentrated in discrete areas.
2	N182	- E289	Unknown	N181	E105 – E293	Hanford Site drawings for the 218-W-4A Burial Ground show this trench as number 2. The trench contains both metallic and nonmetallic material, all within the documented East-West boundaries. The metallic material tends to be concentrated in discrete areas.

Table A8-1. Summary of Results from Burial Ground 218-W-11 (Includes the Southern Part of Burial Ground 218-W-4A), 200 West Area. (2 Pages)

Best Trench Correlation, Based on Drawing H-2-31268, Rev. 8	Approx. Center of Trench, Based on Geo-physical Data	Approx. Ends of Trench, Based on Geo-physical Data	Documented Waste Type	Approx. Center of Trench, Based on Drawing H-2-31268, Rev. 8	Approx. Ends of Trench, Based on Drawing H-2-31268, Rev. 8	Comments
3	N195	Unclear	Unknown	N194	E105 – E296	Hanford Site drawings for the 218-W-4A Burial Ground show this trench as number 3. The trench contains both metallic and nonmetallic material, all within the documented East-West boundaries. The metallic material tends to be concentrated in discrete areas.
4	N206	Unclear	Unknown	N205	E105 – E298	Hanford Site drawings for the 218-W-4A Burial Ground show this trench as number 4. The trench contains both metallic and nonmetallic material, all within the documented East-West boundaries. The metallic material tends to be concentrated in discrete areas.
5	N217	Unclear	Unknown	N217	E105 – E300	Hanford Site drawings for the 218-W-4A Burial Ground show this trench as number 5. The trench contains both metallic and nonmetallic material, all within the documented East-West boundaries. The metallic material tends to be concentrated in discrete areas.

Figure A8-1. Geophysical Investigation Results, 218-W-11 Burial Ground, 200 West Area, June 2006.

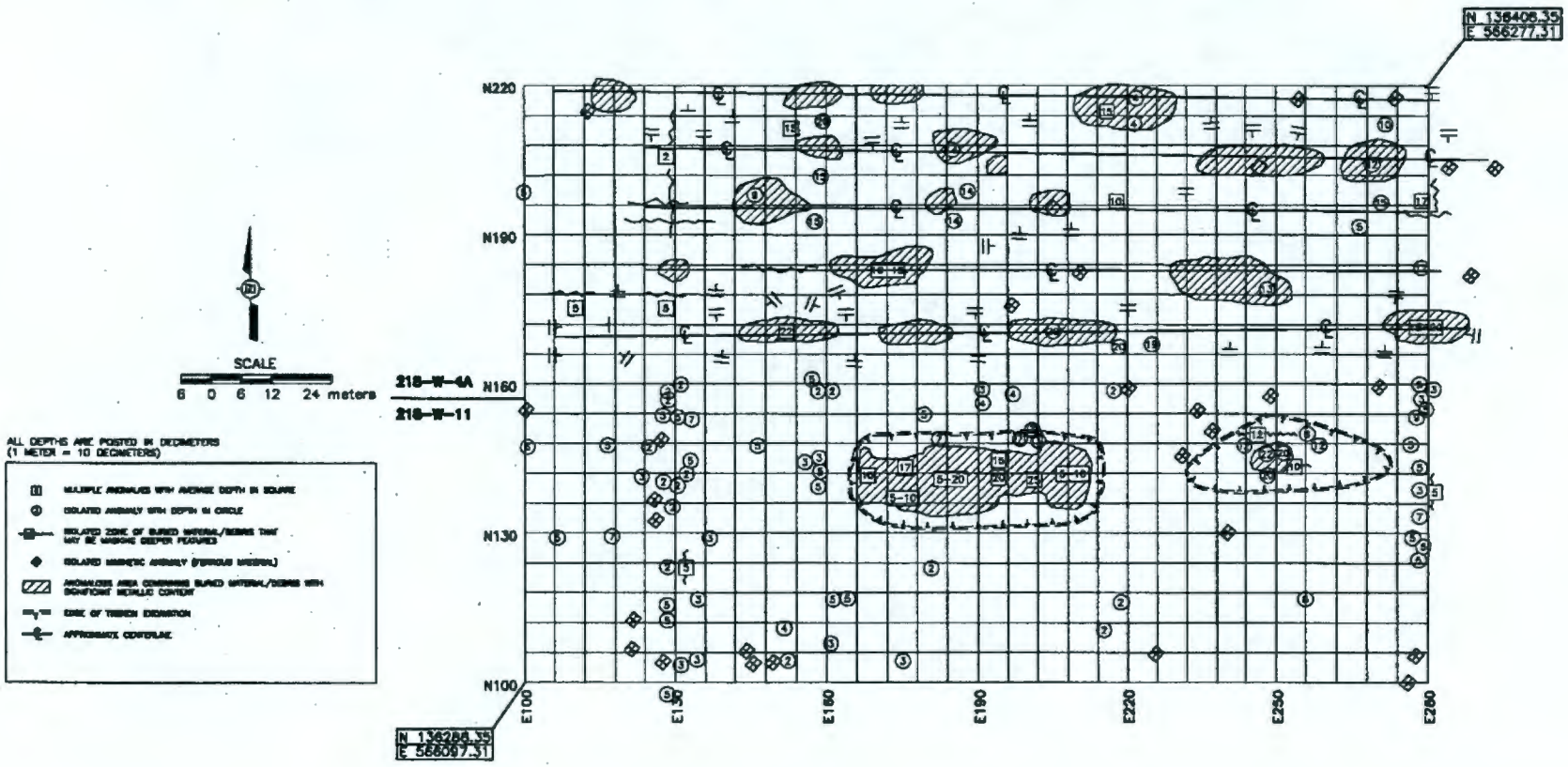


Figure A8-2. Electromagnetic Induction (EM31) Ground Conductivity Data, 218-W-11 Burial Ground, 200 West Area, June 6, 2006.

