SGW-48278
Revision 0

Investigation of Unused Landfill Areas: 218-W-4C, 218-W-6, 218-E-10 and 218-E-12B

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

Contractor for the U.S. Department of Energy
under Contract DE-AC06-08RL14788

CH2MHILL
Plateau Remediation Company

P.O. Box 1600
Richland, Washington 99352

Approved for Public Release:
Further Dissemination Unlimited

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Program/Project: S&GRP

P. N. Seeley
CH2M HILL Plateau Remediation Company

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Executive Summary

This report presents the results of an investigation of partial areas within three landfills (i.e., 218-W-4C, 218-E-10, 218-E-12B), as well as the entire area of the 218-W-6 Landfill. These four landfill areas are located with the 200 West and 200 East Areas of the Hanford Site. The collective footprint of these four areas is about 65 hectares (160 acres).

The purpose of this investigation is to evaluate and determine whether dangerous waste and/or other mixed waste was placed in four landfill areas. Earlier assessments of process knowledge indicate that these areas have not been used for waste disposal. However, to gain additional confidence in the history of these areas, plans for additional investigation were described and approved in *200-SW-1 Nonradioactive Landfills Group Operable Unit and 200-SW-2 Radioactive Landfills Group Operable Unit Remedial Investigation/Feasibility Study Work Plan* (DOE/RL-2004-60, Rev. 0).

This investigation reviewed and evaluated multiple lines of evidence to assess whether the four landfill areas were develop or used. The lines of evidence included the following:

- The Solid Waste Information and Tracking System information
- Engineering design drawings
- Historical aerial photographs
- Physical walk downs of the areas
- Aerial radiation surveys
- Surface geophysical investigations

The results of this investigation support a conclusion that the four landfill areas have not been used in the past for purposes of solid waste disposal.

Removal of these four landfill areas from further remedial investigation could be accomplished using RL-TPA-90-0001, 2007, *Tri-Party Agreement Handbook Management Procedures*, Guideline Number TPA-MP-14 Procedure, "Maintenance of the Waste Information Data System (WIDS)" to reclassify these unused areas as rejected waste sites. This process would allow for documentation of the conclusions reached in this report.

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Terms

DOE	U.S. Department of Energy
Ecology	Washington State Department of Ecology
OU	operable unit
RCRA	*Resource Conservation and Recovery Act*
RI/FS	remedial investigation/feasibility study
SAP	sampling and analysis plan
SWITS	Solid Waste Information and Tracking System
Tri-Parties	Washington State Department of Ecology, U.S. Environmental Protection Agency, and U.S. Department of Energy
TSD	treatment, storage, and/or disposal

1 Introduction

1.1 Background

The 200-SW-2 Operable Unit (OU) currently includes 25 solid waste landfills that are located in the 200 West and 200 East Areas of the Hanford Site. Figures 1-1, 1-2, and 1-3 are maps showing the location of the Hanford Site and the locations of the 200-SW-2 landfills within the 200 West and 200 East Areas, respectively.

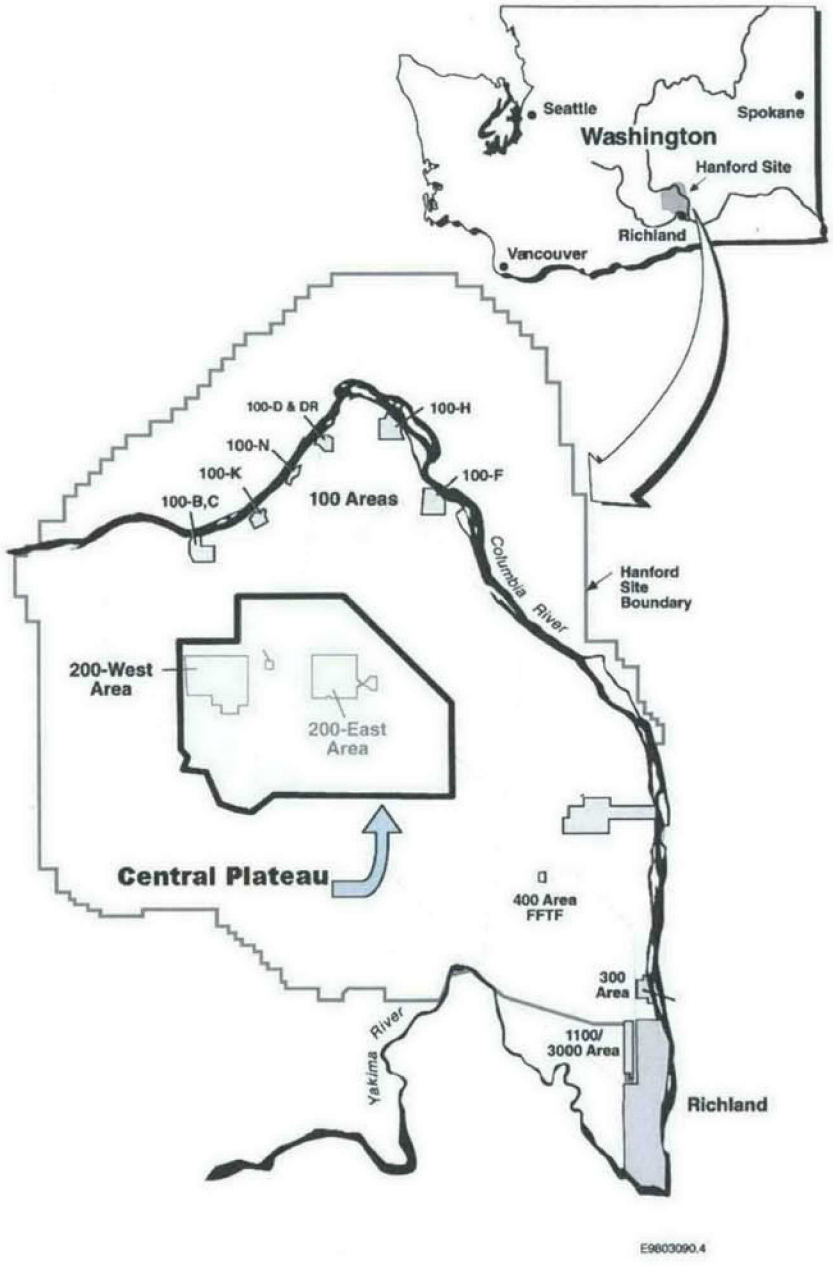

Figure 1-1. Location of the Hanford Site

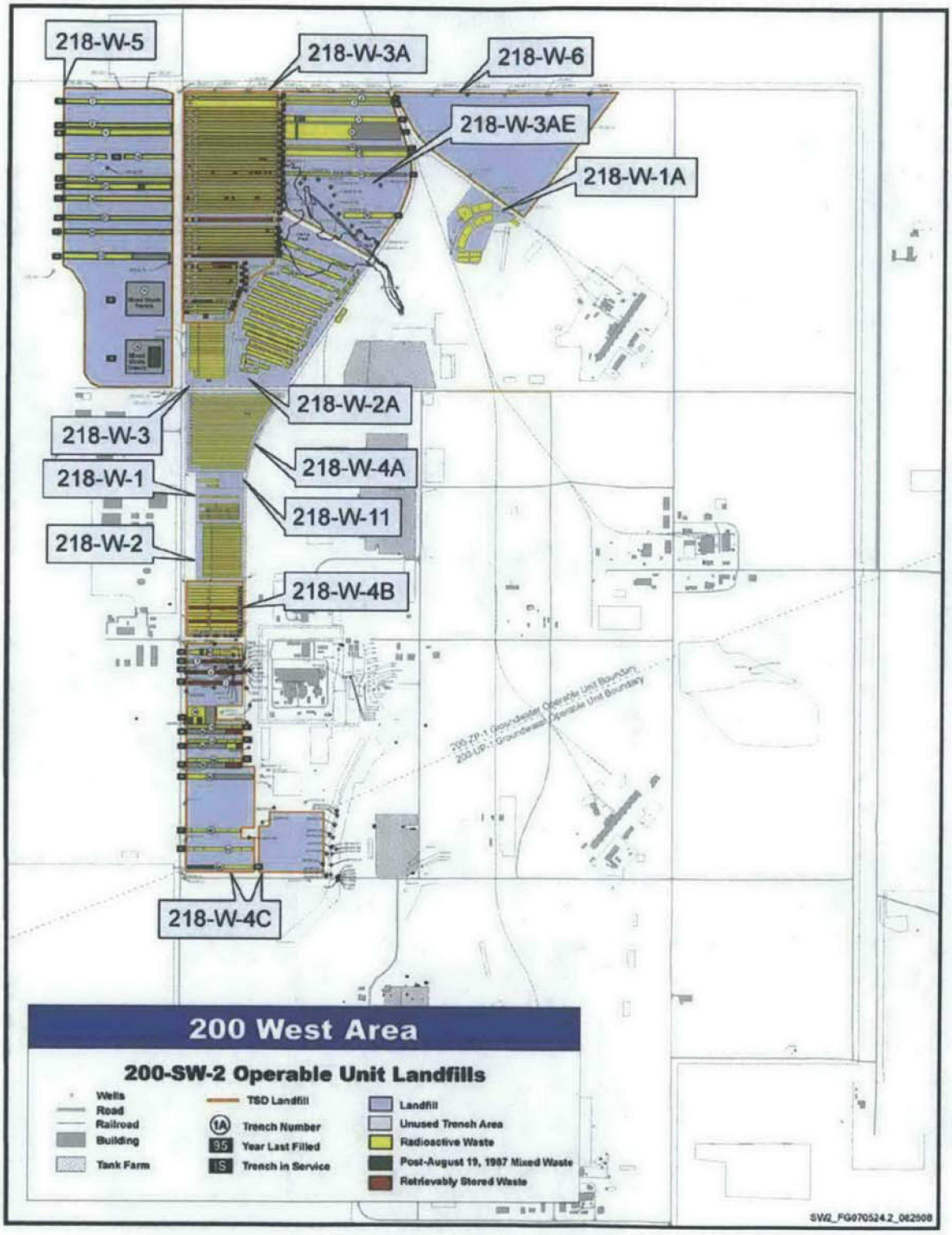

Figure 1-2. Location of 200-SW-2 Operable Unit Landfills in the 200 West Area

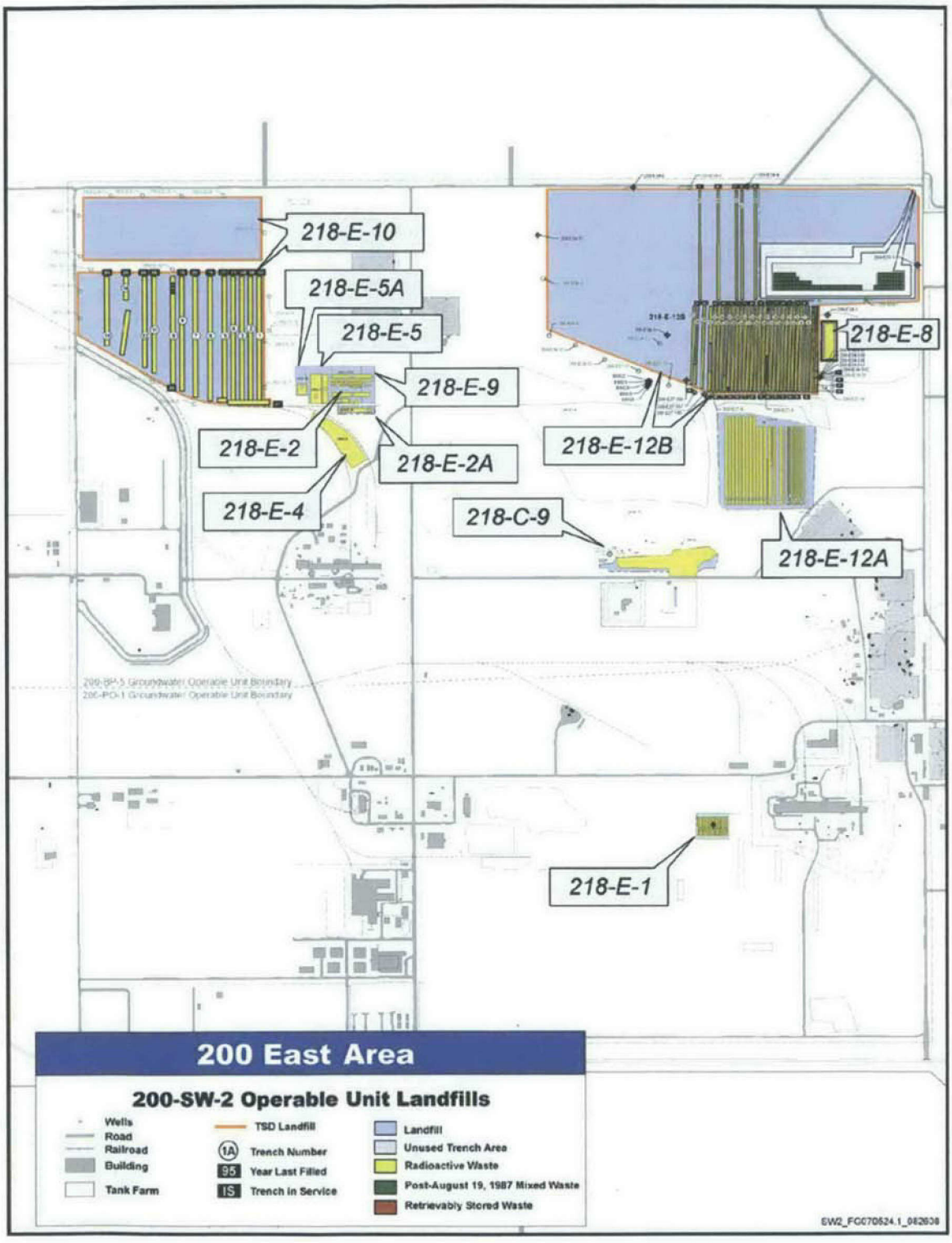

Figure 1-3. Location of 200-SW-2 Operable Unit Landfills in the 200 East Area

From the mid-1940s to 2004, radioactive solid waste was disposed in the pre-planned and designed burial trenches within most of these landfill areas. A detailed description of the background and operational history of each of these landfills is included in DOE/RL-2004-60, *200-SW-1 Nonradioactive Landfills Group Operable Unit and 200-SW-2 Radioactive Landfills Group Operable Unit Remedial Investigation/Feasibility Study Work Plan* (hereinafter referred to as the remedial investigation/feasibility study [RI/FS] work plan). The RI/FS work plan was approved and published in 2008.

The focus of this report is on four landfills known as the 218-W-4C, 218-W-6, 218-E-10, and 218-E-12B Low-Level Burial Grounds. Each of these sites are currently identified as *Resource Conservation and Recovery Act* (RCRA) treatment, storage, and/or disposal (TSD) units. The 218-W-6 landfill has been moved from the 200-SW-2 OU into the 200-OA-1 OU. This move was based on the understanding of the Washington State Department of Ecology (Ecology), the U.S. Environmental Protection Agency, and the U.S. Department of Energy (DOE) (collectively referred to as the Tri-Parties) that this landfill has never been used. (Ecology et al., 1989, Revise Tri-Party Agreement Appendix C to Align Operable Unit Assignments with Proposed Central Plateau Decisions, C-09-07).

The sampling and analysis plan (SAP) that is included in Appendix A of the RI/FS work plan identifies a number of investigations that were planned for the 200-SW-2 OU. One of these investigations involves an additional evaluation the **unused areas of four different landfills areas**. Section A.3.1.1.3 of the SAP includes the following text:

> *"Portions of three of the RCRA TSD unit landfills within the 200-SW-2 OU never have received buried waste. Annexes of the 218-W-4C and 218-E-10 Burial Grounds, as well as unused portions of the 218-E-12B Burial Ground, were intended to be used for future disposal of waste; however, no waste disposals are known to have taken place in these areas. In addition, the 218-W-6 Burial Ground is not known to have received waste.*
>
> *Visual inspection and surface geophysical surveys of unused portions and annexes of landfills will be performed, coupled with review of aerial photographs, to locate disturbed soil within these areas that may indicate the presence of buried waste. Other historical information also may be reviewed to determine if waste has been buried at these sites.*
>
> *After field surveys are completed, these areas of unused landfills will be administratively reclassified in the Waste Information Data System database. Those steps required to reclassify these areas are described in Chapter 5.0 of the RI/FS work plan."*

Most landfill areas included in this investigation were annexed in the mid-1980s for future/potential growth.

1.2 Purpose and Objectives

The purpose of this investigation is to evaluate and determine whether dangerous waste and/or other mixed waste was placed in four landfill areas within sites 218-W-4C, 218-W-6, 218-E-10, and 218-E-12B. Earlier assessment of process knowledge indicated that these areas have not been used for waste disposal. However, to gain additional confidence in the history of these areas, plans for additional investigation were described and approved in the RI/FS work plan. The unused areas addressed by this investigation comprise approximately 60 hectares (150 acres) of the approximate 225 hectares (556 acres) within the Low Level Burial Grounds landfill disposal unit.

2 Investigation Methods Overview

The multiple lines of evidence were used to complete this investigation are listed below, and followed by summary level descriptions of each activity.