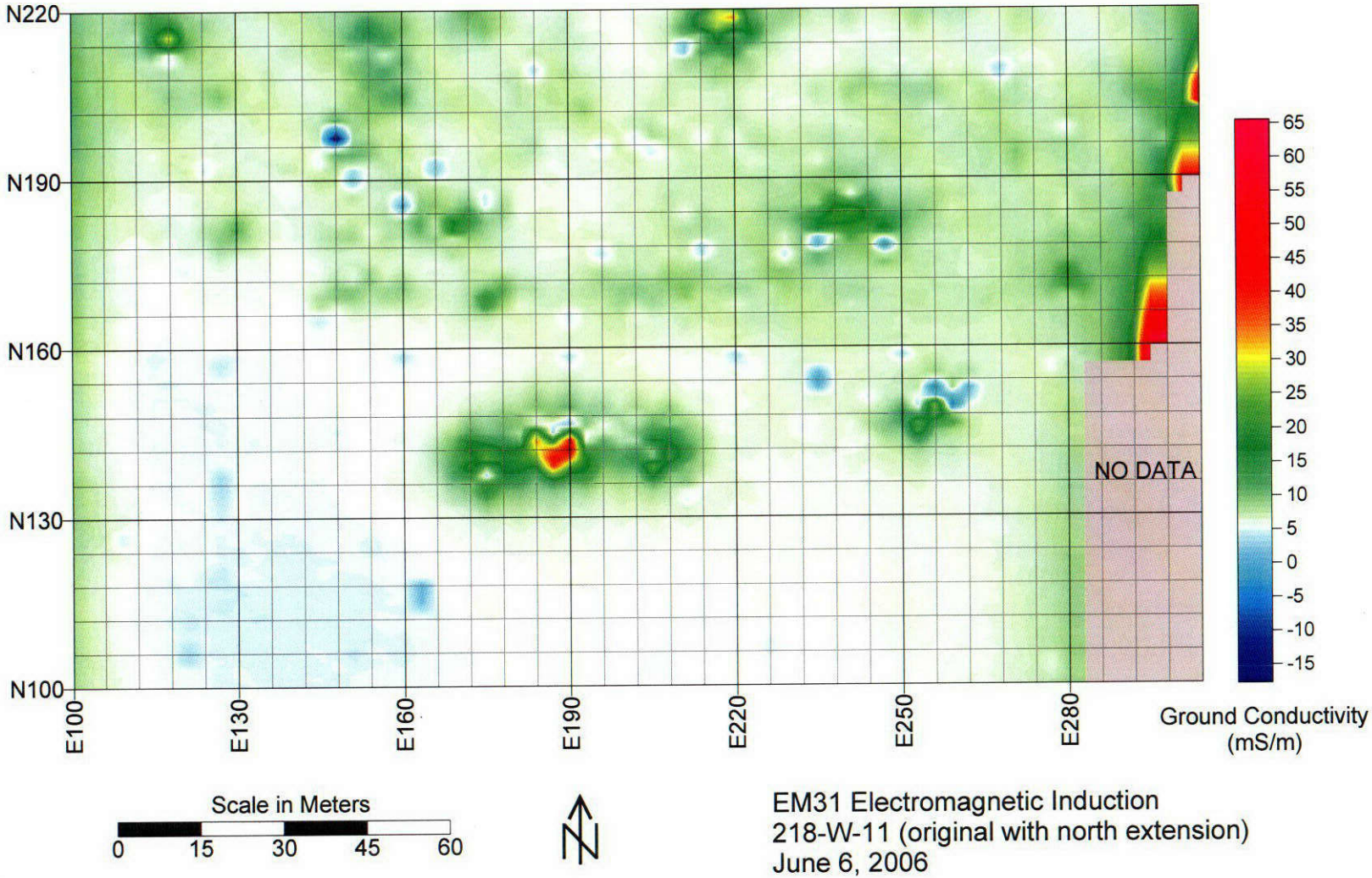


Figure A8-3. Electromagnetic Induction (EM31) In-Phase Data, 218-W-11 Burial Ground, 200 West Area, June 6, 2006.

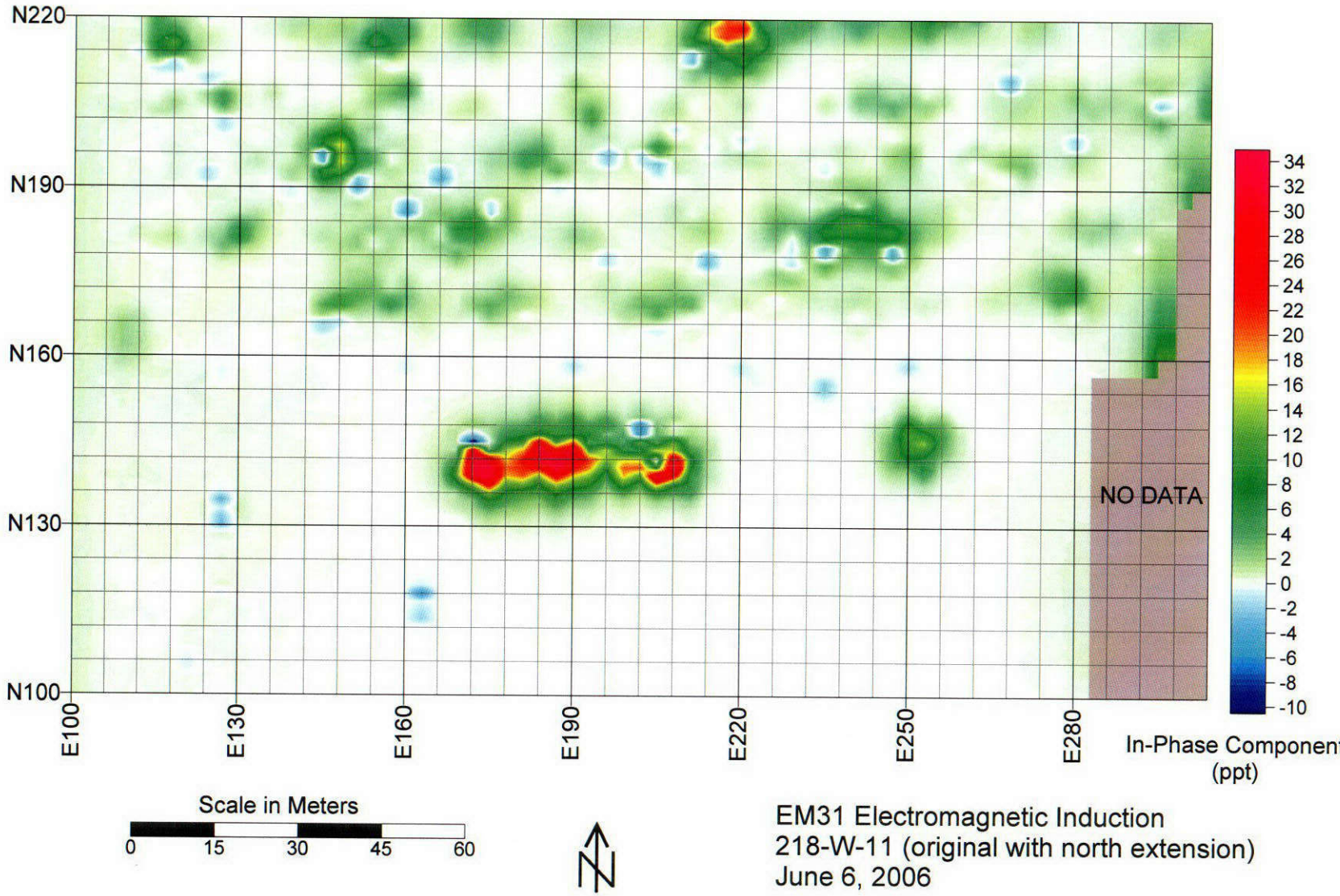
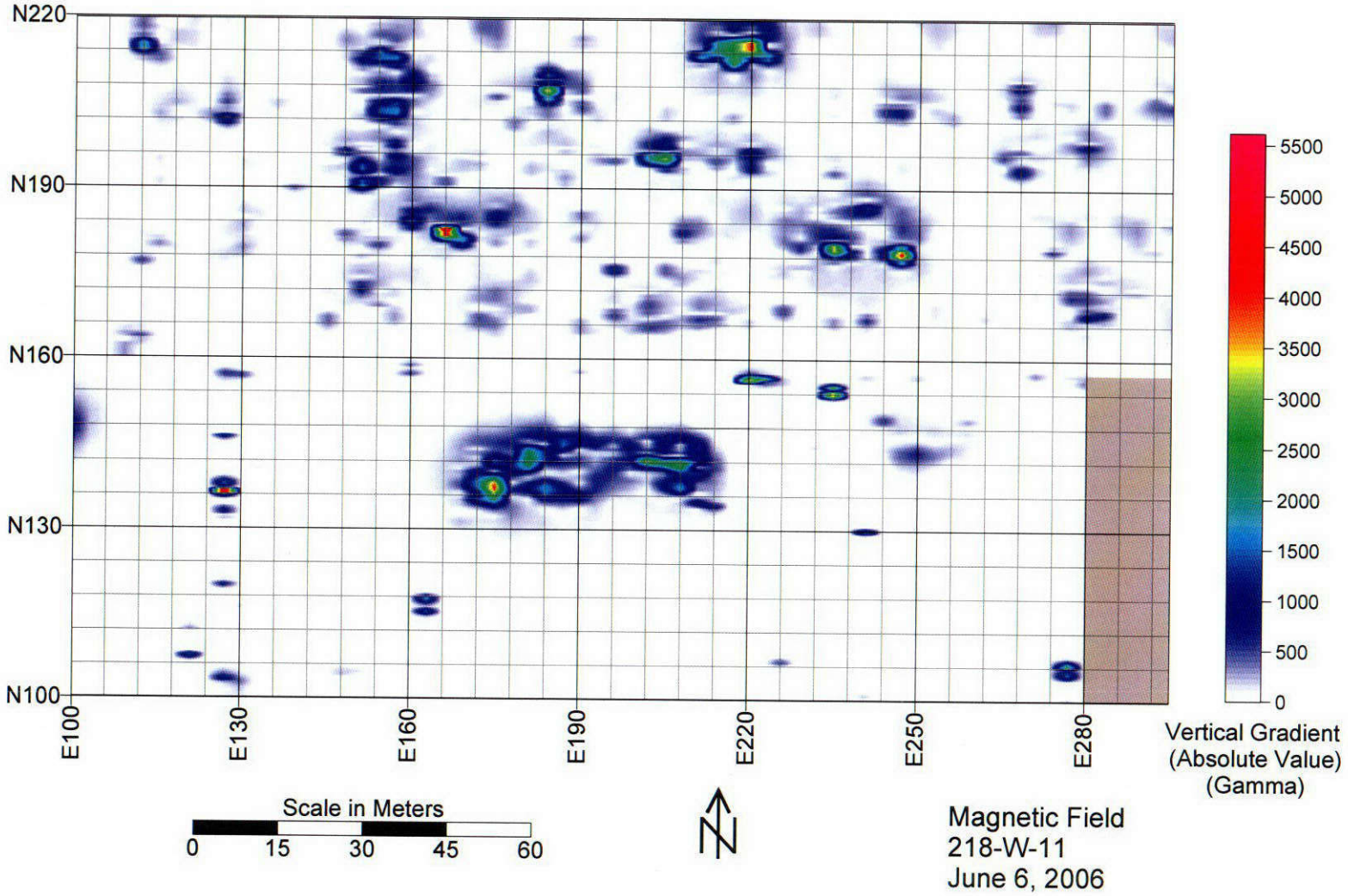