- The Solid Waste Information and Tracking System (SWITS) database
- Engineering design drawings
- Historical aerial photographs
- Physical walk downs of the areas
- Aerial radiation surveys
- Geophysical investigations
- Personnel interviews

Solid Waste Information and Tracking System Database

The SWITS database serves as the information repository for buried solid waste at the Hanford Site. SWITS include a wide range of data fields including waste generator, waste container type, waste disposal locations/coordinates, waste volumes, contaminant inventory, etc. The SWITS database was queried October 27, 2009, for the presence of any buried waste information associated with the footprint of each of the respective unused landfill areas.

Engineering Design Drawings

Similar to other structures on the Hanford Site, engineering drawings exist for landfill facilities. The 200 Area facilities are documented on drawings beginning with an H-2 prefix. Drawings for landfills provide specific location coordinates for the facility boundaries and locations of buried waste trenches and other features. Engineering drawings reviewed for this investigation included the following (provided in Appendix A):

- 218-W-4C Landfill Annex (southeastern addition to 218-W-4C)– drawing H-2-37437, *Dry Waste Burial Ground 218-W-4C*; drawing H-2-821555, Sheet 8, *Subsidence Drawing Burial Ground 218-W-4C*
- 218-W-6 Landfill – drawing H-2-99933, Sheet 1 and Sheet 2, *Dry Waste Burial Ground 218-W-6*
- 218-E-10 Landfill Annex (northern addition to 218-E-10)– drawing H-2-92004, *Industrial Burial Ground 218-E-10 Site—Plan and Details* (site plan); drawing H-2-821555, Sheet 4, *Subsidence Drawing Burial Ground 218-E-10*; drawing H-2-96660, Sheet 1, *East Area Dry Waste Burial Ground*
- 218-E-12B Landfill (area west of Trench 37) – drawing H-2-33276, Sheets 5 and Sheet 6, *Dry Waste Burial Ground 218-E-12B*; drawing H-2-96660, Sheet 2, *East Area Dry Waste Burial Ground*; drawing H-2-821555,Sheet 5 and Sheet 6, *Subsidence Drawing Burial Ground 218-E-12B*

Historical Aerial Photographs

Aerial photographs that depict each of the areas of interest were reviewed for signs or indication of buried waste activity. The photographs selected for review cover a multi-decade period, typically spanning 30 or more years.

Physical Surface Walk-Downs of Sites

The DOE, Ecology and contractor representatives participated in field inspections of each of the areas of interest. All sites were reviewed to determine if there were an feature on the ground surface that could suggest that burial of waste had occurred.

Aerial Radiation Surveys

Imagery from airborne radiation surveys were reviewed for any indications that could suggest the burial of waste within the areas of interest.

Surface Geophysical Investigations

Surface geophysical investigations were conducted on each of the sites from 1973 to 1974 to assess the areas for subsurface anomalies. The deployed technologies included ground penetrating radar; Frequency Domain Electromagnetic Induction (using a Geonics EM31 Terrain Conductivity Meter[1]) and total magnetic field/vertical magnetic gradient (using a Geometrics G-858G Magnetometer/Gradiometer[2]).

Personnel Interviews

Interviews were held with key individuals with first-hand and historic process knowledge of the specific landfill locations. Discussions were held to assess the general history of these areas and/or to help possibly explain the origin of any unique surface features.

3 Investigation Results for Each Landfill Area

The following subsections provide a summary of the investigation results for each of the respective landfill areas of interest. The summary-level narrative for each landfill area references additional detail and/or supporting information that is included in appendices to this report. The appendices include the following information:

- Appendix A – Engineering Drawings
- Appendix B – Historic Aerial Photos
- Appendix C – Aerial Radiation Survey Images
- Appendix D – Surface Geophysical Investigation

3.1 218-W-4C Annex

Conclusions Based on Reviews of SWITS

SWITS does not include any record of buried waste within the 218-W-4C Annex area.

Conclusions Based on Reviews of Engineering Drawings

Engineering design drawings reviewed for the 218-W-4C Annex indicated that there were no buried waste trenches designed, constructed, or used within this area. Appendix A, Figures A-1 series, includes images of the drawings reviewed for this investigation.

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

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

Conclusions Based on Reviews of Historical Aerial Photographs

Aerial photos reviewed for the 218-W-4C Annex support the determination that this area was not used for burial of solid waste. Images of aerial photographs ranging from 1950s to 1990s were reviewed for this investigation; examples are included in Appendix B, Figure B-1 series.

Conclusions Based on Inspection of Site Surfaces by Physical Walk-Downs

A site physical walk-down was conducted on October 26, 2007 and again with DOE and Ecology staff on August 6, 2008. Both inspections identified miscellaneous debris on the surface of the 218-W-4C Annex. Surface debris included three piles of soil/asphalt/concrete, sections of a weather tower, polyvinyl chloride piping with sampling tubes (likely from an abandoned soil vapor sampling experiment), a wood pallet, and a metal plate.

Conclusions Based on Review of the Aerial Radiation Surveys

The review of aerial radiation survey results from 1973 to 1974 did not reveal any sources of contamination that originated from the 218-W-4C Annex area. Appendix C provides images of the radiation survey results that include the 218-W-4C Annex area.

Conclusions Based on Surface Geophysical Investigations

Surface geophysical investigations did not identify the presence of any buried waste or trench-like features at this site. Appendix D provides further detail on the geophysical investigation for this site.

Conclusions Based on Personnel Interviews

Discussions with experienced field operations staff did not result in any information that suggests that waste has been buried in the 218-W-4C Annex area.

3.2 218-W-6 Annex

Conclusions Based on Reviews of SWITS

SWITS does not include any record of buried waste within the 218-W-6 site.

Conclusions Based on Reviews of Engineering Design Drawings

Engineering design drawings reviewed for the 218-W-6 indicated that there were no buried waste trenches designed, constructed, or used within this area. Appendix A, Figures A-2 series, includes images of the drawings reviewed for this investigation.

Conclusions Based on Reviews of Historical Aerial Photographs

Aerial photos reviewed for the 218-W-6 site support the determination that this area was not used for burial of solid waste. Images of aerial photographs ranging from 1950s to 1990s were reviewed for this investigation; examples are included in Appendix B, Figure B-2 series.

Conclusions Based on Inspection of Site Surfaces by Physical Walk-Downs

A site walk-down was conducted on October 26, 2007 and again with DOE and Ecology staff on August 6, 2008. The walk-downs did identify miscellaneous debris on the surface of the 218-W-6 site. Observed surface debris included two sections of wire rope, and several pieces of plywood. In addition, for purposes of fire protection, most of the area was scraped previously of vegetation. The scraped debris (comprised of soil and sagebrush) has been mounded into about seven tall piles.

Conclusions Based on Review of the Aerial Radiation Surveys

The review of aerial radiation survey results from prior years did not reveal any sources of contamination that originated from the 218-W-6 area. Appendix C provides images of the radiation survey results that include the 218-W-6 site.

Conclusions Based on Surface Geophysical Investigations

Surface geophysical investigations did not identify the presence of any buried waste or trench-like features at this site. Appendix D provides further detail on the geophysical investigation for this site.

Conclusions Based on Personnel Interviews

Discussions with experienced field operations staff did not result in any information that suggests that waste has been buried in the 218-W-6 area.

3.3 218-E-10 Annex

Conclusions Based on Reviews of SWITS

SWITS does not include any record of buried waste within the 218-E-10 Annex area.

Conclusions Based on Reviews of Engineering Design Drawings

Engineering drawings reviewed for the 218-E-10 Annex indicated that there were no buried waste trenches designed, constructed, or used within this area. Appendix A, Figures A-3 series, include images of the drawings reviewed for this investigation.

Conclusions Based on Reviews of Historical Aerial Photographs

Aerial photos reviewed for the 218-E-10 Annex support the determination that this area was not used for burial of solid waste. Images of aerial photographs ranging from 1950s to 1990s were reviewed for this investigation; examples are included in Appendix B, Figure B-3 series.

Conclusions Based on Inspection of Site Surfaces via Physical Walk-downs

A site walk-down was conducted on October 26, 2007 and again with DOE and Ecology staff on August 6, 2008. The walk-downs did identify miscellaneous debris on the surface of the 218-E-10 Annex area. Observed surface debris included a small area (<1 m^2 [<11 ft^2]) section of concrete slag (likely from construction of a nearby well), and seven approximately 0.5 m (1.6 ft)-long sections of metal piping laying on the surface or and partially inserted into the surface soil, a steel bar, and a steel wheel.

Conclusions Based on Review of the Aerial Radiation Surveys

The review of aerial radiation survey results from prior years did not reveal any sources of contamination that originated from the 218-E-10 Annex area. Appendix C provides images of the radiation survey results that include the 218-E-10 area.

Conclusions Based on Surface Geophysical Investigations

Surface geophysical investigations did not identify the presence of any buried materials or trench-like features at this site with the exception of an anomaly that is approximately 10 × 20 m (33 × 65 ft) in area centered about N137700 and E572990. Ground-penetrating radar data indicate that this area likely contains shallow, scattered material from 0.3 to 1.0 m (1 to 3.3 ft) below the surface. Appendix D provides further details about the geophysical investigation for this site.

Conclusions Based on Personnel Interviews

Discussions with experienced field operations staff did not result in any information that suggests that waste has been buried in the 218-E-10 Annex area.

3.4 218-E-12B (Area West of Trench 37)

Conclusions Based on Reviews of SWITS

SWITS does not include any record of buried waste within the western portion of the 218-E-12B site.

Conclusions Based on Reviews of Engineering Design Drawings

Engineering design drawings reviewed for the 218-E-12B landfill indicated that there were no buried waste trenches designed, constructed, or used west of Trench 37. Images of the drawings reviewed for this investigation are included in Appendix A, Figures A-4 series.

Conclusions Based on Reviews of Historical Aerial Photographs

Aerial photos reviewed for the western region of the 218-E-12B site support the determination that this area was not used for burial of solid waste. Images of aerial photographs ranging from 1950s to 1990s were reviewed for this investigation; examples are included in Appendix B, Figure B-4 series.

Conclusions Based on Inspection of Site Surfaces by Physical Walk-Downs

A site walk-down was conducted on October 26, 2007 and again with DOE and Ecology staff on August 6, 2008. The walk-downs did identify miscellaneous debris on the surface of the 218-E-10 Annex area. Observed surface debris included a small area (<1 m^2 [11 ft^2]) section of concrete slag and a steel cable.

Conclusions Based on Review of the Aerial Radiation Surveys

The review of aerial radiation survey results from prior years did not reveal any sources of contamination that originated from the 218-E-12B area. Appendix C provides images of the radiation survey results that include the 218-E-12B area.

Conclusions Based on Surface Geophysical Investigations

Surface geophysical investigations did not identify the presence of any buried waste or trench-like features at this site. Appendix D provides further detail on the geophysical investigation for this site.

Conclusions Based on Personnel Interviews

Discussions with experienced field operations staff did not result in any information that suggests that waste has been buried in the western region of the 218-E-12B site.

4 Conclusions

Based on the investigations summarized in the previous sections of this report, there is no evidence of solid waste being buried in the the 218-W-4C Annex, the entire 218-W-6, and the western portion of the 218-E-12B Landfill. Furthermore, the decision to move the 218-W-6 landfill from the 200-SW-2 OU into the 200-OA-1 OU was based on the understanding of the Tri-Parties that this landfill has never been used.

There is one exception to the otherwise benign character of the 218-E-10 Annex as described in Section 3.4. This subsurface anomaly can be seen as a surface expression on the 1954 aerial photograph.

Operations of the 218-E-10 landfill (southern portion) did not begin until 1955. The northern portion of 218-E-10 (the 218-E-10 Annex) is documented as never having been used for waste disposal.

Removal of these four landfill areas from further remedial investigation could be accomplished using RL-TPA-90-0001, 2007, *Tri-Party Agreement Handbook Management Procedures*, Guideline Number TPA-MP-14 Procedure, "Maintenance of the Waste Information Data System (WIDS)" to reclassify these unused areas as rejected waste sites. This process would allow for documentation of the conclusions reached in this report.

5 References

DOE/RL-2004-60, 2008, *200-SW-1 Nonradioactive Landfills Group Operable Unit and 200-SW-2 Radioactive Landfills Group Operable Unit Remedial Investigation/Feasibility Study Work Plan*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://www2.hanford.gov/arpir/?content=findpage&AKey=0901080231.

Resource Conservation and Recovery Act of 1976, 42 USC 6901, et seq. Available at: http://epw.senate.gov/rcra.pdf.

RL-TPA-90-0001, 2007, *Tri-Party Agreement Handbook Management Procedures*, Guideline Number TPA-MP-14, "Maintenance of the Waste Information Data System (WIDS)," Rev. 1, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://www.hanford.gov/files.cfm/TPA-MP14.pdf.

Appendix A

Engineering Drawings

The following pages include images of the engineering design drawings that were reviewed as part of this investigation.

Figures A-1. Engineering Drawing H-2-37437 of the 218-W-4C Landfill

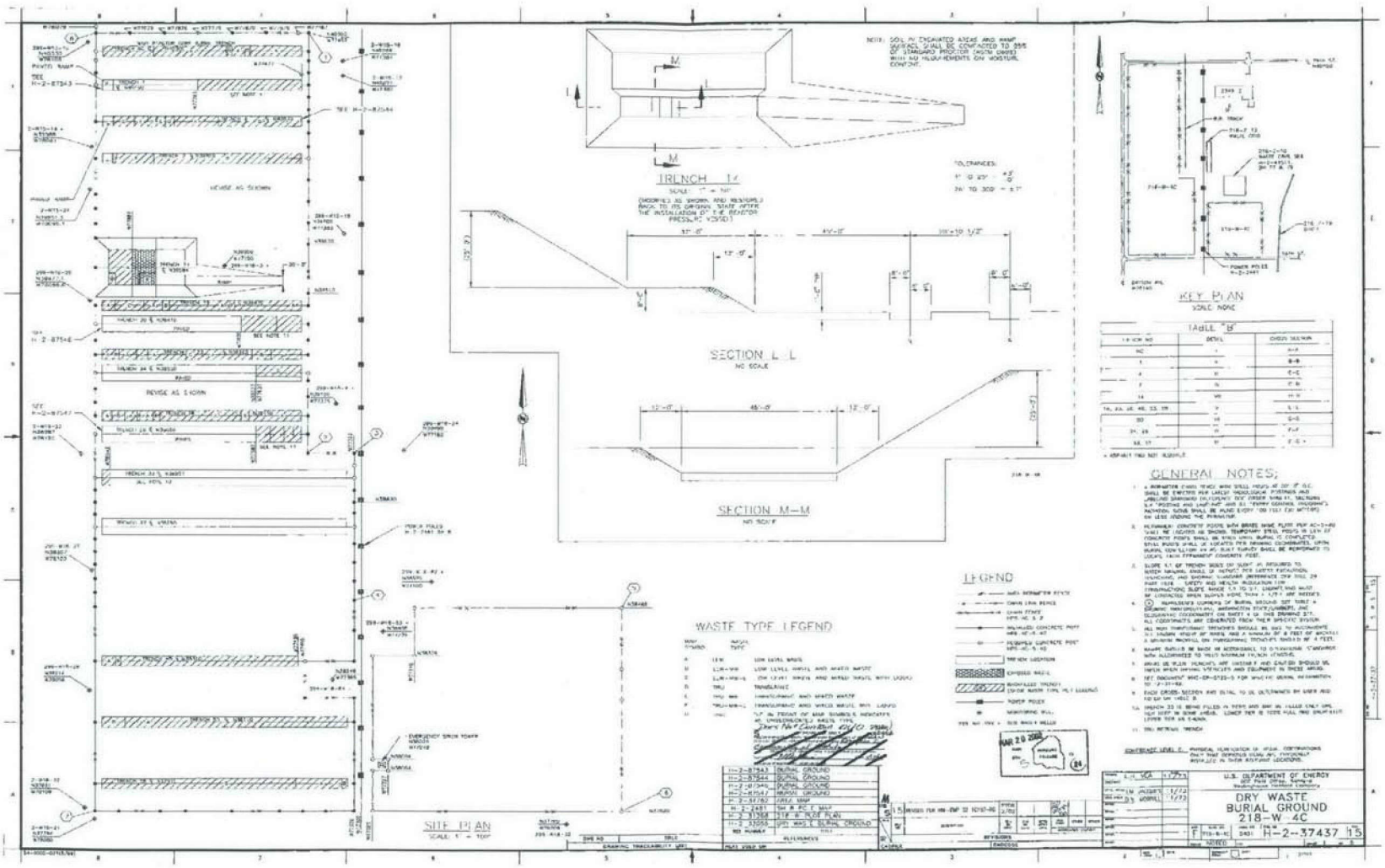


Figure A-2. Engineering Drawing H-2-821555 of the 218-W-4C Landfill

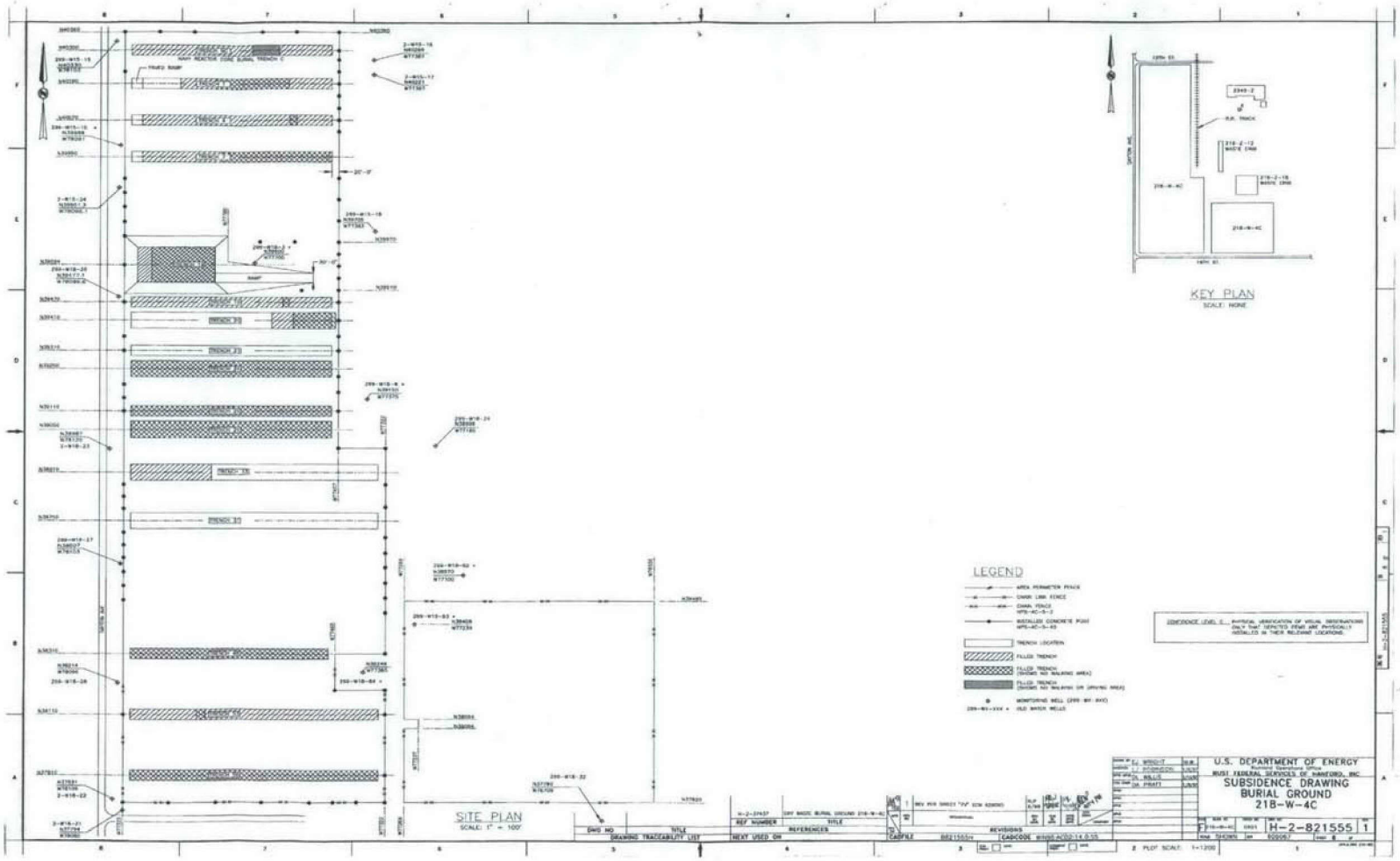


Figure A-3. Engineering Drawing H-2-99933 of the 218-W-6 Landfill

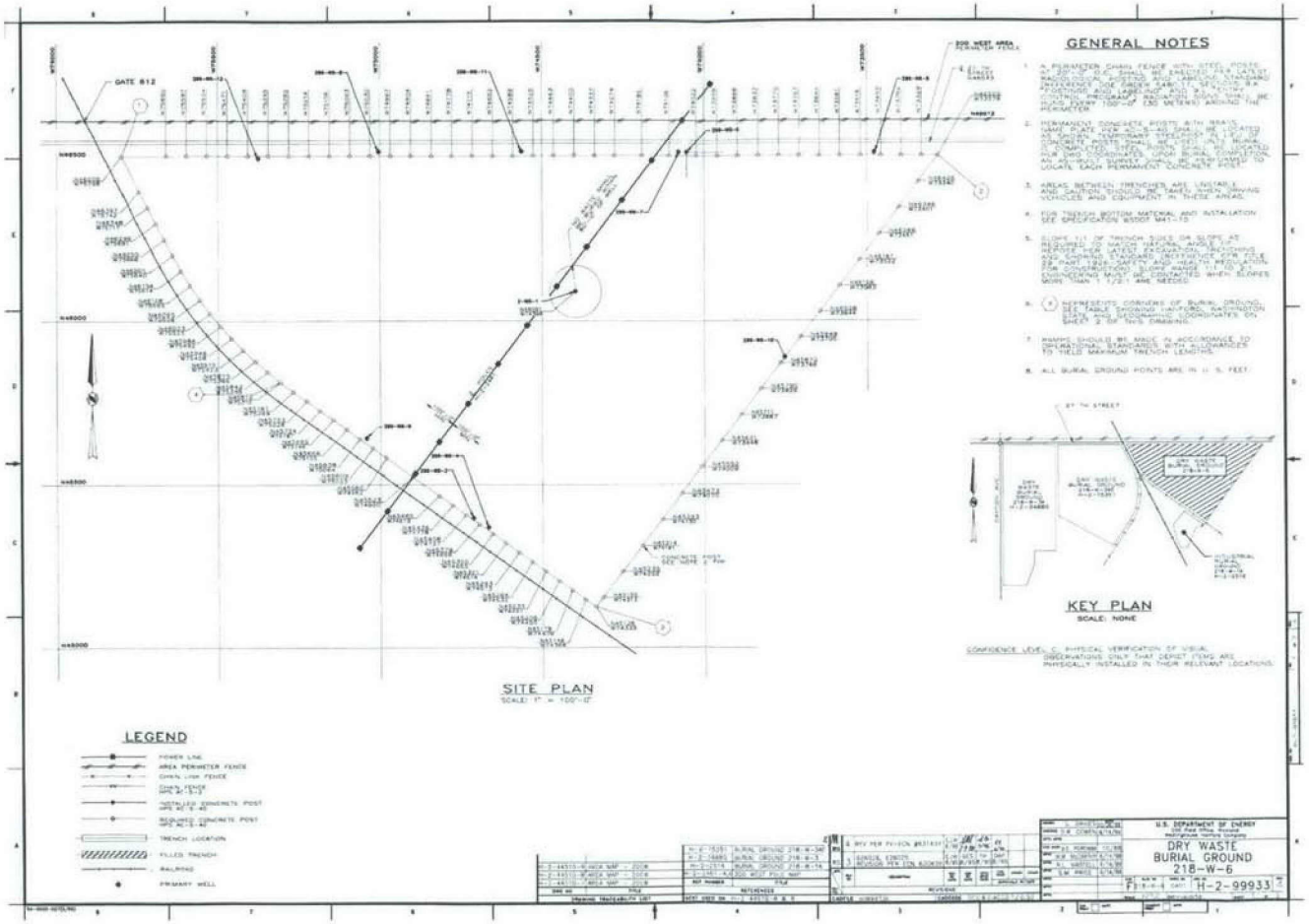
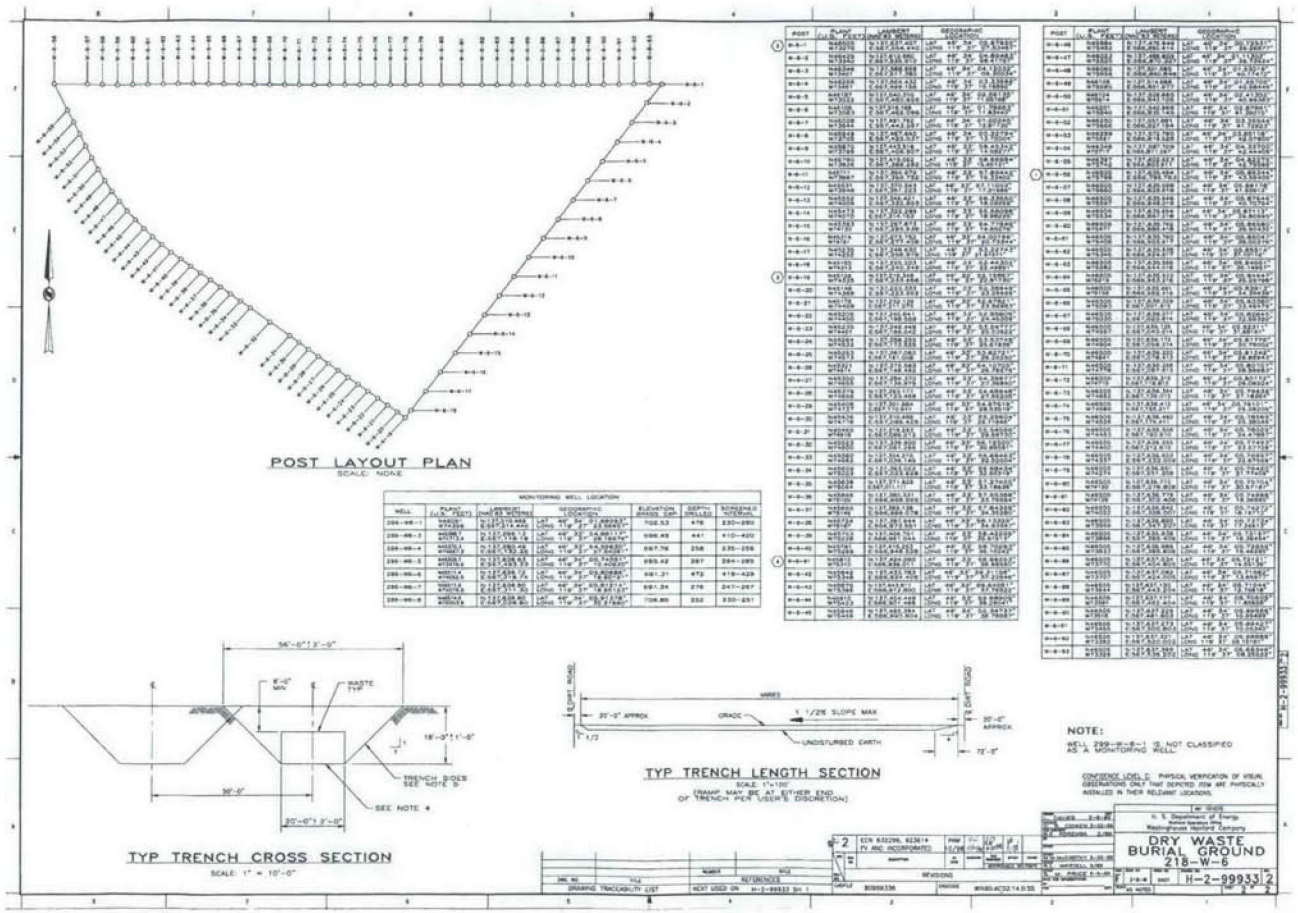


Figure A-4. Engineering Drawing H-2-99933 of the 218-W-6 Landfill



Figures A-5. Engineering Drawing H-2-92004 of the 218-E-10 Landfill

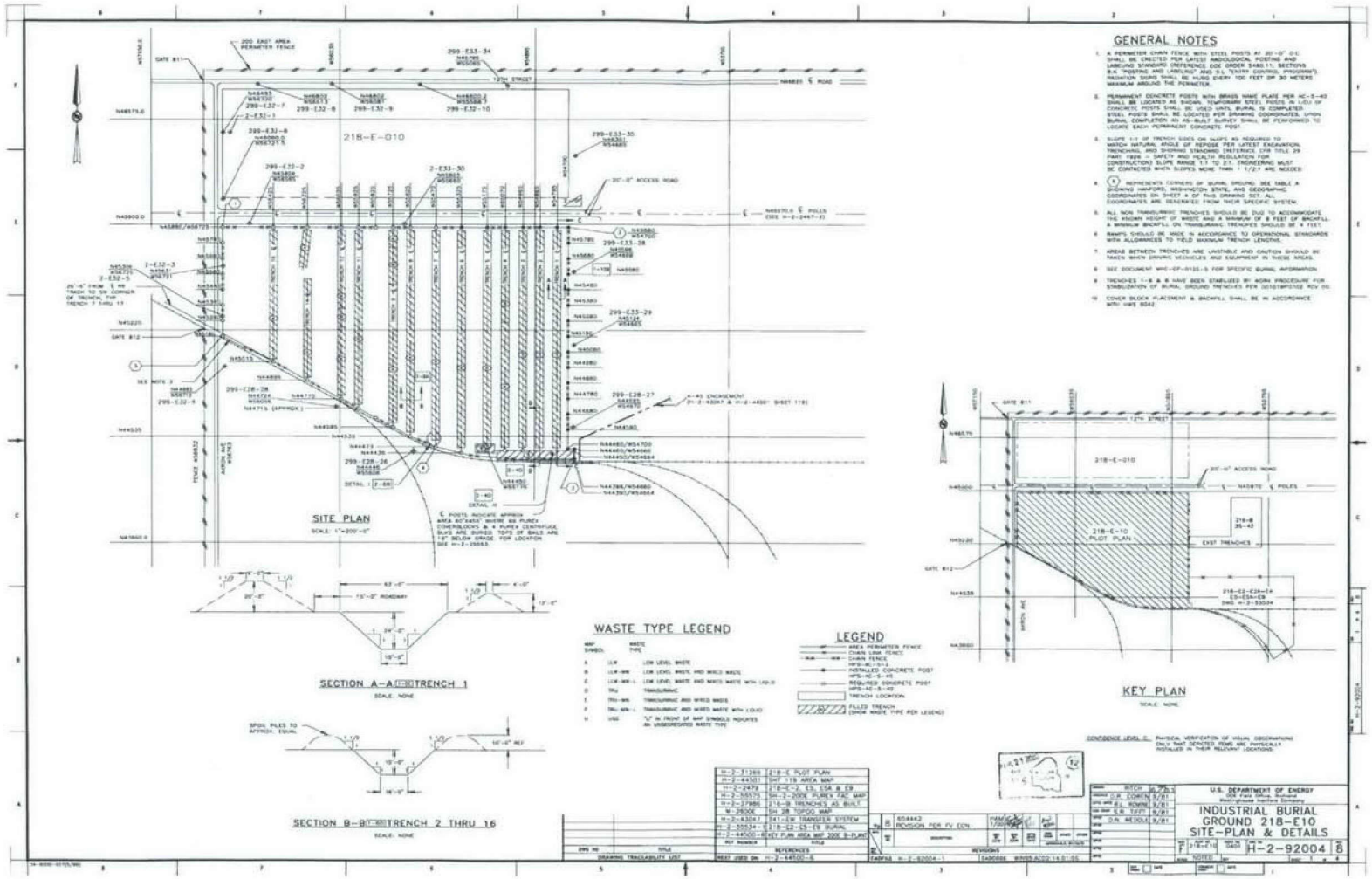
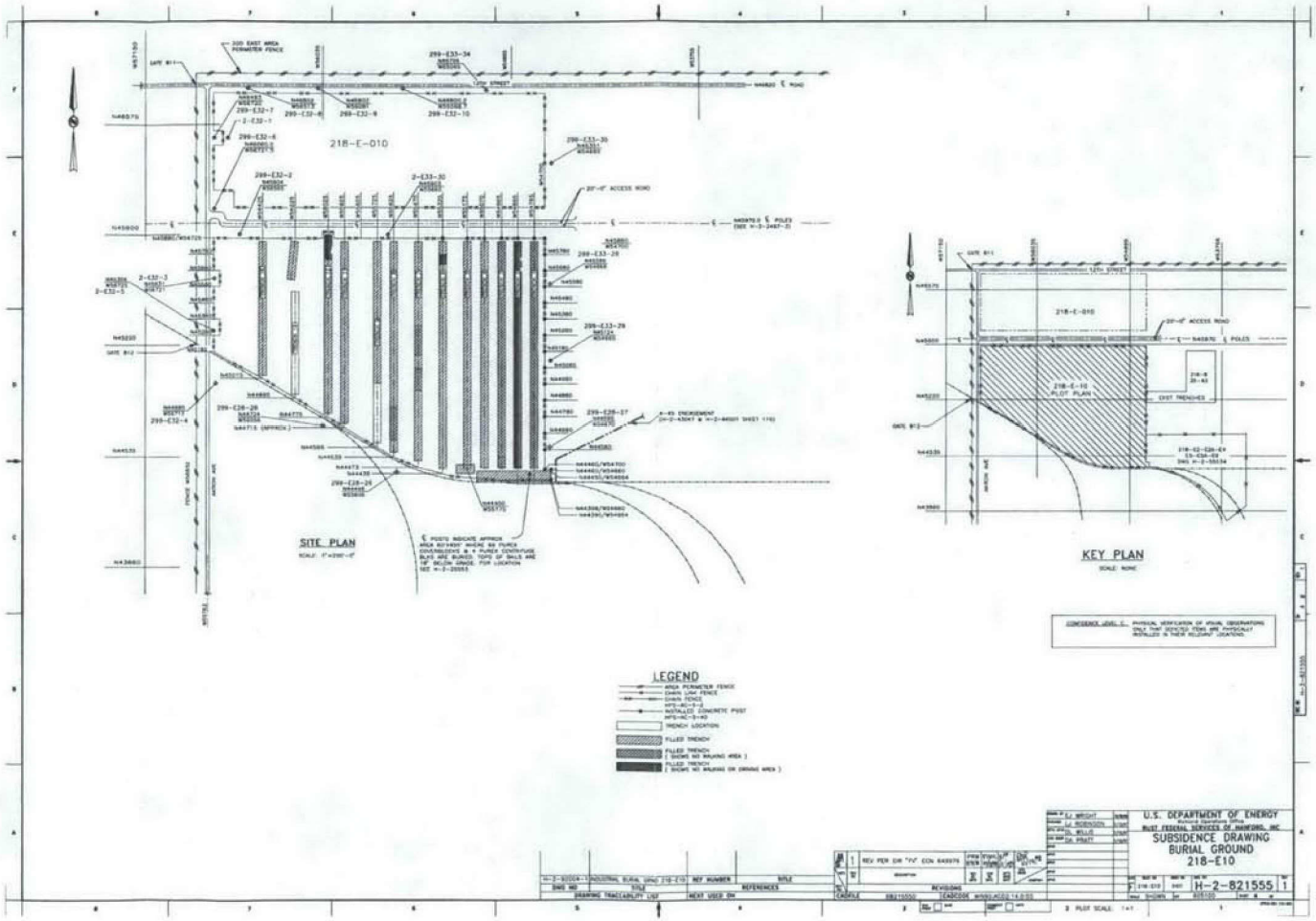