Figure A8-4. Total Magnetic Field (G858/G) Data, 218-W-11 Burial Ground, 200 West Area, June 6, 2006



A9.0 TRADEMARK PRODUCTS AND SOFTWARE CITED IN THIS DOCUMENT

DAT31.exe is a trademark of Geonics Limited, Mississauga, Ontario, Canada.

DAT61.exe is a trademark of Geonics Limited, Mississauga, Ontario, Canada.

EM31 (ground conductivity meter) is a trademark of Geonics Limited, Mississauga, Ontario, Canada.

EM61-MK2 (high sensitivity metal detector) is a trademark of Geonics Limited, Mississauga, Ontario, Canada.

Excel is a trademark of Microsoft Corporation, Redmond, Washington.

G-858/G (cesium vapor magnetometer/gradiometer) is a trademark of Geometrics, Inc., San Jose, California.

Gator Utility Vehicle is a trademark of John Deere & Company, Moline, Illinois.

Lynx is a HarvestMaster brand electronic data acquisition system owned by Juniper Systems, Inc., Logan, Utah.

MagMapper2000.exe is a trademark of Geometrics, Inc., San Jose, California.

Polycorder 720 is a registered trademark of Wescor, Inc., Logan Utah.

PRO4000 (data logger) is a trademark of Juniper Systems, Inc., Logan, Utah.

SIR-10A (ground-penetrating radar system) is a registered trademark of Geophysical Survey Systems, Inc., North Salem, New Hampshire.

Surfer is a trademark of Golden Software, Inc., Golden, Colorado.

A10.0 REFERENCES

D&D-28379, 2006, *Geophysical Investigations Summary Report; 200 Area Burial Grounds: 218-C-9, 218-E-2A, 218-E-5, 218-E-5A, 218-E-8, 218-W-1A, 218-W-2A, and 218-W-11*, Rev. 0, prepared by CH2M HILL, Inc., for Fluor Hanford, Inc., Richland, Washington.

Hanford Site Drawings:

- H-2-124, *218-E-1 Dry Waste Burial Ground*, Rev. 3
- H-2-2503, *218-W-2 Dry Waste Burial Ground*, Rev. 3
- H-2-31268, Rev. 8, *Solid Waste Burial Grounds Plot Plan*, Rev. 8
- H-2-32095, Sheets 1 & 2, *218-W-2A Industrial Burial Ground & 218-W-3 Dry Waste Burial Ground*, Rev. 11
- H-2-32560, *As-Built Dry Waste Burial Site #218-E-12A*, Rev. 2
- H-2-33276, Sheet 1 of 24, *Dry Waste Burial Ground 218-E-12B*, Rev. 17, and Sheet 3 of Rev. 6
- H-2-55534, *218-E2, E2A, E4, E5, E5A, & E9 Industrial Burial Ground Plan & Details*, Rev. 16
- H-2-75149, *Dry Waste Burial Ground 218-W-1*, Rev. 1
- H-2-94250, *Dry Waste Burial Ground 218-W-11*, Rev. 1.

APPENDIX B

OVERLAYS OF GEOPHYSICAL INTERPRETATIONS WITH SITE DRAWINGS

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APPENDIX B

OVERLAYS OF GEOPHYSICAL INTERPRETATIONS WITH SITE DRAWINGS

This appendix presents the geophysical results, overlaid on a site drawing that shows the expected locations of trenches within the burial grounds investigated (Figures B-1 through B-8).

Alignment and scale on the overlays were achieved using coordinates on the various drawings and standard conversions between old Hanford Site coordinate systems and new Washington State Plane systems. The drawings generally were enlarged for these displays, which can distort feature size and location. While the scale and alignment are considered generally good, they have not been fully checked and verified for absolute accuracy.

REFERENCES

Hanford Site Drawings:

- H-2-124, *218-E-1 Dry Waste Burial Ground*, Rev. 3
- H-2-2503, *218-W-2 Dry Waste Burial Ground*, Rev. 3
- H-2-32095, Sheets 1 & 2, *218-W-2A Industrial Burial Ground & 218-W-3 Dry Waste Burial Ground*, Rev. 11
- H-2-32560, *As-Built Dry Waste Burial Site #218-E-12A*, Rev. 2
- H-2-33276, Sheet 1 of 24, *Dry Waste Burial Ground 218-E-12B*, Rev. 17 and Sheet 3 of Rev. 6
- H-2-55534, *218-E2, E2A, E4, E5, E5A, & E9 Industrial Burial Ground Plan & Details*, Rev. 16
- H-2-75149, *Dry Waste Burial Ground 218-W-1*, Rev. 1
- H-2-94250, *Dry Waste Burial Ground 218-W-11*, Rev. 1

FIGURES

Figure B-1. Geophysical Results Overlaid on Drawing H-2-124, 218-E-1 Burial Ground, July 2006. 3

Figure B-2. Geophysical Results Overlaid on Drawing H-2-55534, 218-E-2A Burial Ground, July 2006. 4

Figure B-3. Geophysical Results Overlaid on Drawing H-2-33276, 218-E-8 Burial Ground, July 2006. 5

Figure B-4. Geophysical Results Overlaid on Drawing H-2-32560, 218-E-12A Burial Ground, July 2006. 6

Figure B-5. Geophysical Results Overlaid on Drawing H-2-75149, 218-W-1 Burial Ground, July 2006. 7

Figure B-6. Geophysical Results Overlaid on Drawing H-2-2503, 218-W-2 Burial Ground, July 2006. 8

Figure B-7. Geophysical Results Overlaid on Drawing H-2-32095, 218-W-3 Burial Ground, July 2006. 9

Figure B-8. Geophysical Results Overlaid on Drawing H-2-94250, 218-W-11 Burial Ground, July 2006. 10

Figure B-1. Geophysical Results Overlaid on Drawing H-2-124, 218-E-1 Burial Ground, July 2006.