Figure A-6. Engineering Drawing H-2-821555 of the 218-E-10 Landfill



Figures A-7. Engineering Drawing H-2-96660 of the 218-E-10 Landfill

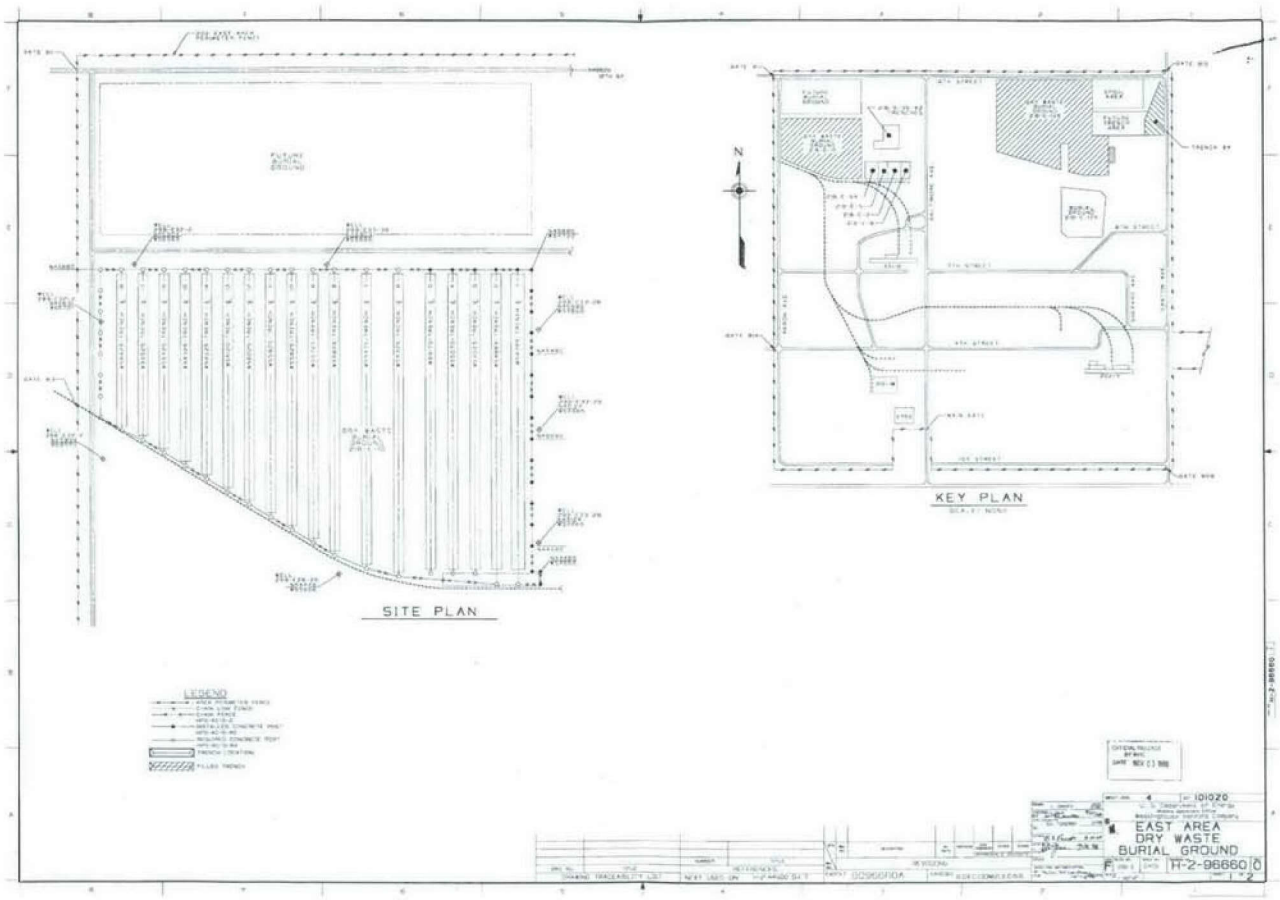


Figure A-8. Engineering Drawing H-2-33276 of the 218-E-12B Landfill

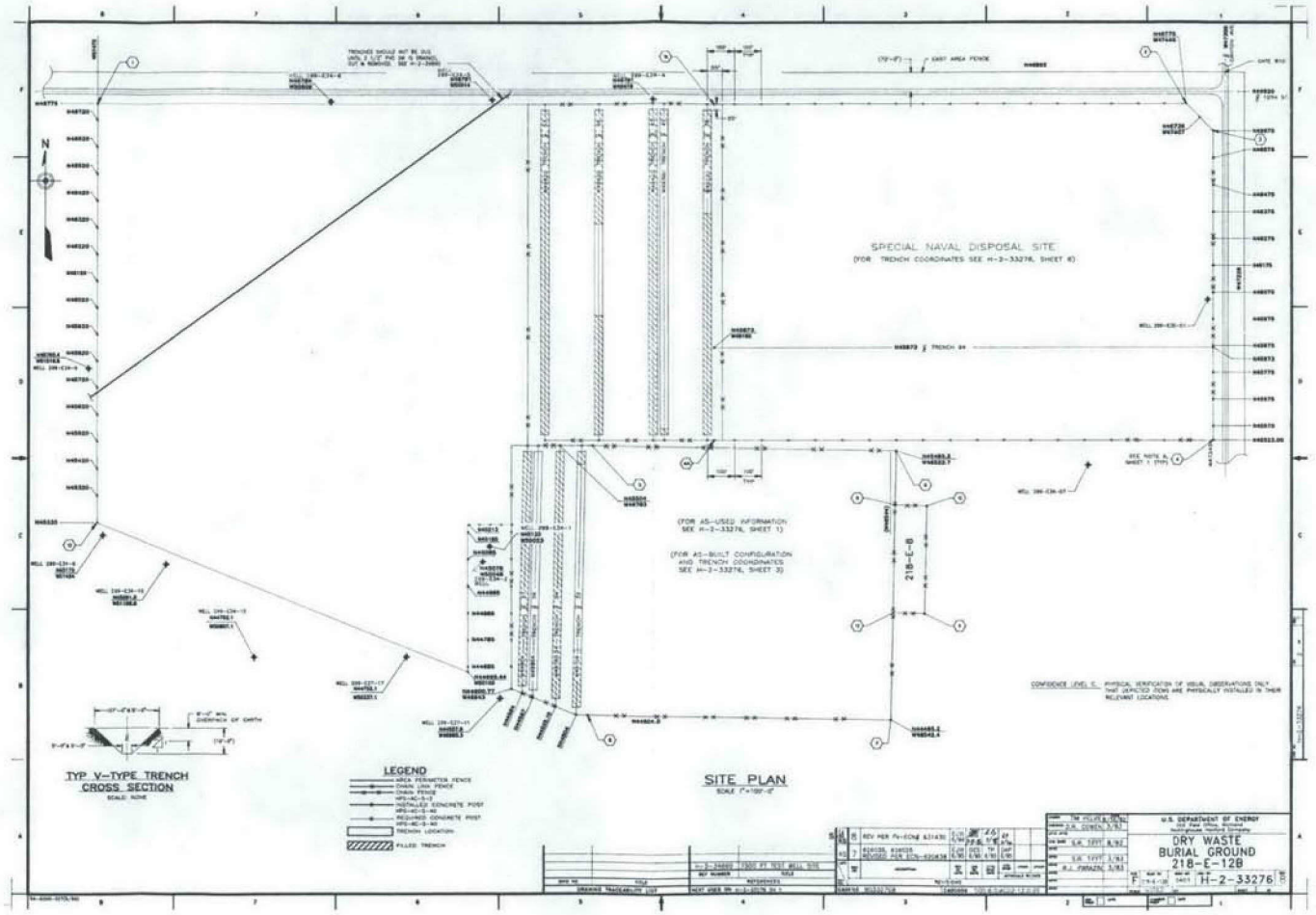


Figure A-9. Engineering Drawing H-2-33276 of the 218-E-12B Landfill

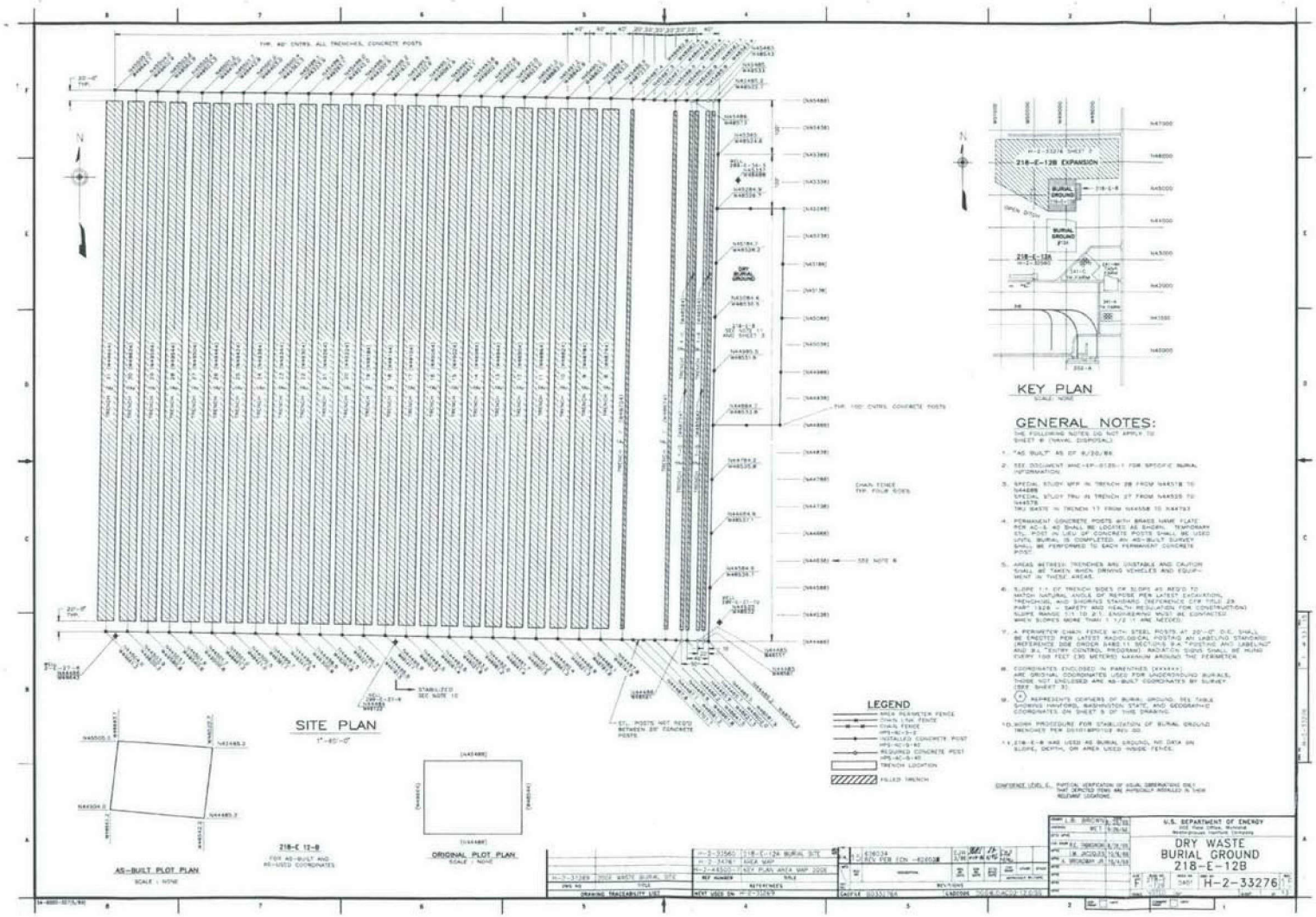


Figure A-10. Engineering Drawing H-2-821555 of the 218-E-12B Landfill

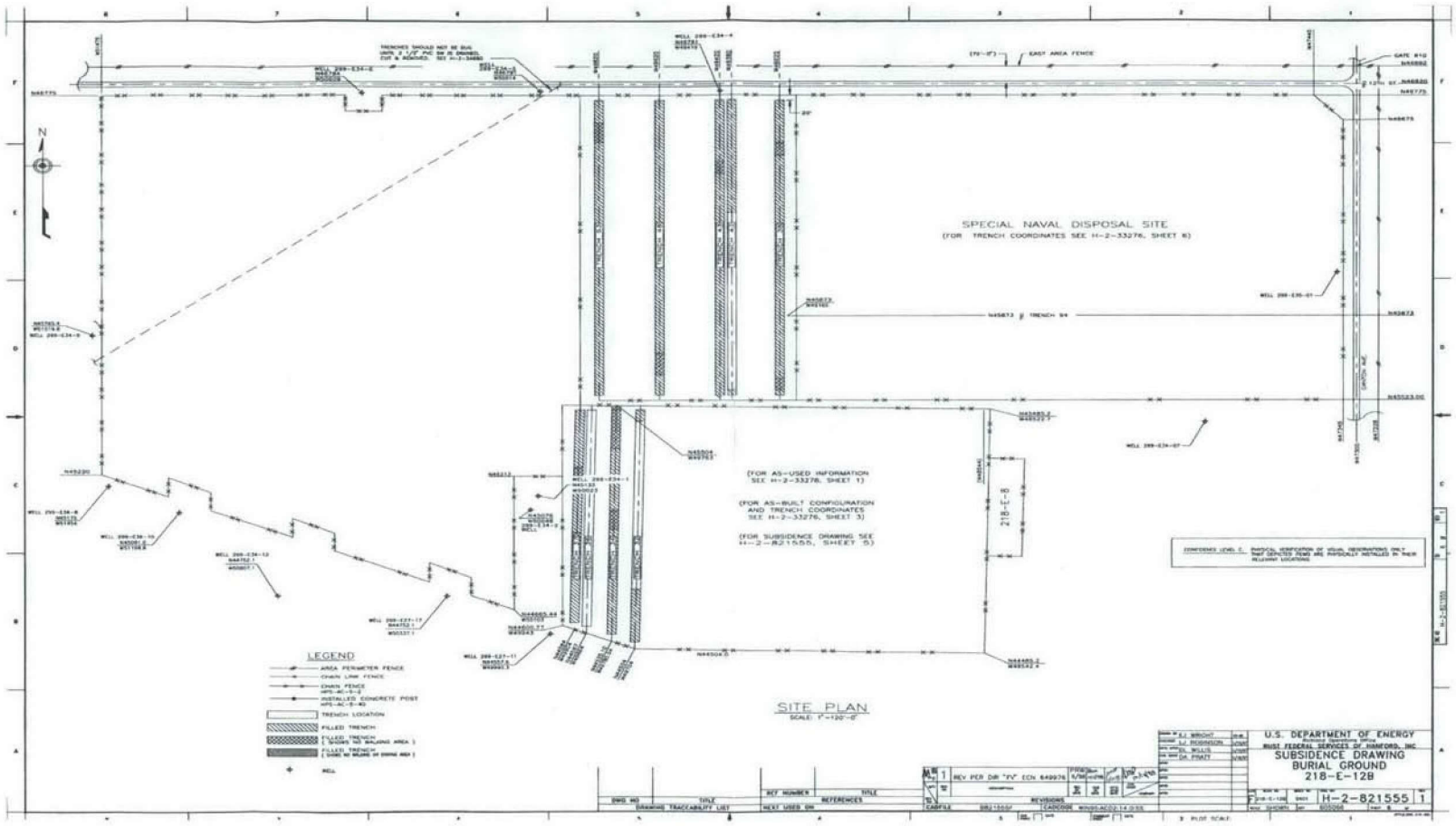


Figure A-11. Engineering Drawing H-2-821555 of the 218-E-12B Landfill

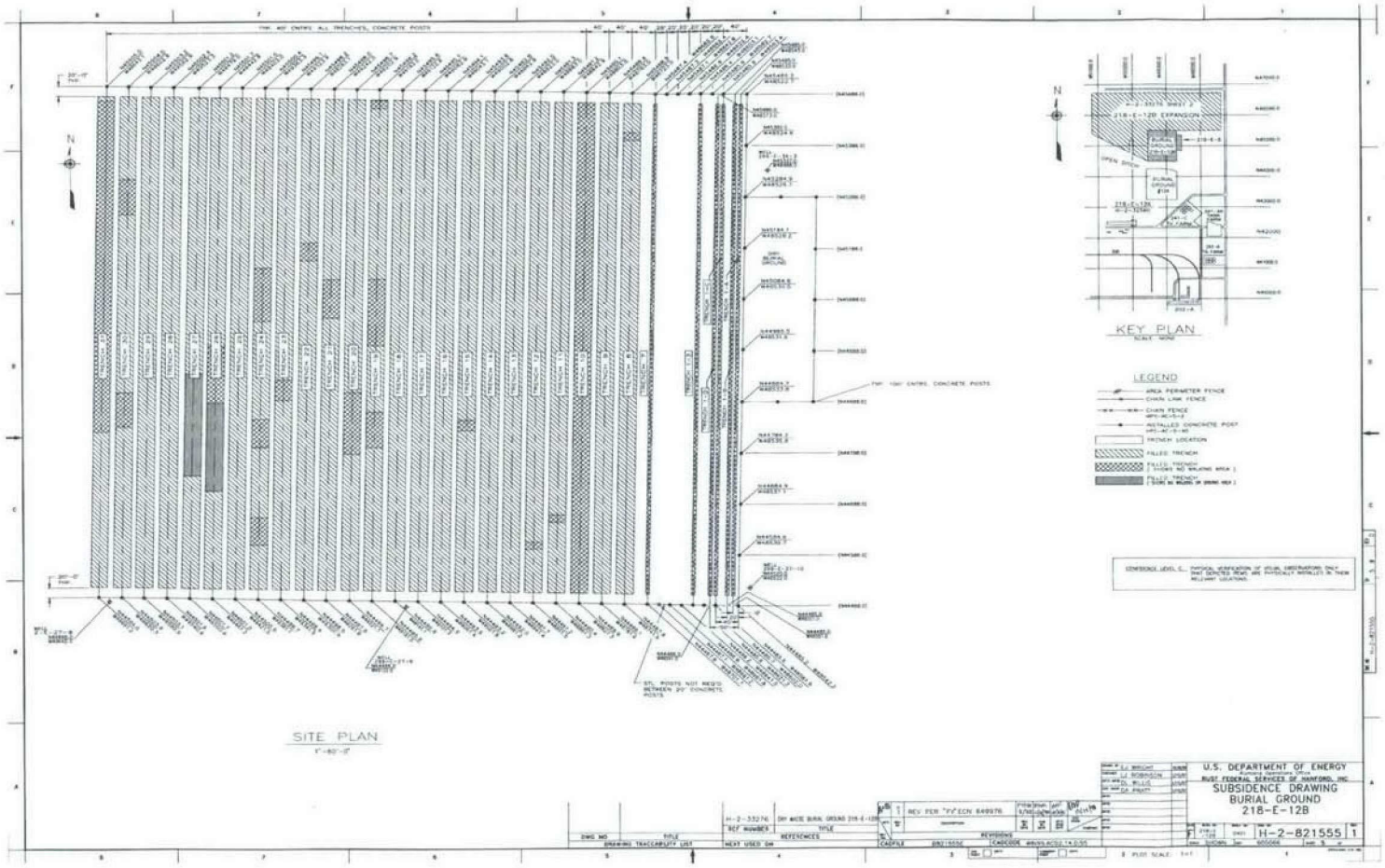
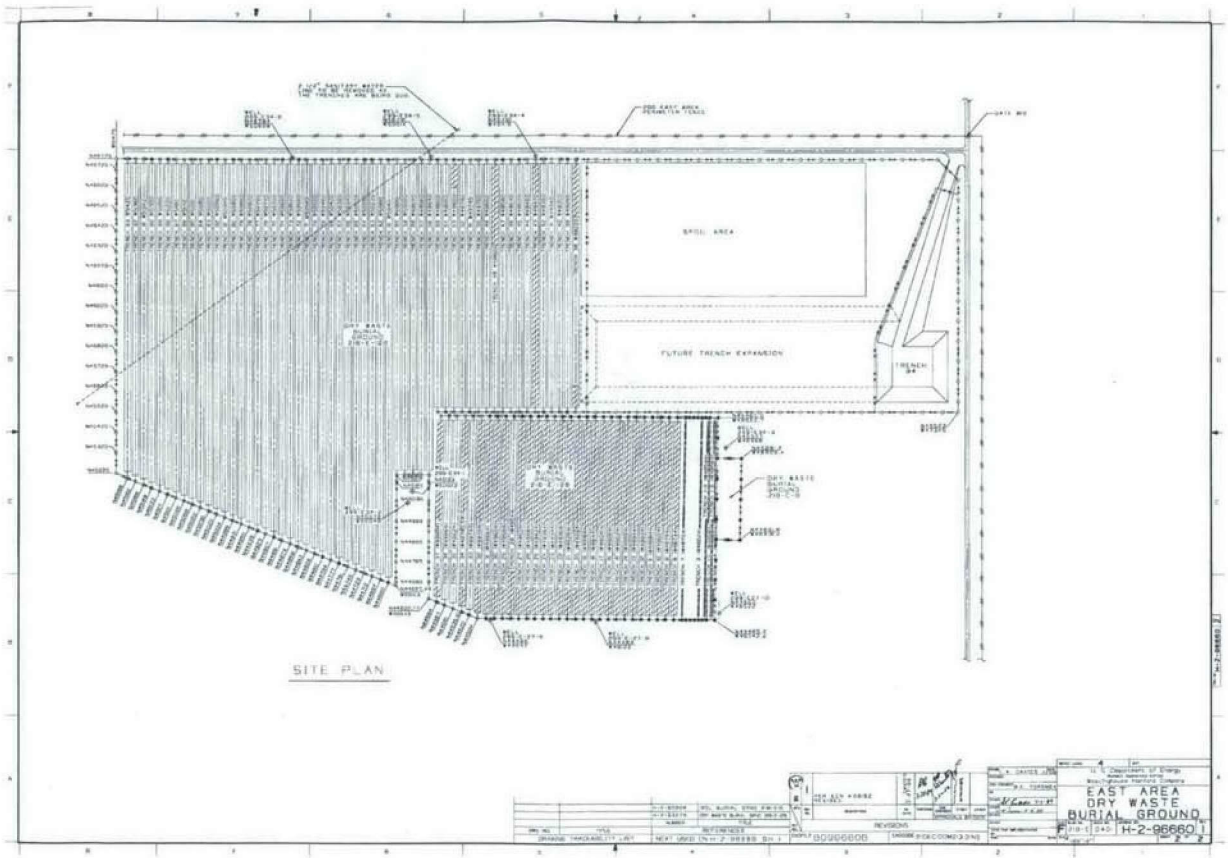


Figure A-12. Engineering Drawing H-2-96660 of the 218-E-12B Landfill



Appendix B

Historical Aerial Photos

The following pages include examples of the historical aerial photographs that were reviewed as part of this investigation.

Figure B-1 Series -- Photographic Chronology Documenting Unused Area of 218-W-4C

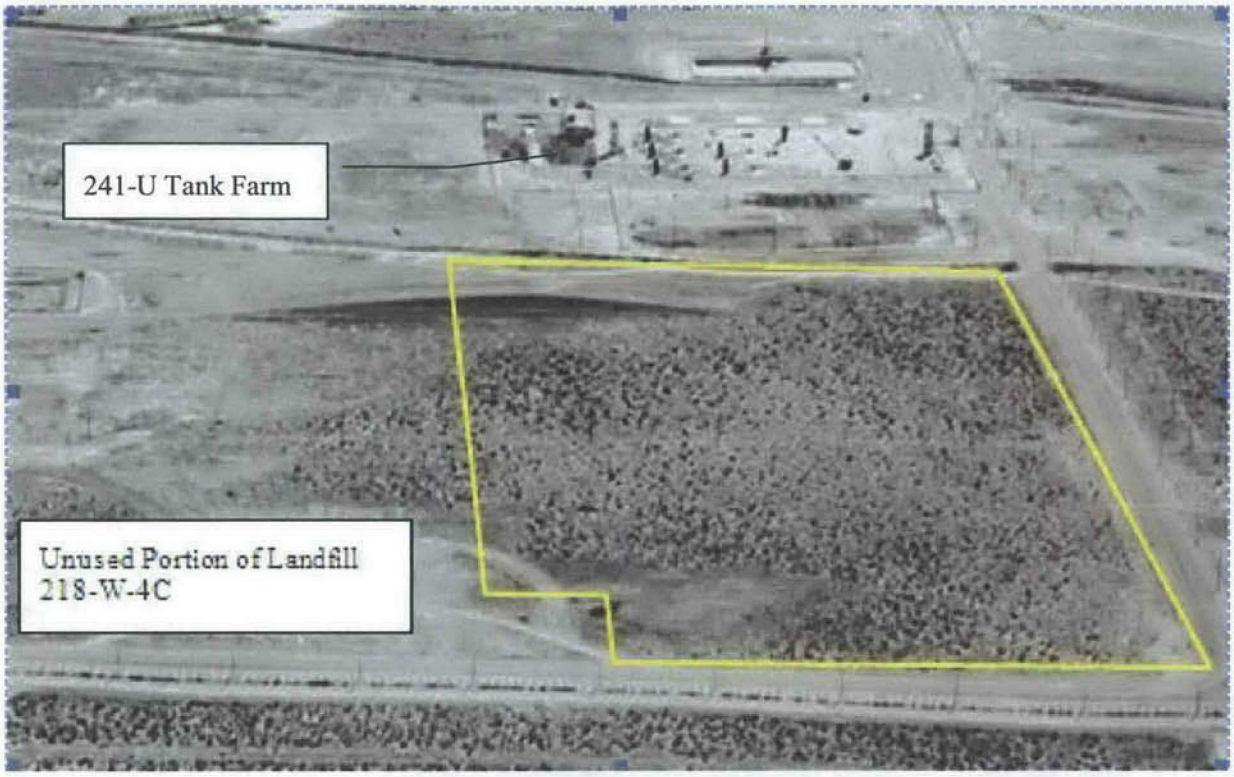


Figure B-1. Aerial Photo, Dated 1956, of 218-W-4C (boundaries are approximate)

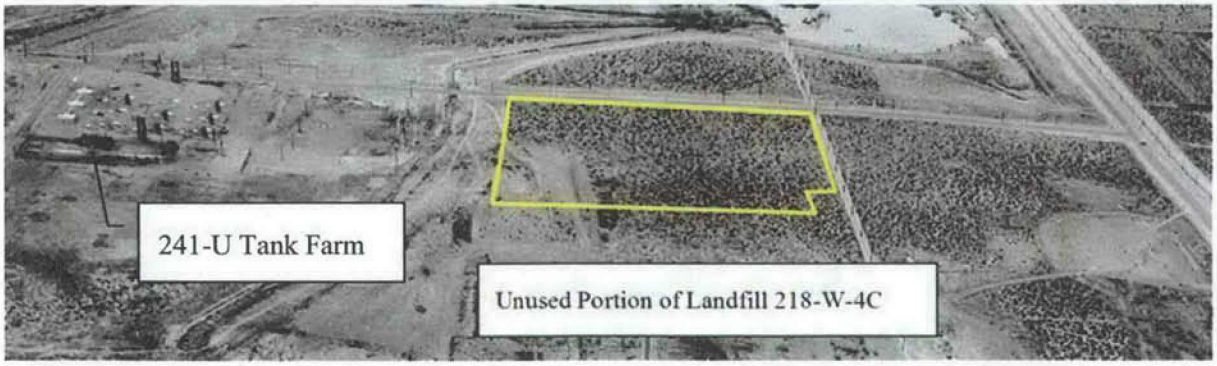


Figure B-2. Aerial Photo, Dated 1962, of 218-W-4C (boundaries are approximate)

Figure B-3. Aerial Photo, Dated 1962, of 218-W-4C (boundaries are approximate)

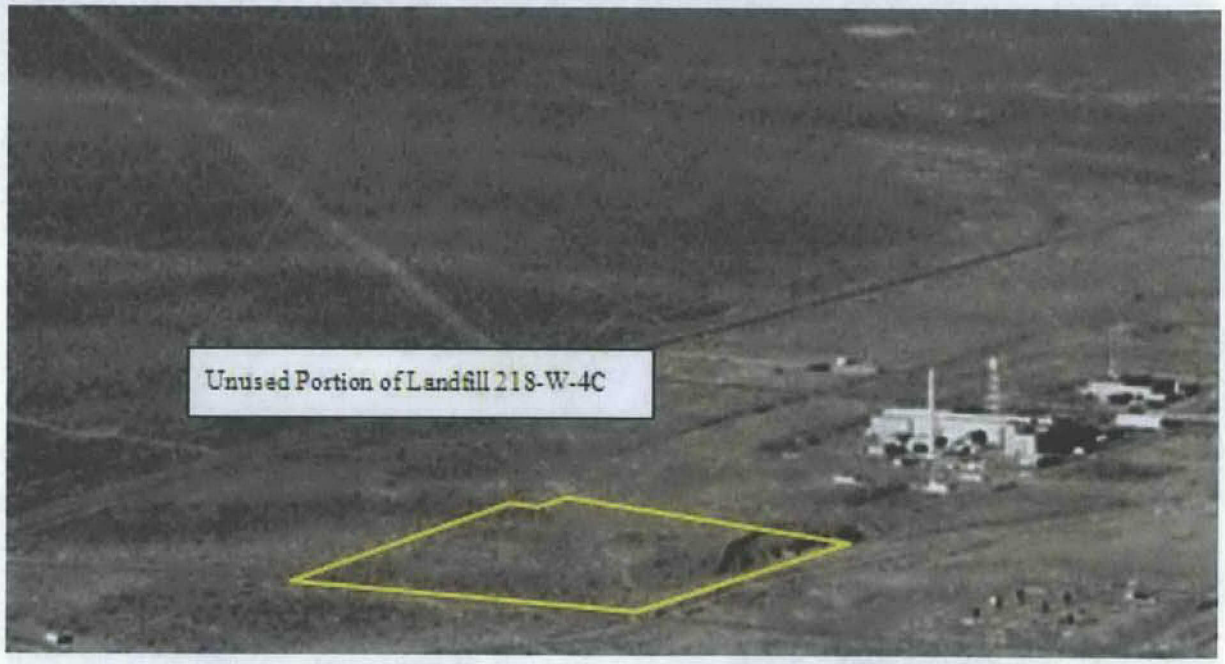


Figure B-4. Aerial Photo, Dated 1973, of 218-W-4C (boundaries are approximate)

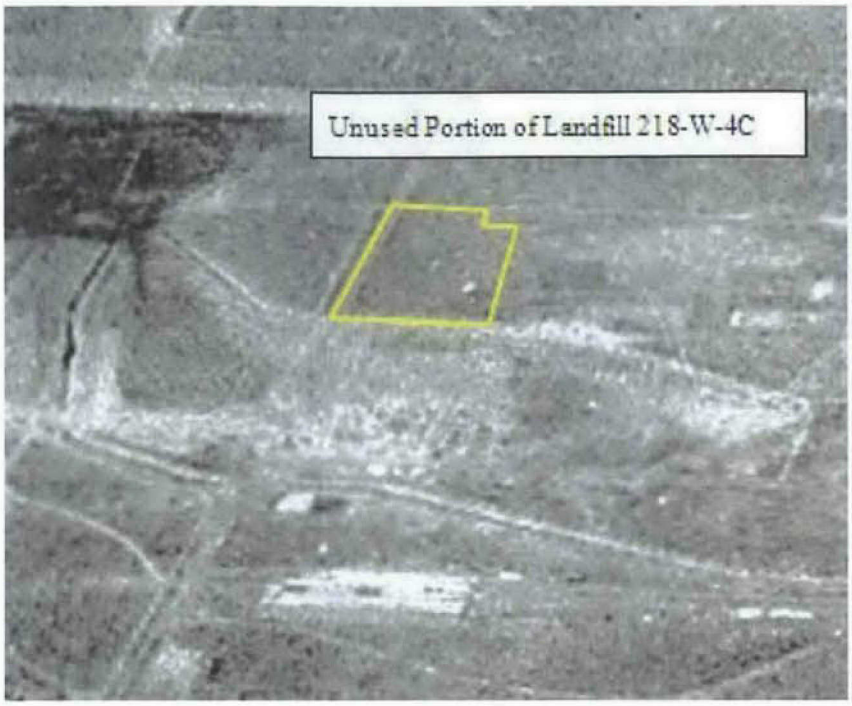


Figure B-5. Aerial Photo, Dated 1975, of 218-W-4C (boundaries are approximate)