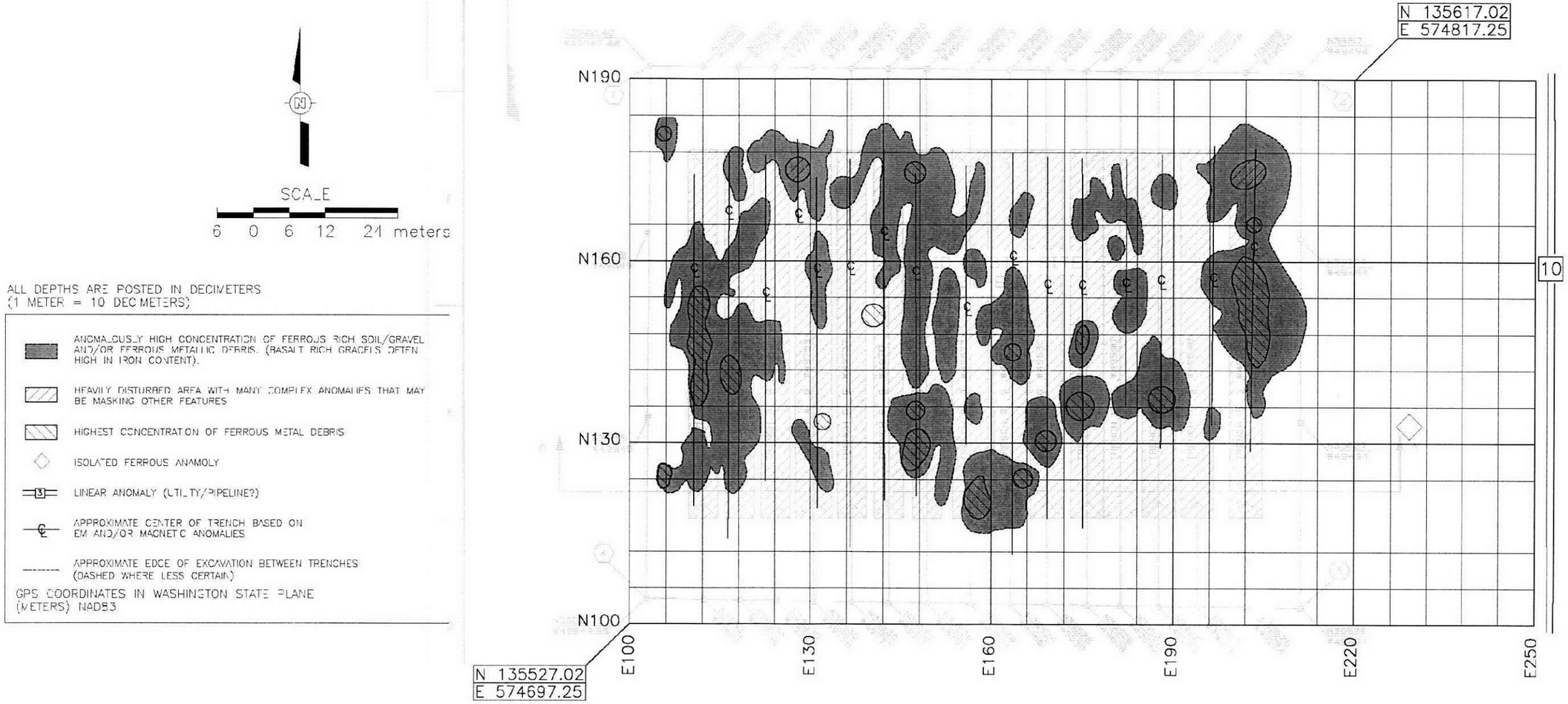


Figure B-2. Geophysical Results Overlaid on Drawing H-2-55534, 218-E-2A Burial Ground, July 2006.

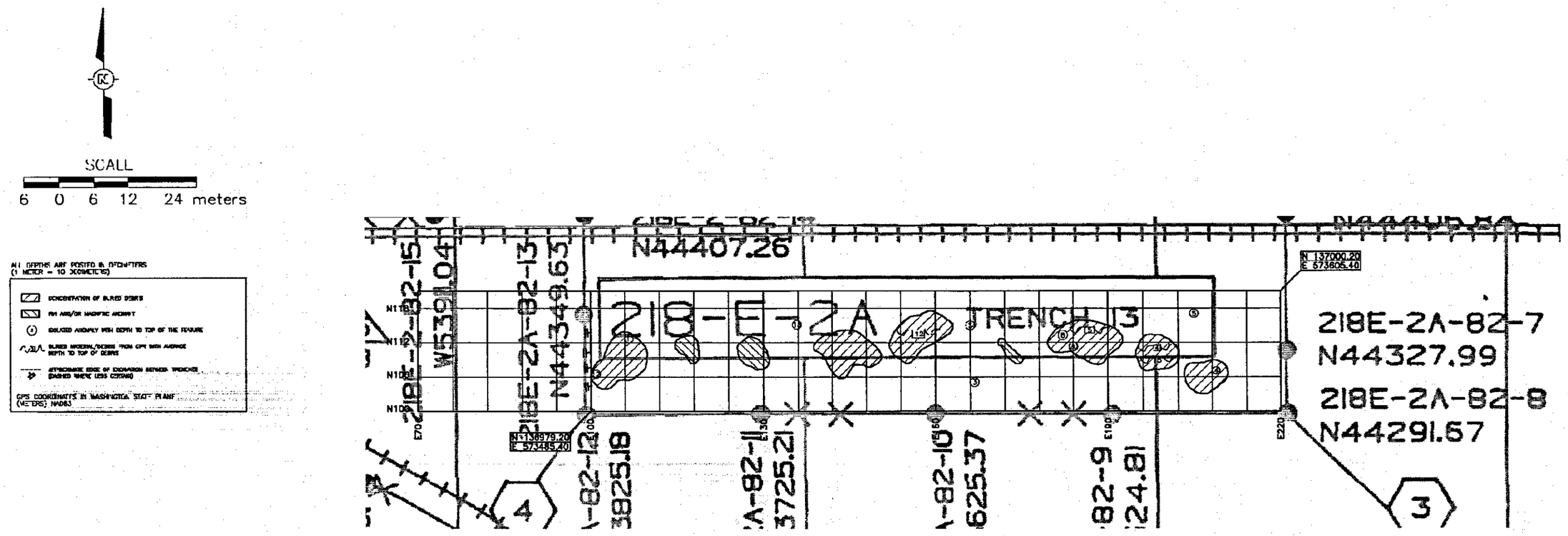


Figure B-3. Geophysical Results Overlaid on Drawing H-2-33276, 218-E-8 Burial Ground, July 2006.