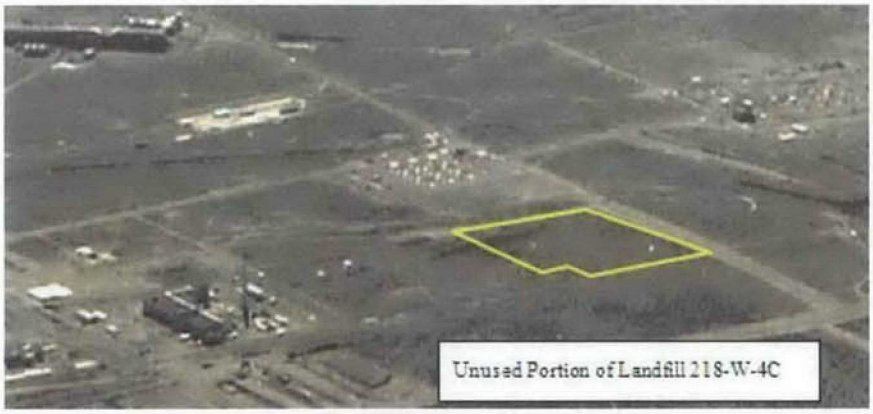


Figure B-6. Aerial Photo, Dated 1980, of 218-W-4C (boundaries are approximate)

Figure B-7. Aerial Photo, Dated 1988, of 218-W-4C (boundaries are approximate)

Figure B-8. Aerial Photo, Dated 2006, of 218-W-4C (boundaries are approximate)

Figure B-2 Series. Photographic Chronology Documenting Unused Landfill 218-W-6

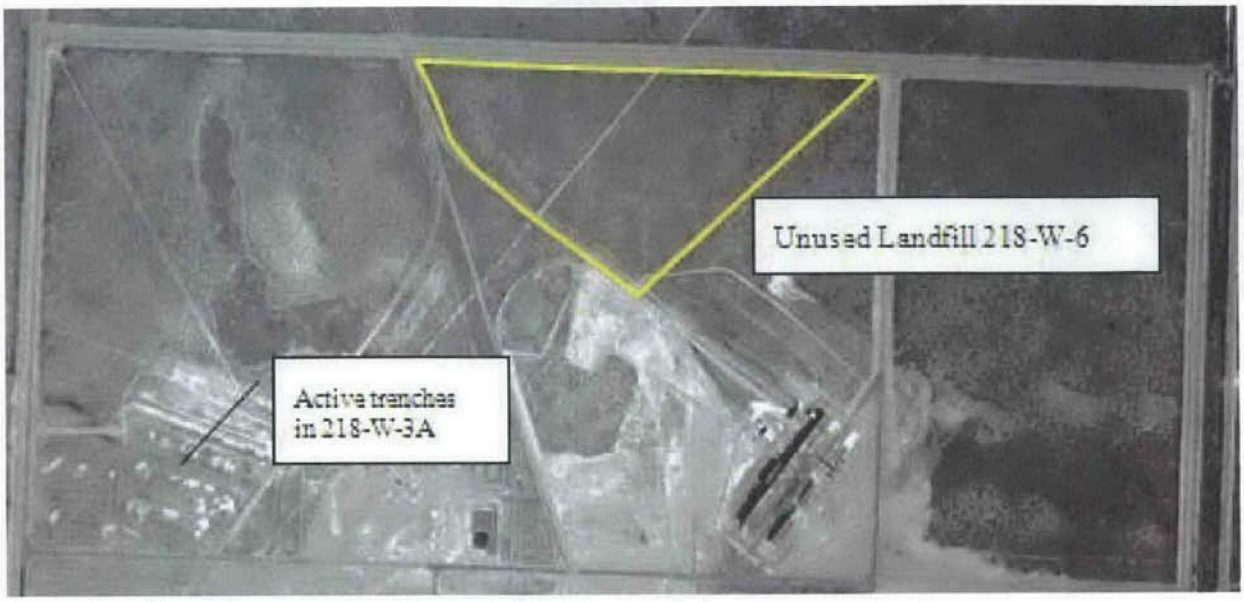


Figure B-9. Aerial Photo, Dated 1969, of 218-W-6 (boundaries are approximate)

Figure B-10. Aerial Photo, Dated 1971, of 218-W-6 (boundaries are approximate)

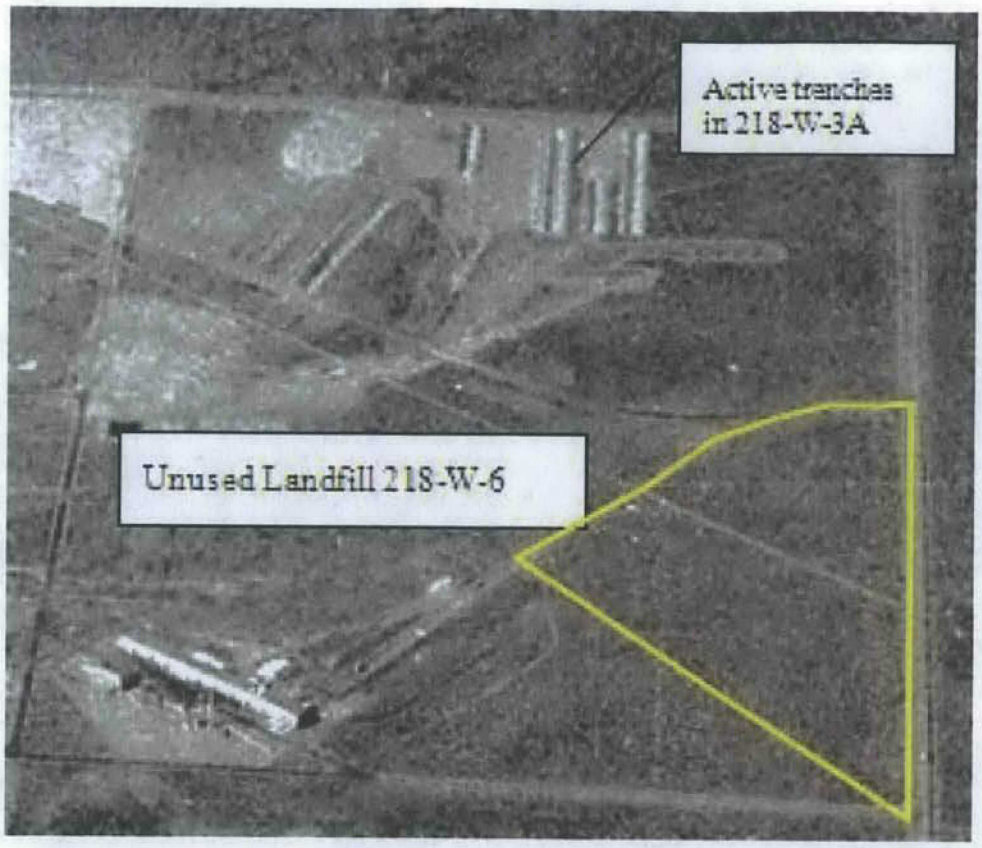


Figure B-11. Aerial Photo, Dated 1975, of 218-W-6 (boundaries are approximate)

Figure B-12. Aerial Photo, Dated 1980, of 218-W-6 (boundaries are approximate)

Figure B-13. Aerial Photo, Dated 1988, of 218-W-6 (boundaries are approximate)

Figure B-14. Aerial Photo, Dated 2006, of 218-W-6 (boundaries are approximate)

Figure B-3 Series. Photographic Chronology Documenting Unused Areas of Hanford Landfills

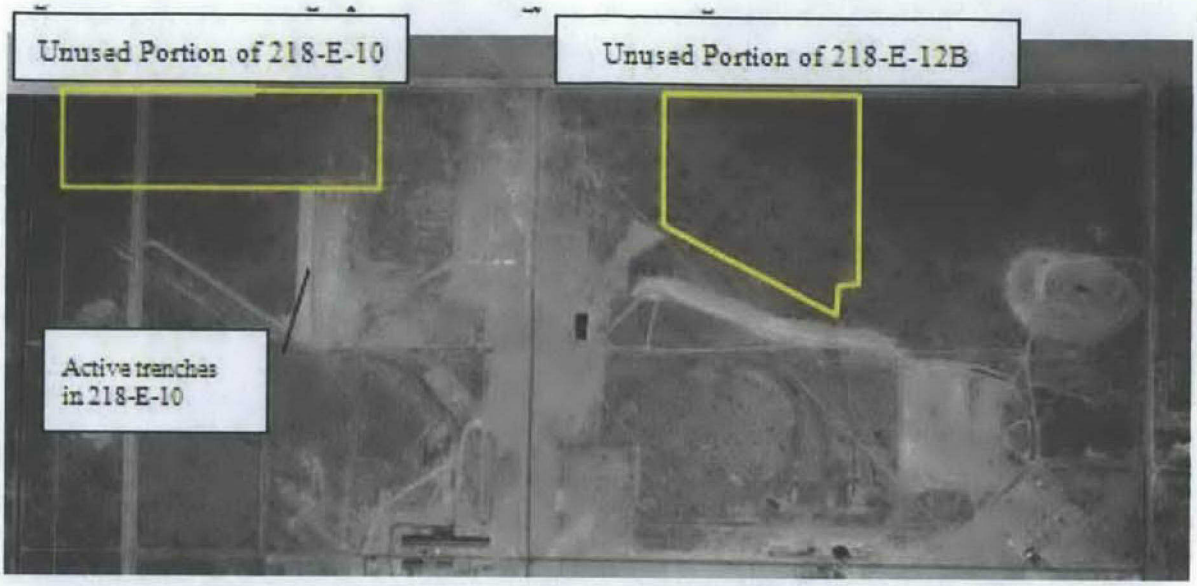


Figure B-15. Aerial Photo of 218-E-10 and 218-E-12B, Dated 1954 (boundaries are approximate)

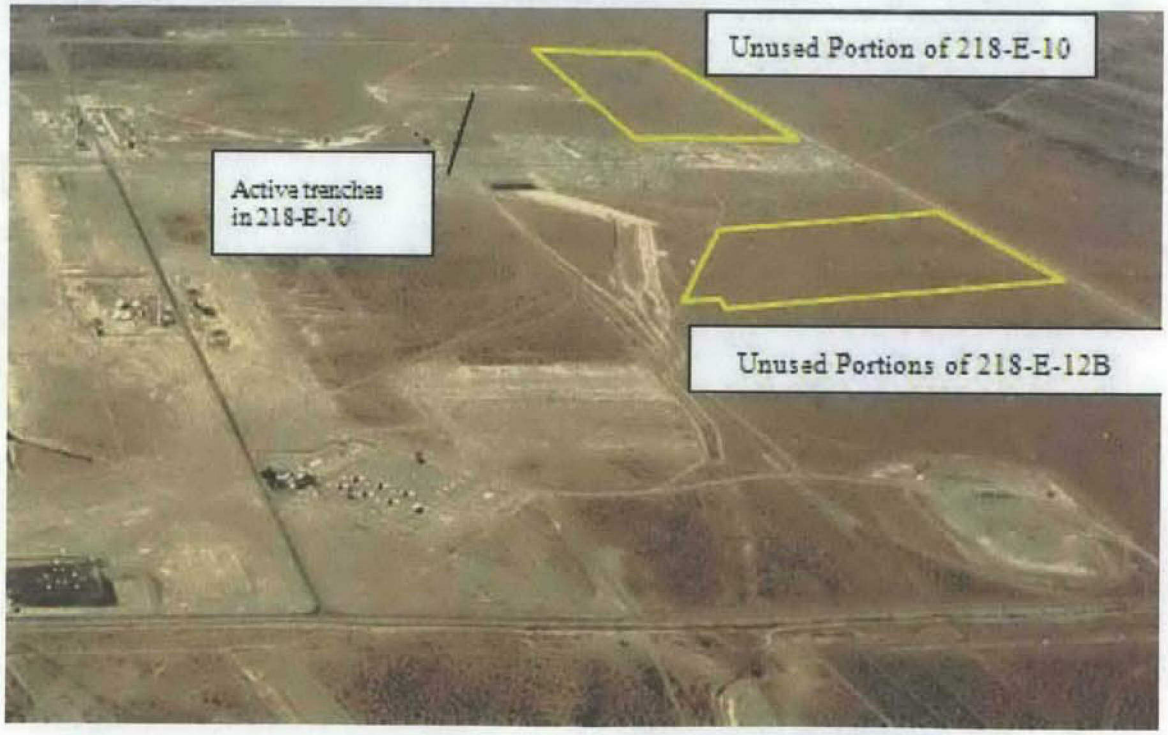


Figure B-16. Aerial Photo of 218-E-10 and 218-E-12B, Dated 1966 (boundaries are approximate)

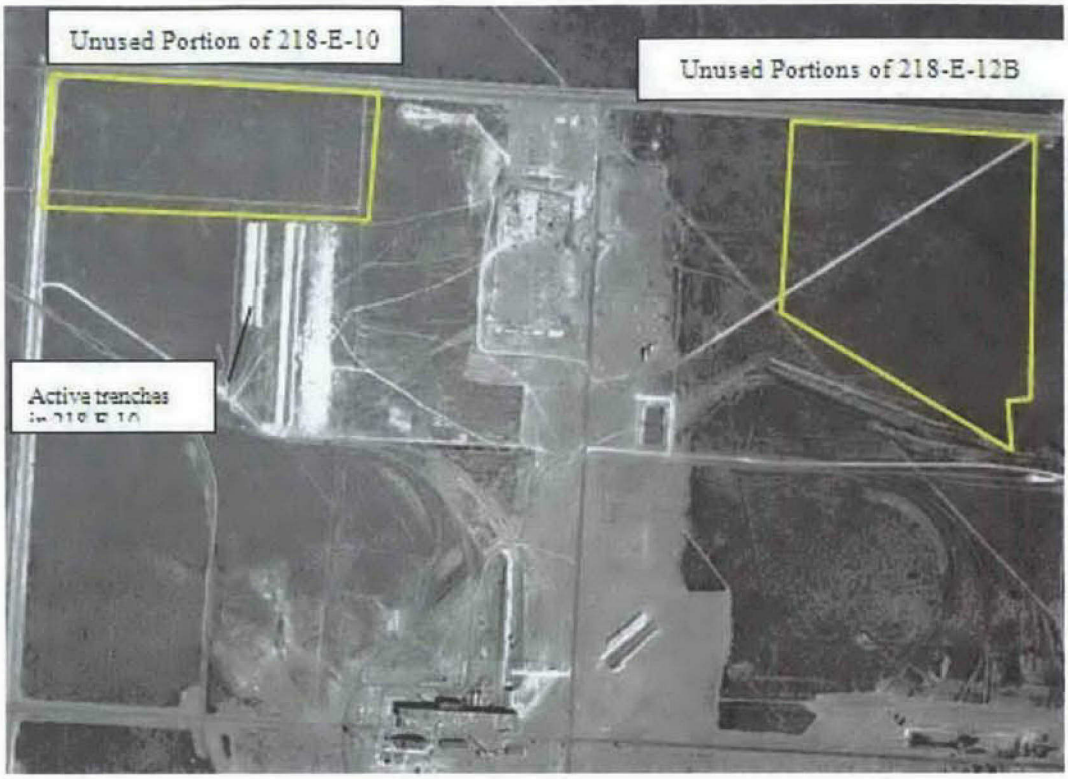


Figure B-17. Aerial Photo of 218-E-10 and 218-E-12B, Dated 1969 (boundaries are approximate)

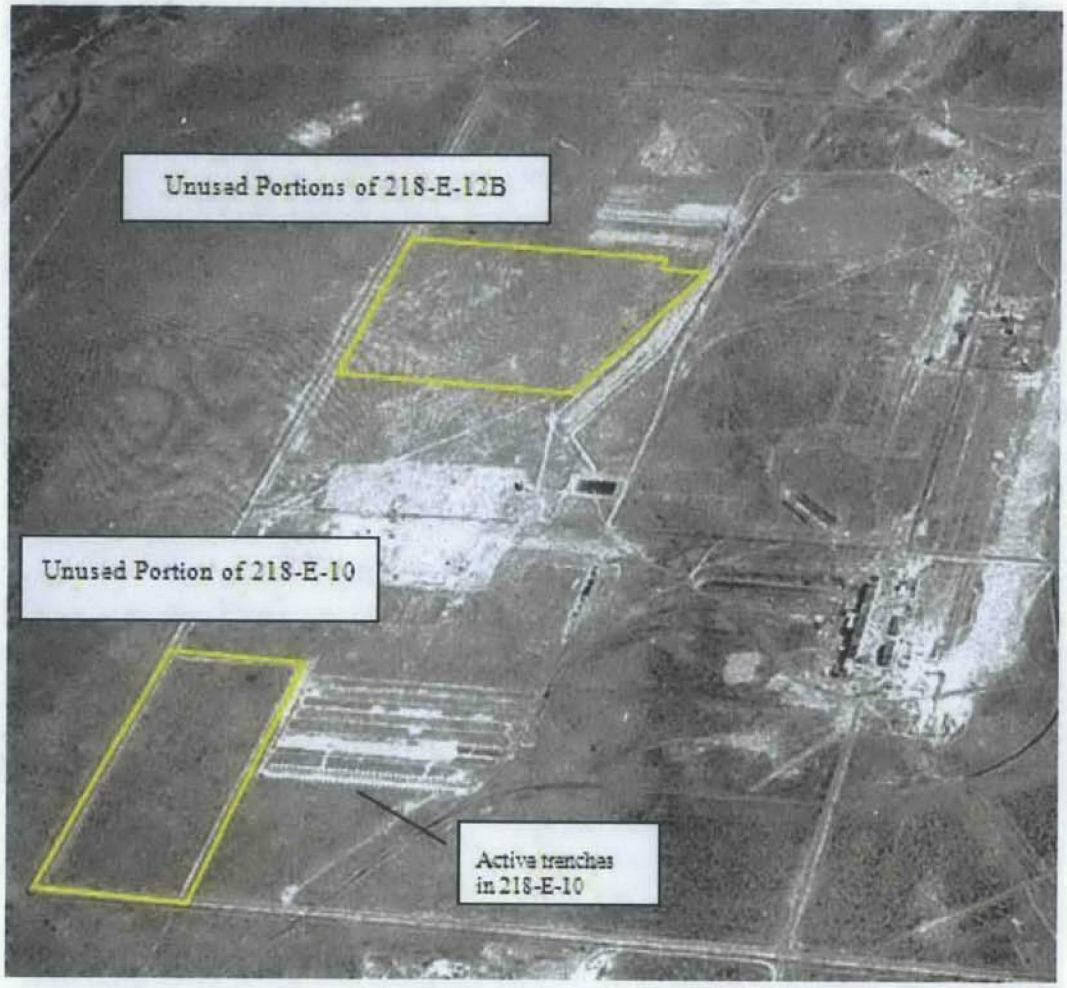


Figure B-18. Aerial Photo of 218-E-10 and 218-E-12B, Dated 1975 (boundaries are approximate)