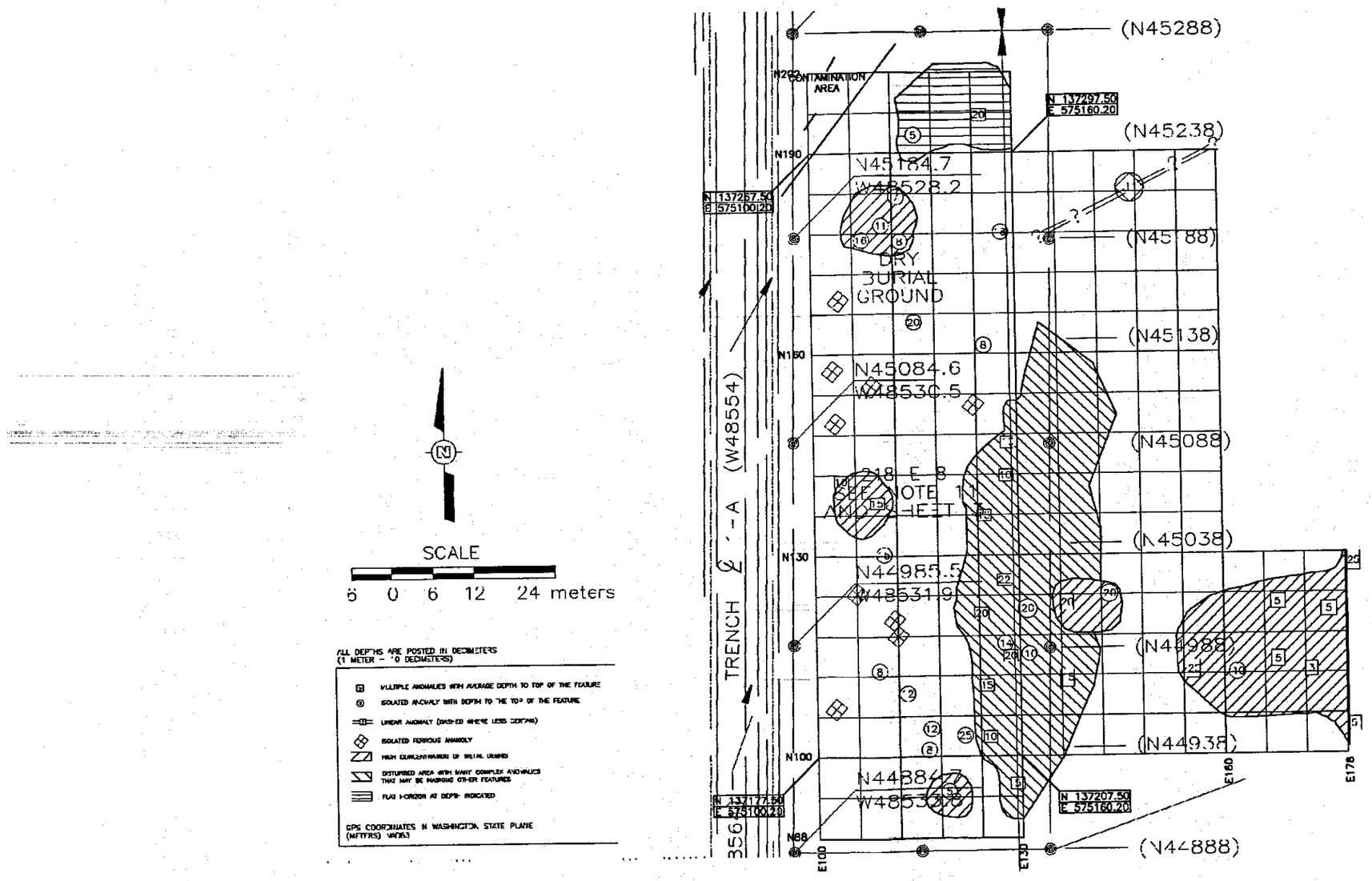


Figure B-4. Geophysical Results Overlaid on Drawing H-2-32560, 218-E-12A Burial Ground, July 2006.

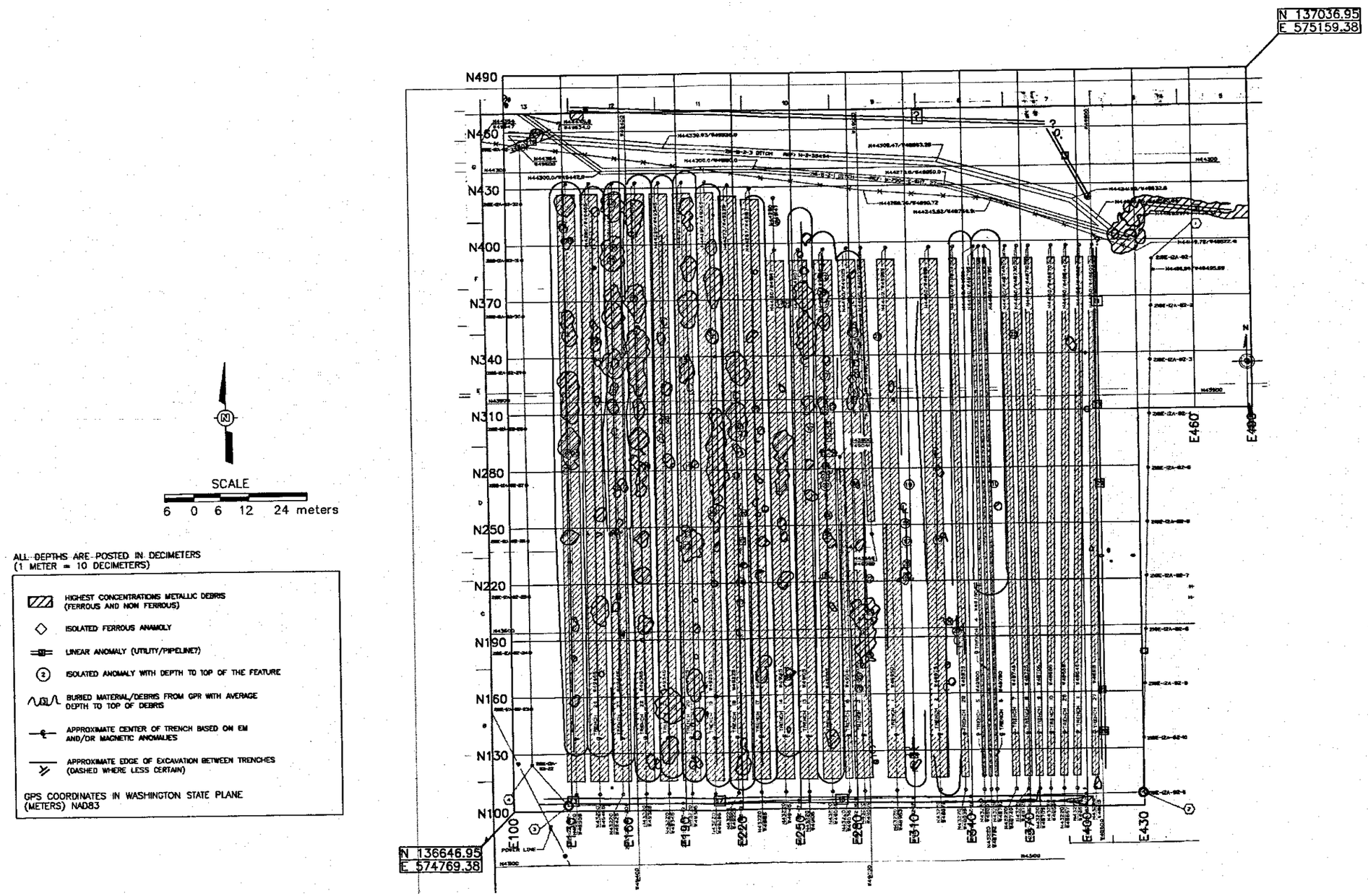


Figure B-5. Geophysical Results Overlaid on Drawing H-2-75149, 218-W-1 Burial Ground, July 2006.