Figure B-19. Aerial Photo of 218-E-10 and 218-E-12B, Dated 1982 (boundaries are approximate)

Figure B-20. Aerial Photo of 218-E-10 and 218-E-12B, Dated 1988 (boundaries are approximate)

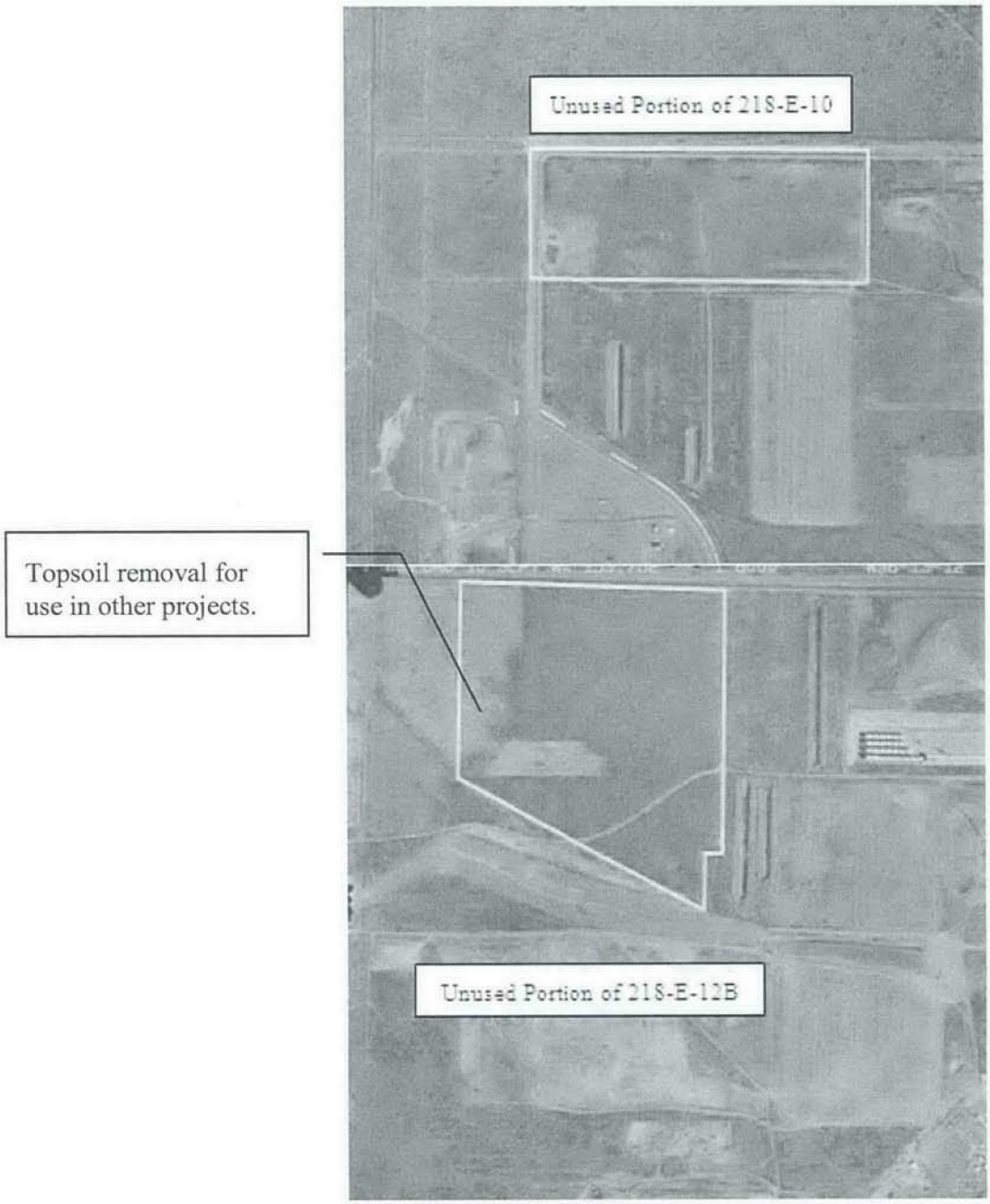


Figure B-21. Aerial Photos of 218-E-10 (top) and 218-E-12B (bottom), Dated 1996 (boundaries are approximate)

Figure B-22. Aerial Photo of 218-E-10, Dated 2006 (boundaries are approximate)

Figure B-23. Aerial Photo of Unused Portion of 218-E-12B, Dated 2006 (boundaries are approximate)

Appendix C

Aerial Radiation Survey Images

The following pages include images of aerial radiation survey results that were reviewed as part of this investigation.

C1 200 West Area -- Aerial Radiation Measurement System Results

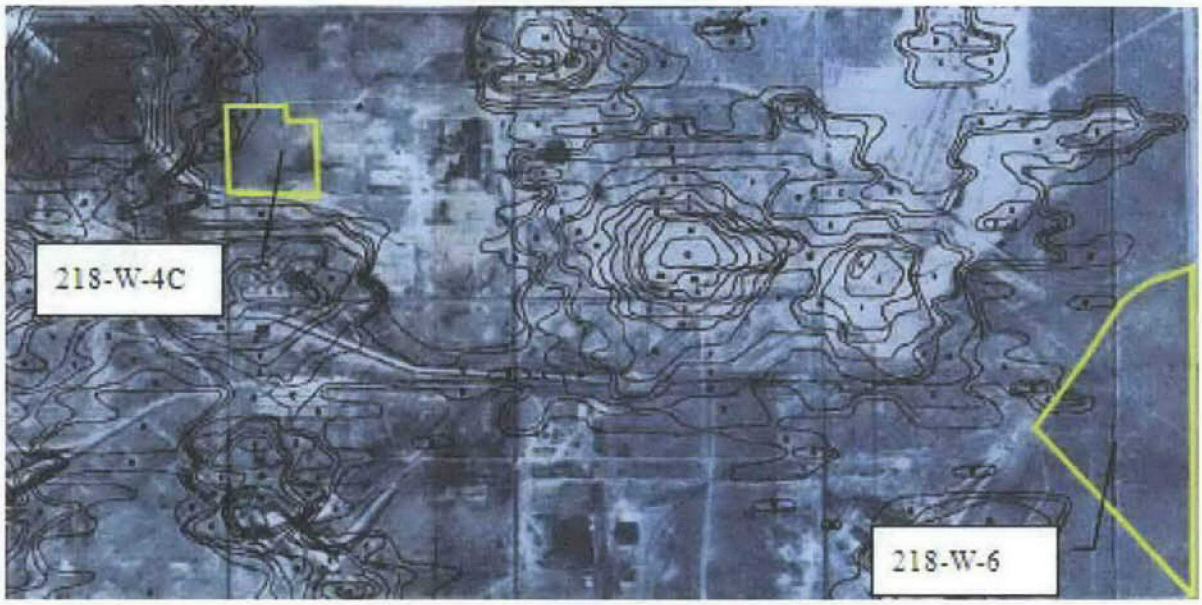


Figure C-1. 200-West Concentration and Gamma Exposure Rate Isopleths for ^{137}Cs (EGG-1183-1661)

Figure C-2. 200 East Isopleth Map of Total Gamma Ray Count Between 50 keV and 3 MeV (EGG-1183-1661)

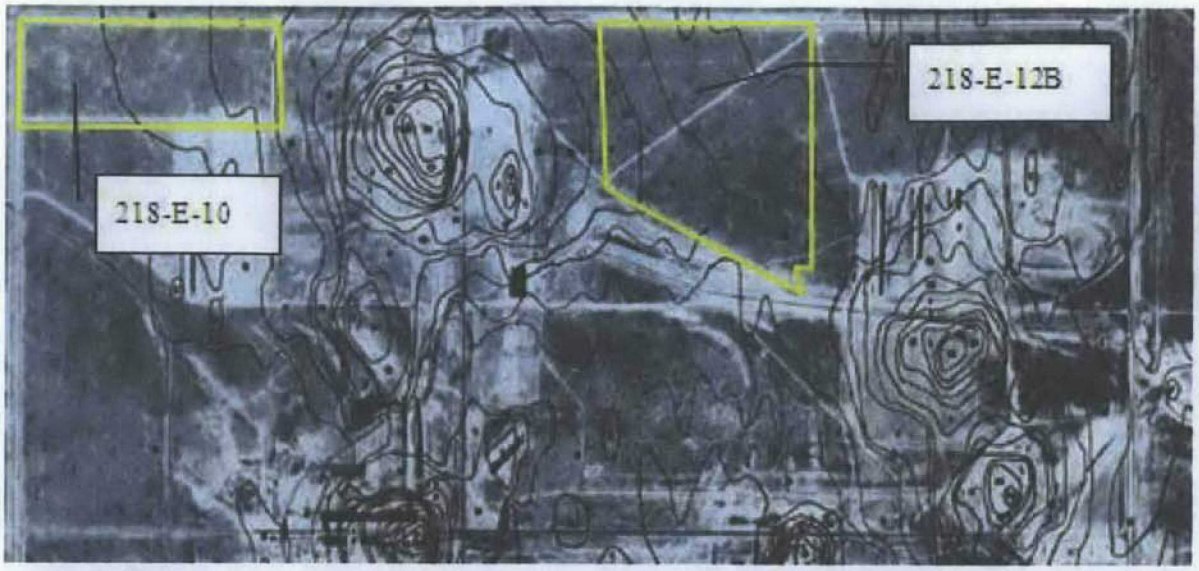


Figure C-3. 200 East Concentration and Gamma Exposure Rate Isopleths for ^{137}Cs (EGG-1183-1661)

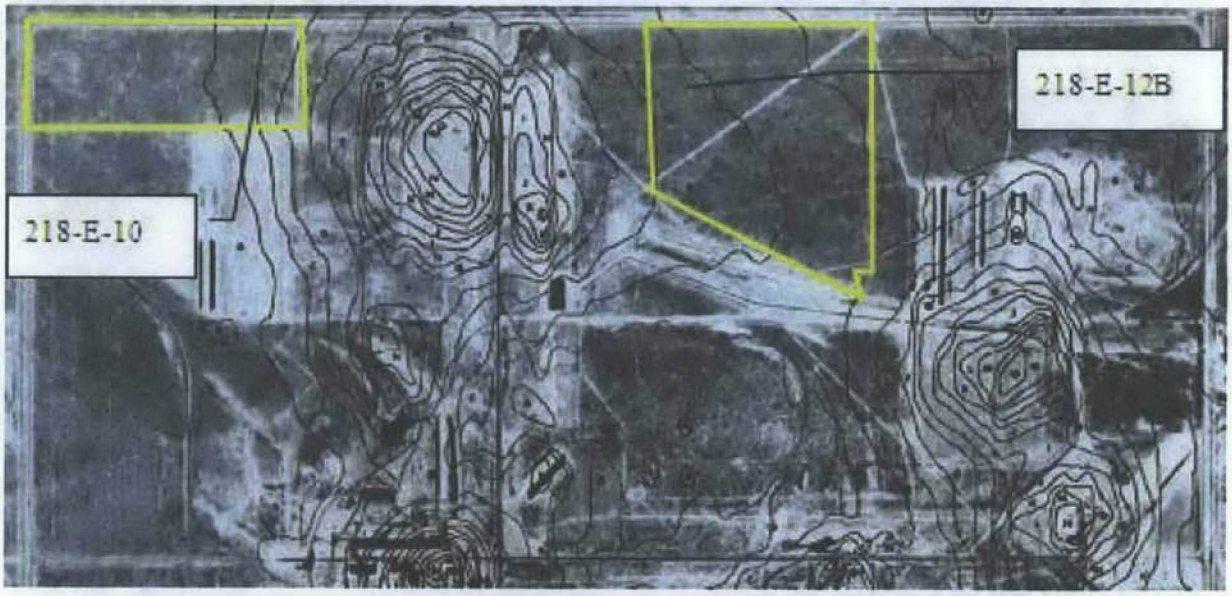


Figure C-4. 200 East Isopleth Map of Total Gamma Ray Count Between 50 keV and 3 MeV (EGG-1183-1661)

C2 Reference

EGG-1183-1661, 1975, *An Aerial Radiological Survey of the U.S. Energy Research and Development Administration's Hanford Reservation (Survey Period: 1973-1974)*, EG&G Energy Measurements, Inc., Las Vegas, Nevada.

Appendix D

Surface Geophysical Investigations

Contents

Attachments

Figures

Terms

EM	electromagnetic
EMI	electromagnetic induction
Fluor Hanford	Fluor Hanford, Inc.
FM	frequency modulation
GPR	ground-penetrating radar
GPS	global positioning system
mS/m	millisiemens per meter
nT	nanotesla
NCR	Nonconformance Report
TMF	total magnetic field
WCH	Washington Closure Hanford

D1 Introduction

This document summarizes the results of geophysical investigations conducted at four unused burial ground areas located within the 200 East and 200 West Areas of the Hanford Site. The geophysical investigations were performed by Washington Closure Hanford (WCH) for Fluor Hanford, Inc., (Fluor Hanford) during July, August, and September 2008. The geophysical techniques used in the investigations were ground-penetrating radar (GPR), electromagnetic induction (EMI), and total magnetic field (magnetic) methods.

D1.1 Scope and Objectives

The following burial grounds were investigated:

- 218-E-10 Annex
- 218-E-12B (Western Portion)
- 218-W-4C Annex
- 218-W-6

The geophysical surveys were reconnaissance-type surveys that were aimed at verifying the unused status of the landfill areas. However, if large, i.e., dump truck size, anomalies or those consistent with a 55-gallon drum were interpreted from the data, then determination of the following characteristics were to be attempted:

- Locations of buried anomalies
- Characteristics of detected anomalies (metallic versus non-metallic)
- Depth of soil cover above the anomaly

D1.2 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 Operable Unit.

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.

A second phase of geophysical investigations was conducted during June 2006. This activity is documented in D&D-30708, *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*. The second phase of geophysical investigations was directed at resolving the potential discrepancies at the 218-E-2A, 218-E-8, and 218-W-11 landfills and also included geophysical investigations at five other, older and inactive landfills (218-E-1, 218-E-12A, 218-W-1, 218-W-2, and 218-W-3).

A third pphase of geophysical investigations was performed in 2009 and documented in SGW-43771, Geophysical Investigations Summary Report – 200 Area burial Grounds: 218-E-2, 218-E-4, 218-E-9 and 218-W-4A. This effort included the remainder of the 200-SW-2 OU landfills that operated prior to 1970.

Large areas of 218-W-4C, 218-E-10, and 218-E-12B were once intended for future buried waste, but are believed to have never been used. Additionally, the entire 218-W-6 landfill area is believed to never have been used. These potentially unused landfill areas account for approximately 60 ha (150 ac). The current investigation, as described in this report, was designed to determine the unused status of these large areas.

D1.3 Geologic Setting

The depth of investigation for the geophysical instruments used in this work was generally limited to approximately 3 to 4 m (10 to 13 ft). 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.

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

D2 Methodology

D2.1 Survey Grid Parameters

Fluor Hanford provided site drawings to WCH to develop base grids at each site. Using the drawings, WCH determined Washington State Plane coordinates (NAD83, *North American Datum of 1983*, as revised) to create base grids with 30 m (98 ft) nodes, extending to or beyond the documented site boundaries. The grid nodes were intentionally chosen to be at state plane coordinates ending at the nearest even 10 m (33 ft) increment. 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. Survey reports for each of the four survey areas are included in Attachment D1. WCH personnel then marked data collection lines at 6 m intervals between the 30 m (98 ft) nodes, using 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 (98 ft) fiducials, depending on the instrument. In areas of significant sagebrush, real-time GPS guidance was used to maintain profile spacing.

The geophysical data plots are presented in Washington State Plane Meters.

D2.2 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.