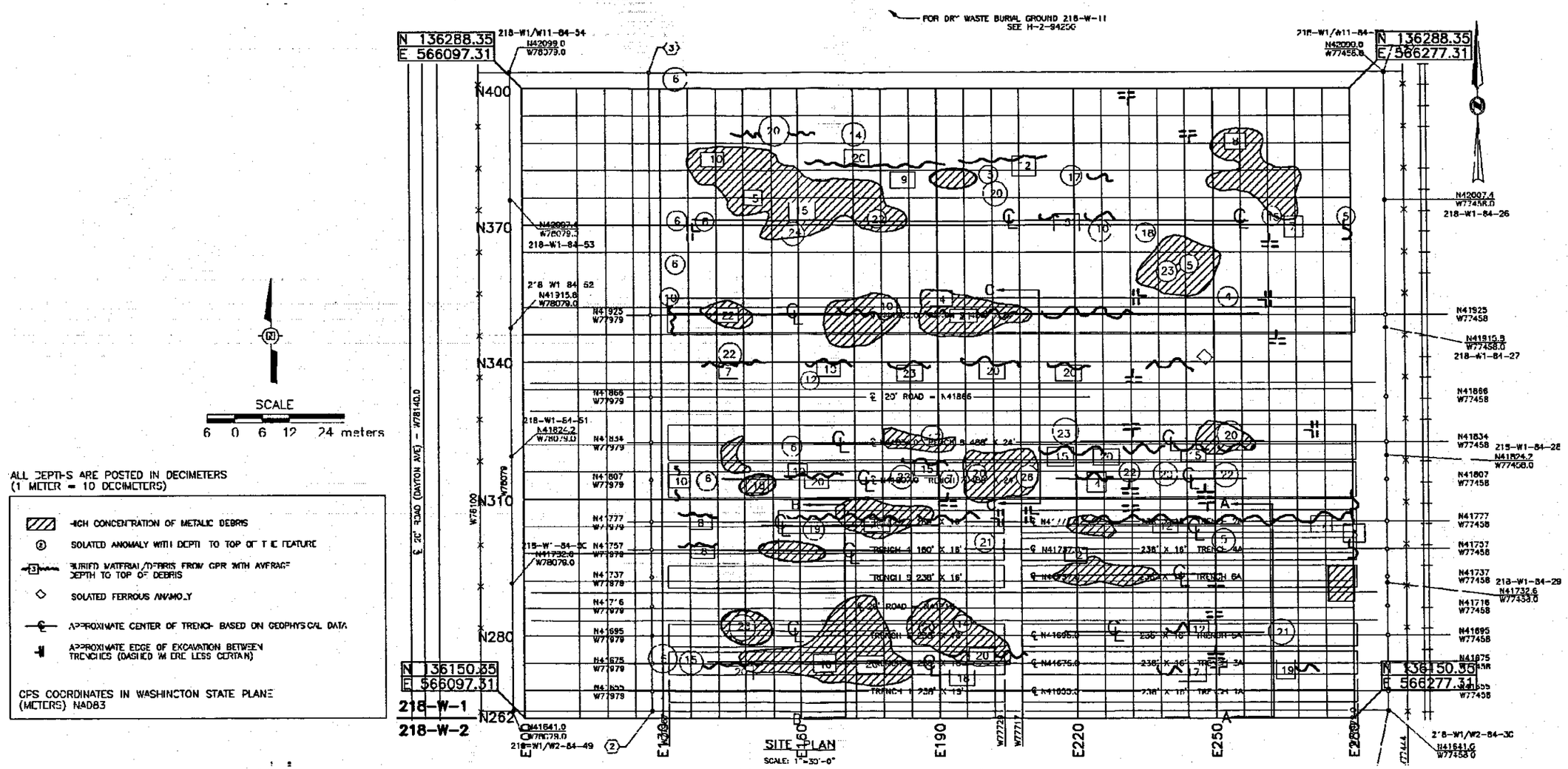


Figure B-6. Geophysical Results Overlaid on Drawing H-2-2503, 218-W-2 Burial Ground, July 2006.

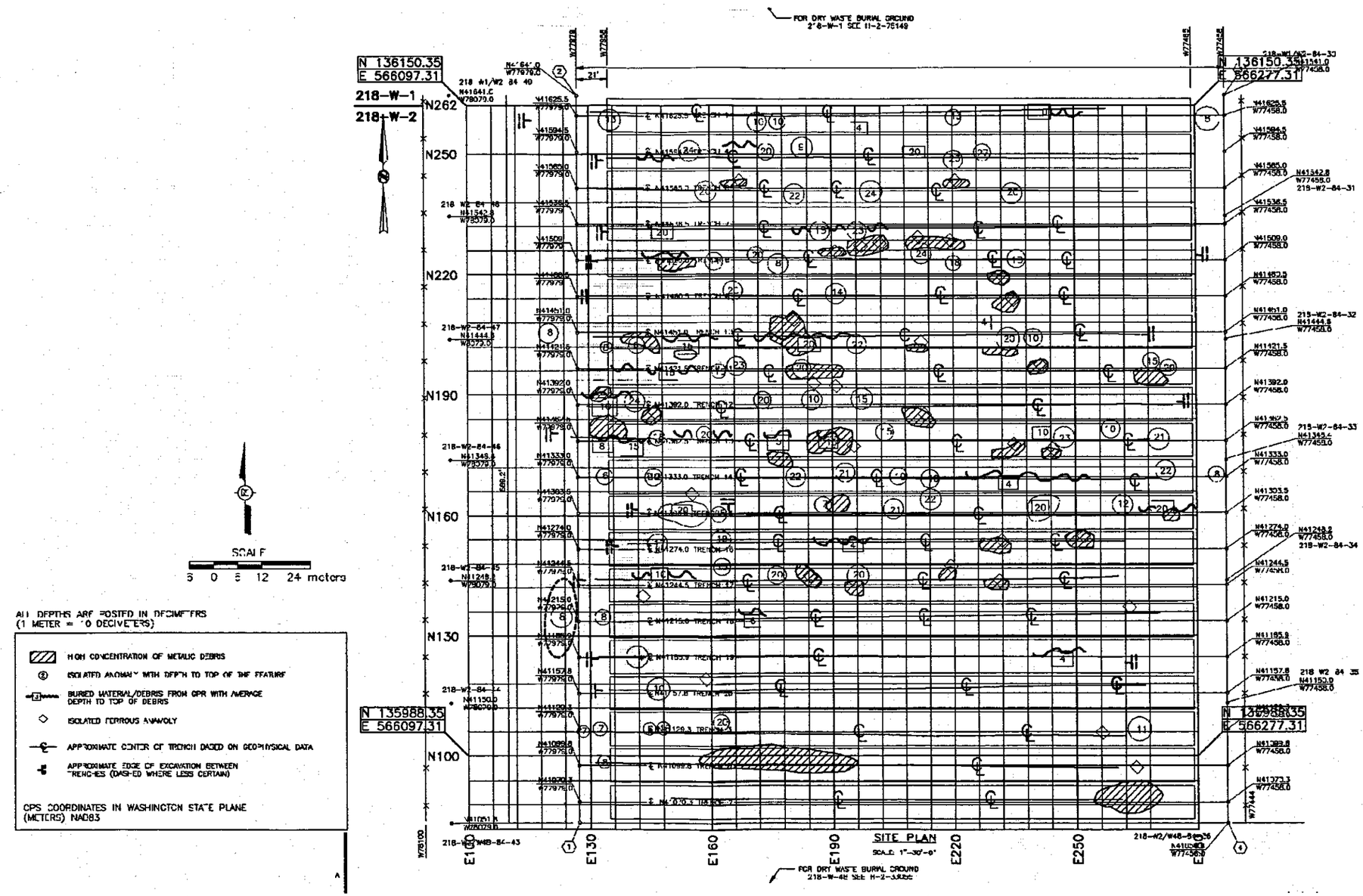


Figure B-7. Geophysical Results Overlaid on Drawing H-2-32095, 218-W-3 Burial Ground, July 2006.

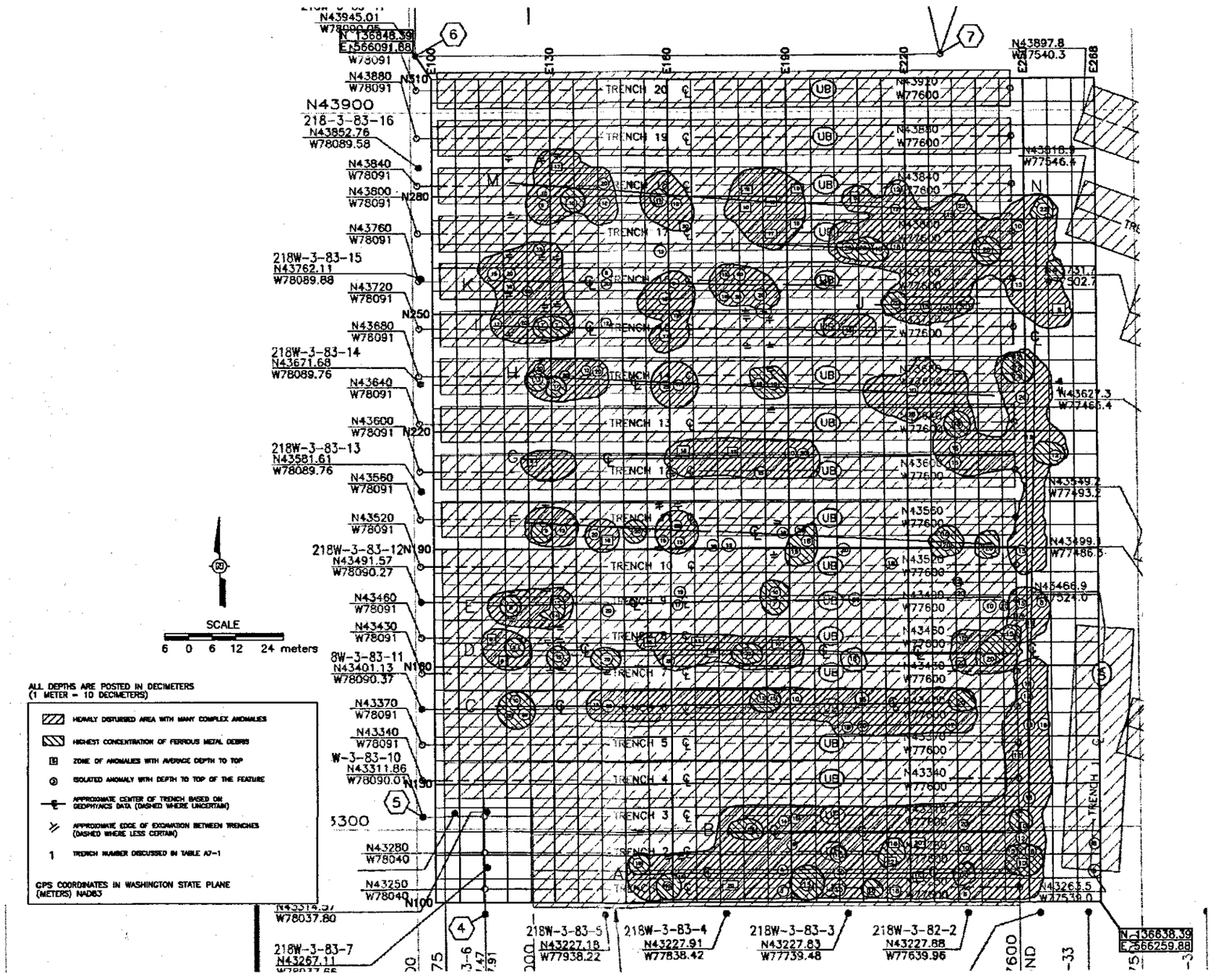
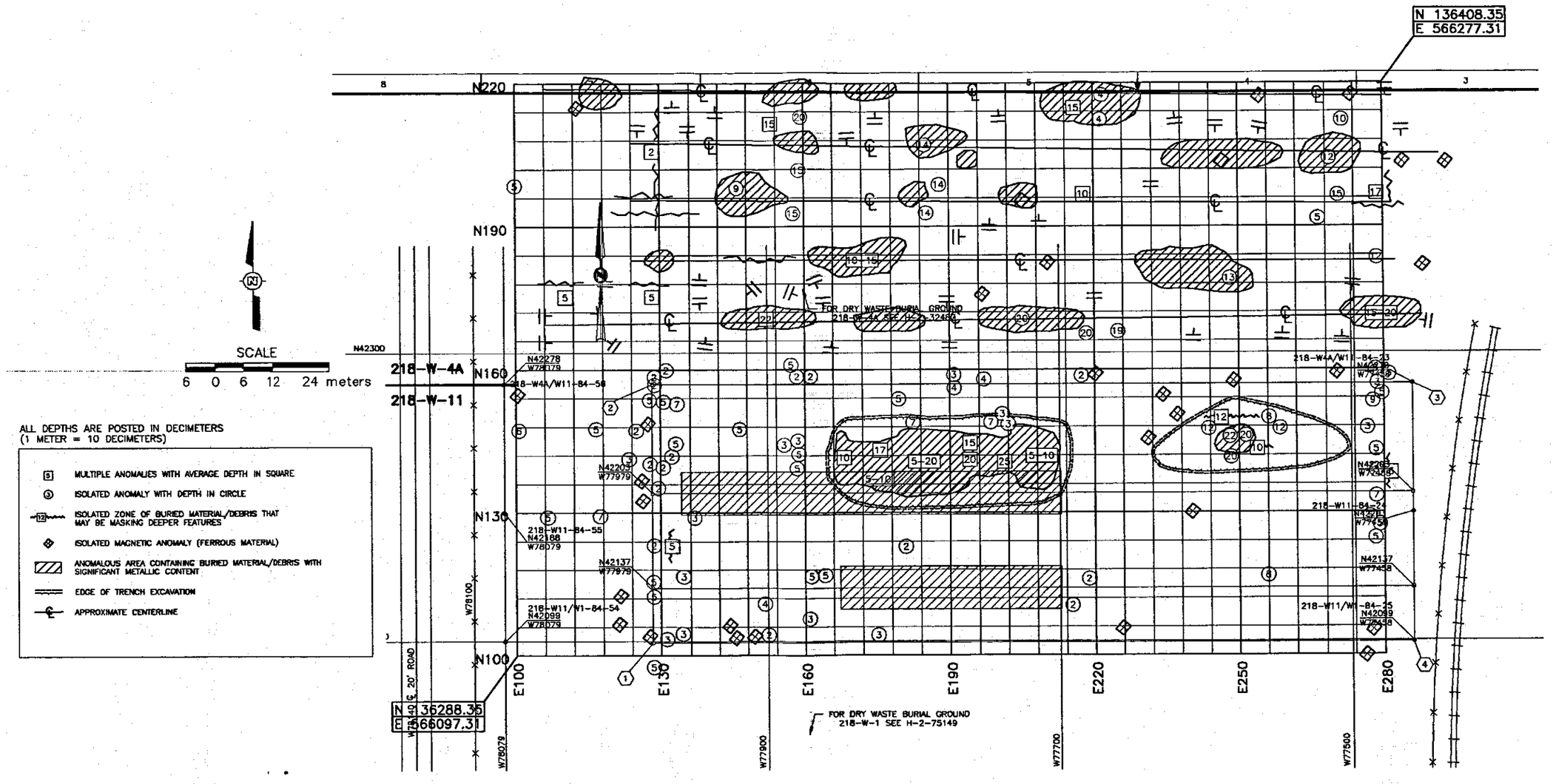


Figure B-8. Geophysical Results Overlaid on Drawing H-2-94250, 218-W-11 Burial Ground, July 2006.



APPENDIX C

SOFTWARE VERIFICATION AND VALIDATION DATA FILE

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APPENDIX C

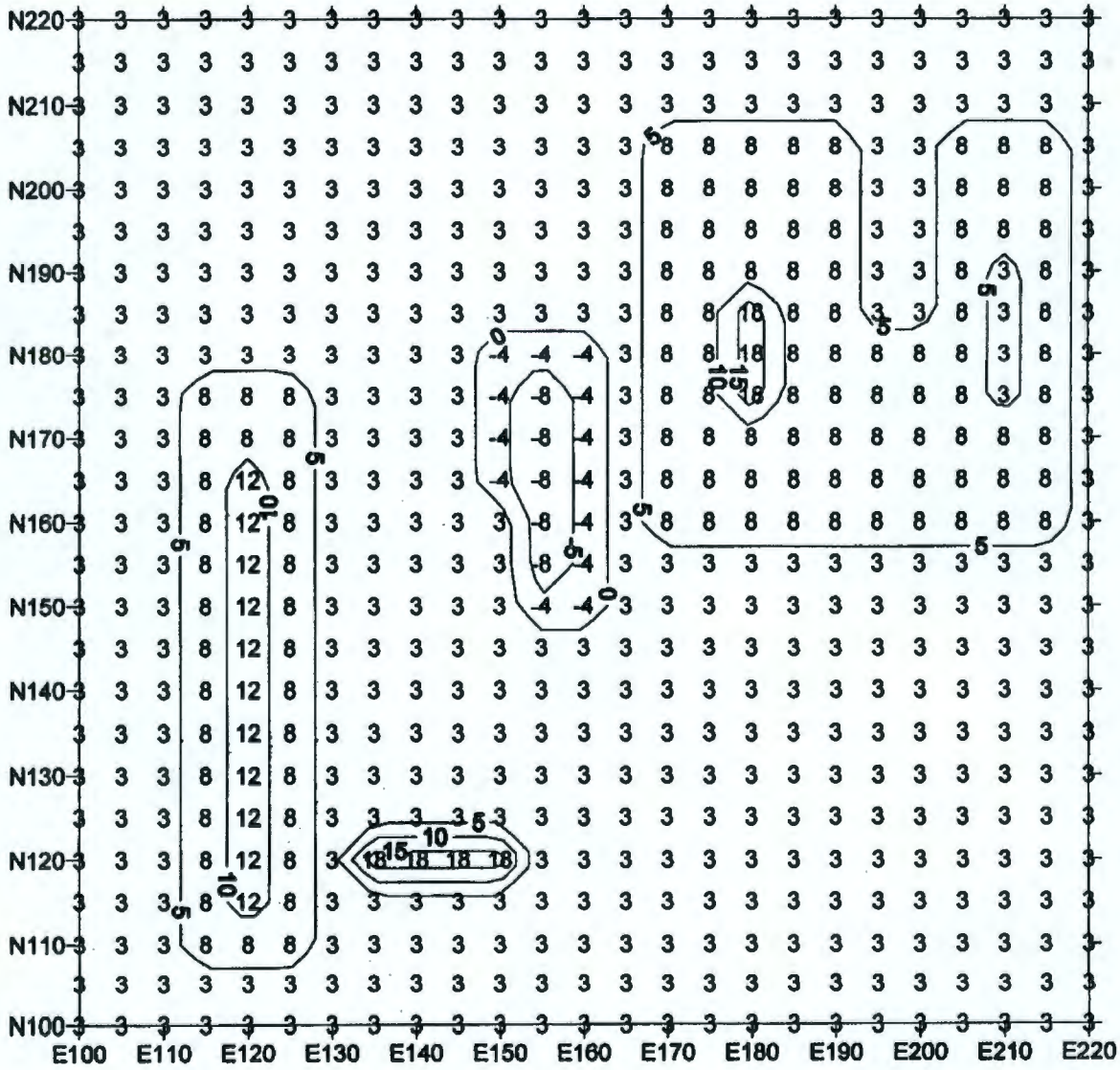
SOFTWARE VERIFICATION AND VALIDATION DATA FILE

To demonstrate proper contour calculation and placement (i.e., software verification), a regular grid of arbitrary numbers was created and processed by the software. Shown in Figure C-1 are the numbers plotted in their respective locations. These data then were gridded using the nearest neighbor method (as was used in the investigation). Contours were calculated by the software and superimposed over the grid of numbers. Inspection of Figure C-1 shows that the contours were correctly placed, based on the numbers shown in the grid.

FIGURE

Figure C-1. Software and Verification and Validation Demonstration, Golden Software Surfer, Version 8.05, July 29, 2006 ..... C-2

Figure C-1. Software and Verification and Validation Demonstration, Golden Software Surfer, Version 8.05, July 29, 2006.



Software Verification Plot
SURFER Version 8.05
Gridding Method: Nearest Neighbor
Cell Size: 5 x 5
Contour Interval: 5 units

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Cook, Sylvia V

From: Roddy, Francis M
Sent: Thursday, January 24, 2008 3:53 PM
To: Cook, Sylvia V
Subject: FW: Admin Record -- Document Submittals

Please add these documents to the Administrative Record. Thanks.

Frank Roddy

From: Berlin, Gregory T
Sent: Wednesday, January 23, 2008 4:55 PM
To: Roddy, Francis M
Cc: Cook, Sylvia V; Berlin, Gregory T
Subject: FW: Admin Record -- Document Submittals

Frank -- I would like to have the following documents submitted to the AR. If you agree with this action, please forward this note to Sylvia Cook to signify your approval.
Thanks,

Greg

D&D-28283, 2006, *Sampling and Analysis Instruction for Nonintrusive Characterization of Bin 3A and Bin 3B Waste Sites in the 200-SW-2 Operable Unit*, Rev. 0 Reissue, Fluor Hanford, Inc., Richland, Washington. Accession # DA02684114 (in IDMS)

D&D-30708, 2006, *Geophysical Investigations Summary Report; 200 Areas Burial Grounds: 218-E-1, 218-E-2A, 218-E-8, 218-E-12A, 218-W-1, 218-W-2, 218-W-3, and 218-W-11*, Fluor Hanford, Inc., Richland, Washington. Accession # DA04022312 (in IDMS)

SGW-33253, *Data Quality Objectives Summary Report for Landfills in the 200-SW-1 and 200-SW-2 Operable Units*, Fluor Hanford, Inc., Richland, Washington. Accession # DA06293920 (in IDMS)