D2.2.1 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 (10 to 13 ft) (in ideal situations). The EM31 meter consists of a transmitter coil and receiver coil at either end of a 4 m (13 ft)-long boom. The transmitter generates pulses of electromagnetic (EM) 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 EM 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 near the instrument, assuming homogeneous conditions. This assumption becomes less valid in the presence of metal or other significant conductivity changes. However, the contrasts in conductivities are used generally 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 (10 to 13 ft) in ideal situations, the lateral resolution of the position of detected objects is about 1 m (3 ft).

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 same phenomenon 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 (16 to 23 ft). Sites with a significant number of buried utilities also may generate data that are difficult to interpret.

D2.2.1.1 EM31 Data-Collection Procedures

Geonics, 1994, *EM31 Terrain Conductivity Operating Manual* discusses data collection procedures in detail. 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. A functional check was performed each day at a specific location having a geophysically quiet background. These checks were documented and recorded electronically.

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

- Collect the data along profiles that are spaced a predetermined distance apart. The data are then typically collected along the individual profiles at evenly spaced distances, either discretely or at constant time intervals, while walking at a constant rate.
- Estimate visually, pace the location of data points, and/or use GPS guidance to collect between surveyed grid points.

D2.2.1.2 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 near the actual data points (with close-spaced data) using Golden Software's Surfer[2] or equivalent.

D2.2.2 Total Magnetic Field / Vertical Magnetic Gradient

A magnetometer measures the intensity of the earth's magnetic field. The presence of ferrous material, manufactured 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 is the total magnetic field (TMF) intensity. The TMF 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.

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

A Geometrics G-858G Magnetometer/Gradiometer[3] consists of two cesium vapor magnetometers. The magnetometers are mounted vertically on a pole with a 0.75 m (2.5 ft) 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.

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.

D2.2.2.1 Magnetic Data-Collection Procedures

The document 25309-OM, *G-858 MagMapper*, Rev. D, discusses data collection procedures in detail. 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 were performed as outlined in the manufacturer-supplied operator's manual. Functional checks were performed each day at a specific location (the same location used for the EM31 functional checks) having a geophysically quiet background. These checks were documented and recorded electronically.
- 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. GPS guidance was used for the western half of the 218-W-4C Annex due to the "old growth" sagebrush.

D2.2.2.2 Magnetic Data Processing Procedures

Specific data-processing procedures are as follows:

- Download the magnetic field data to a laptop computer via Geometrics software, MagMap2000[4].

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

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

- Edit the data with all null readings (sensor null readings) removed from the data.
- 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. Two types of contour maps were the foundation for interpretation.
- Magnetic field apparent vertical gradient: The absolute value of the difference between the top and bottom sensor reading. This value primarily represents discrete, shallow anomalies.
- Top sensor residual: Statistics were run for top sensor readings (the top sensor is less affected than the bottom sensor by small ground surface debris) and the mean value determined. This value (about 54,600 nanoteslas [nT]) was then subtracted from the total sensor reading to produce values more conducive to contouring in order to better show subtle anomalies.

D2.2.3 Ground-Penetrating Radar

Ground-penetrating radar uses a transducer to transmit frequency modulation (FM) EM 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 EM energy.

The dielectric constant and magnetic susceptibility of the medium primarily controls the velocity of the EM energy. 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 because 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, which 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.

D2.2.3.1 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[5], 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 pulling the antenna by hand.

D2.2.3.2 Ground-Penetrating Radar Data-Processing Procedures

Data processing of the GPR data consisted of reviewing of unfiltered data as well as application of various horizontal filters (as necessary). The horizontal filters, when used, had the effect of removing coherent noise so that anomalies were more visible in the records. Such noise can often be attributed to other sources (e.g., interference from internal electronic noise from field equipment, or reflections from objectes above the ground surface). When filters were used on records, unfiltered data also were used to give multiple images of the data for interpretation.

D2.3 Approach to Data Collection

Typically, profiles would be oriented perpendicular to the strike of known trenches. However, since the survey areas are believed to have been unused, there were no preferred directions for profile orientation. Therefore, the magnetic data profiles were collected along true north-south lines, spaced 3 m (9.8 ft) apart. The EM31 data were collected along true north-south and east-west orientations, with 6 m (19.6 ft) profile spacing. These profile spacings and orientations offer the best possibility of detecting anomalies that would be caused by significant trench or pit contents regardless of anomaly orientation. For the magnetic field data, recordings were at a constant time interval of 0.3 s, yielding data-point recordings approximately every 0.3 m (1 ft). In the EM31 data, recordings were taken at 0.5 s intervals along each profile, yielding data-point readings approximately every 0.5 m (1.6 ft). Data were downloaded from the field instruments daily and reviewed regularly.

Preliminary plots of the EM31 data and magnetic field data were used to screen areas that would warrant more detailed characterization using GPR. Only two areas required the more detailed GPR investigation, one at 218-E-10 Annex, and one at the 218-W-4C Annex.

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

The site investigation summaries (Attachment D2) discuss the details of the data collection at each burial ground.

D3 Results

Figures D1 through D6 display summary-level interpretations of the geophysical data. These interpretation maps represent an integration of all of the geophysical data and other site information and engineering drawings, as available.

Attachment D2 presents plots of the EMI and magnetic data collected, along with details of the investigation at each site. Additionally, Attachment D2 presents surface feature base maps and overlays between data sets and surface features. 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.

D3.1 Geophysical Data Interpretation

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. The apparent vertical gradient readings of the total magnetic field are very useful for discretely identifying shallow anomalies. The top sensor total field readings are useful for looking deeper and identifying larger anomalous areas. For simplicity of data plotting, the absolute value of the vertical field often is used to minimize the dipole effect produced by some anomalies. For the total field plots, the average total field value (typically ~54,600 nT for these surveys) is subtracted from the individual values in order to accommodate detailed contour maps.

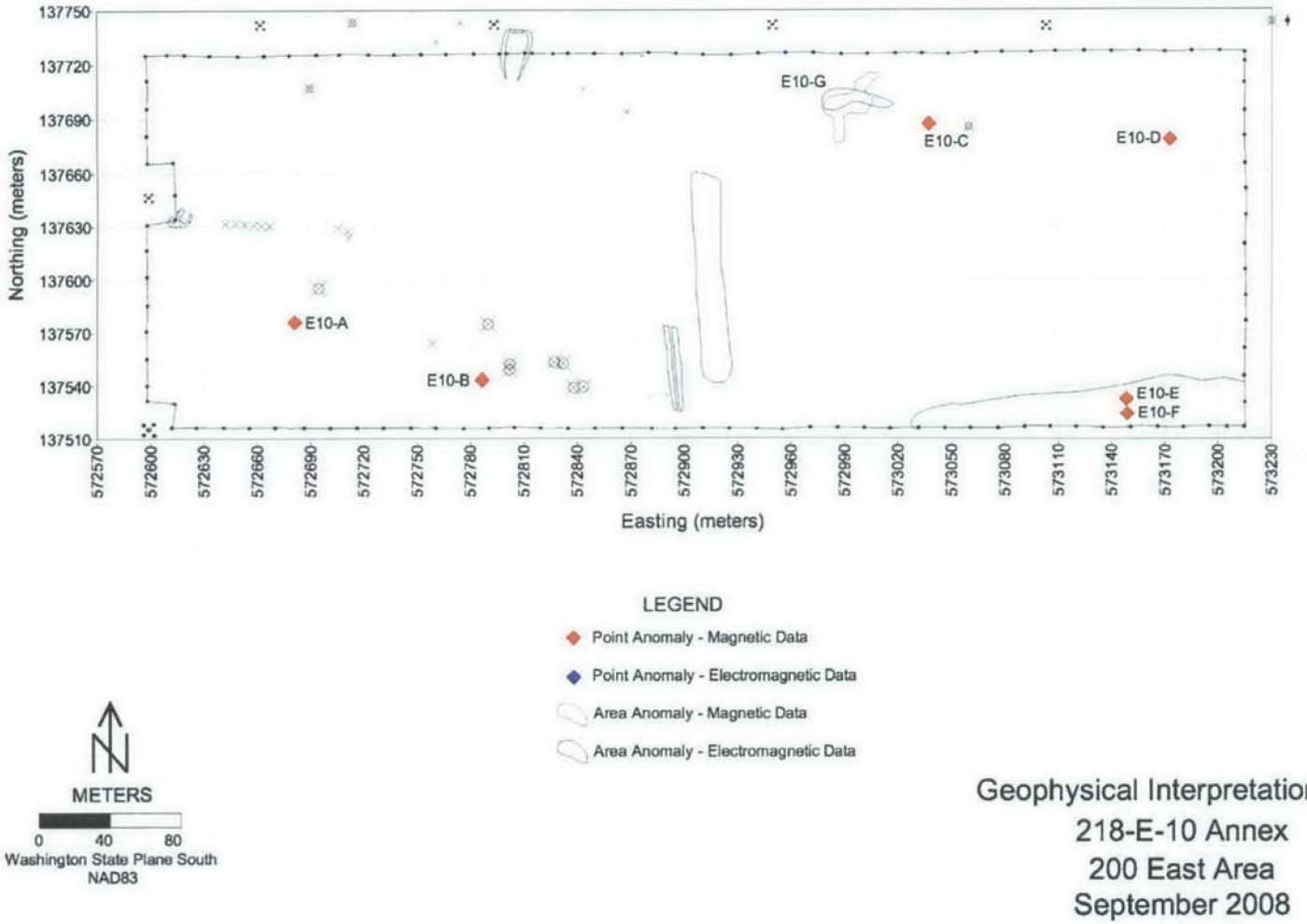

Figure D1. Geophysical Interpretation Map, 218-E-10 Annex, 200 East Area, September 2008

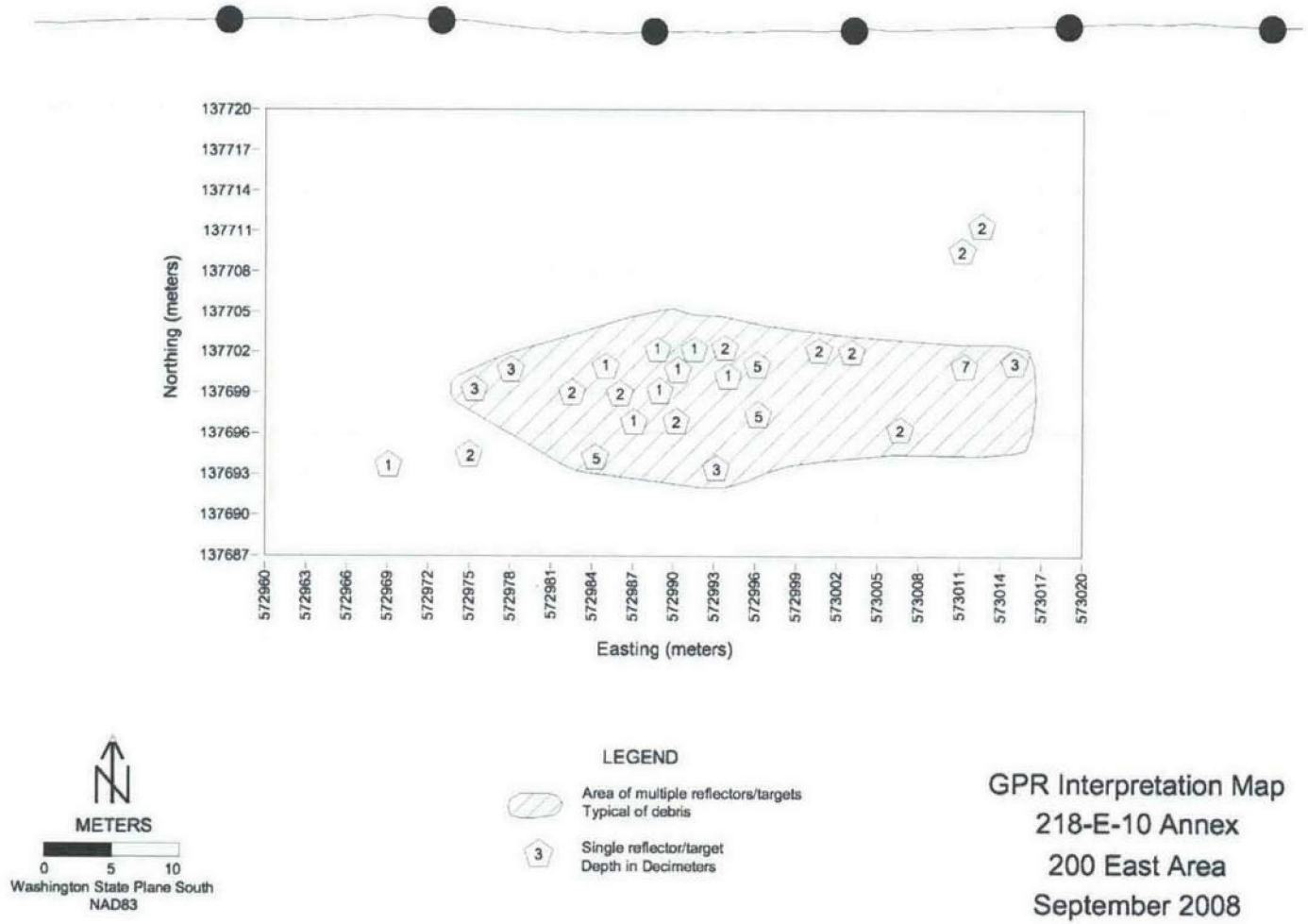

Figure D2. Ground-Penetrating Radar Interpretation Map, 218-E-10 Annex Detail Area, 200 East Area, September 2008

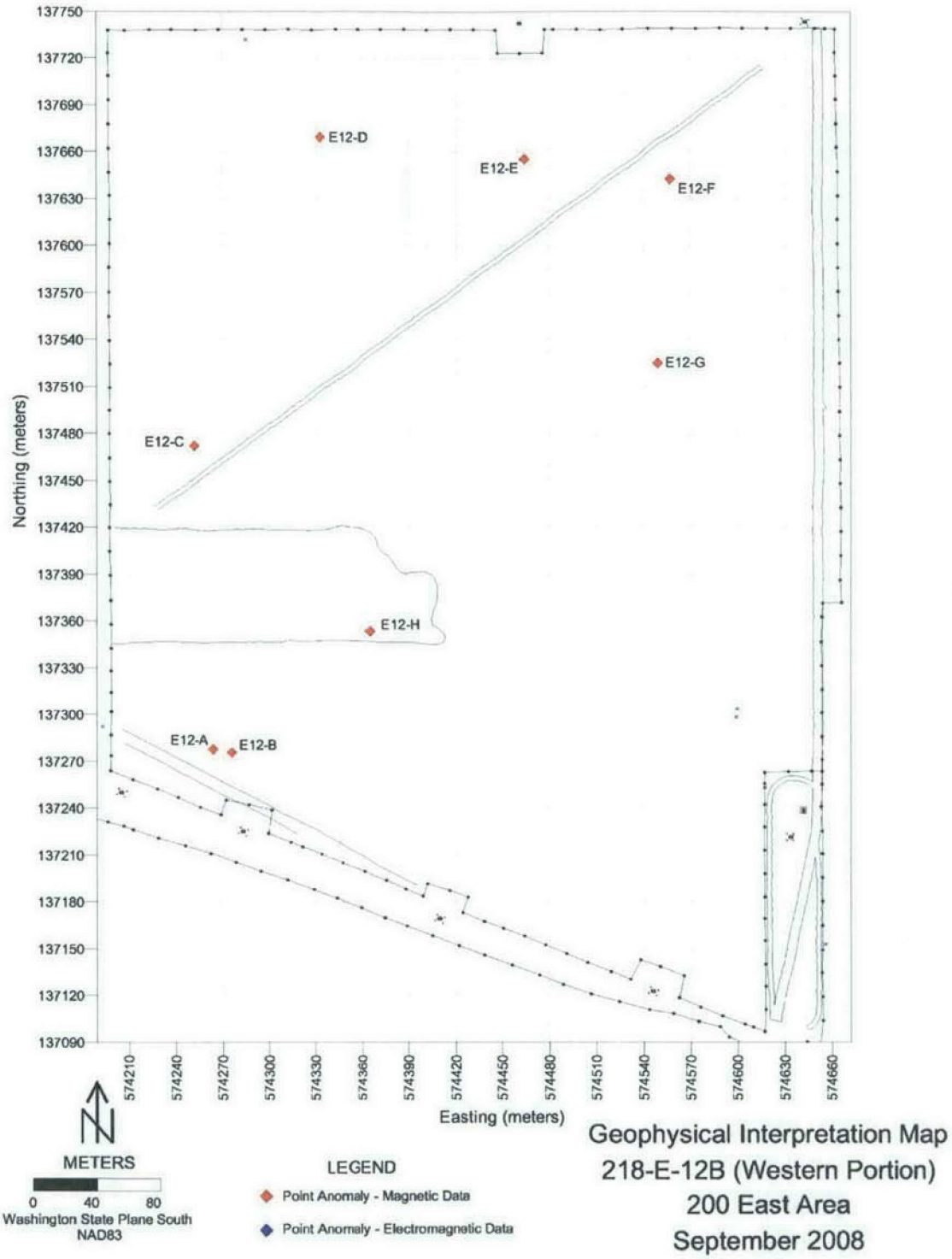

Figure D3. Geophysical Interpretation Map, 218-E-12B (Western Portion), 200 East Area, September 2008

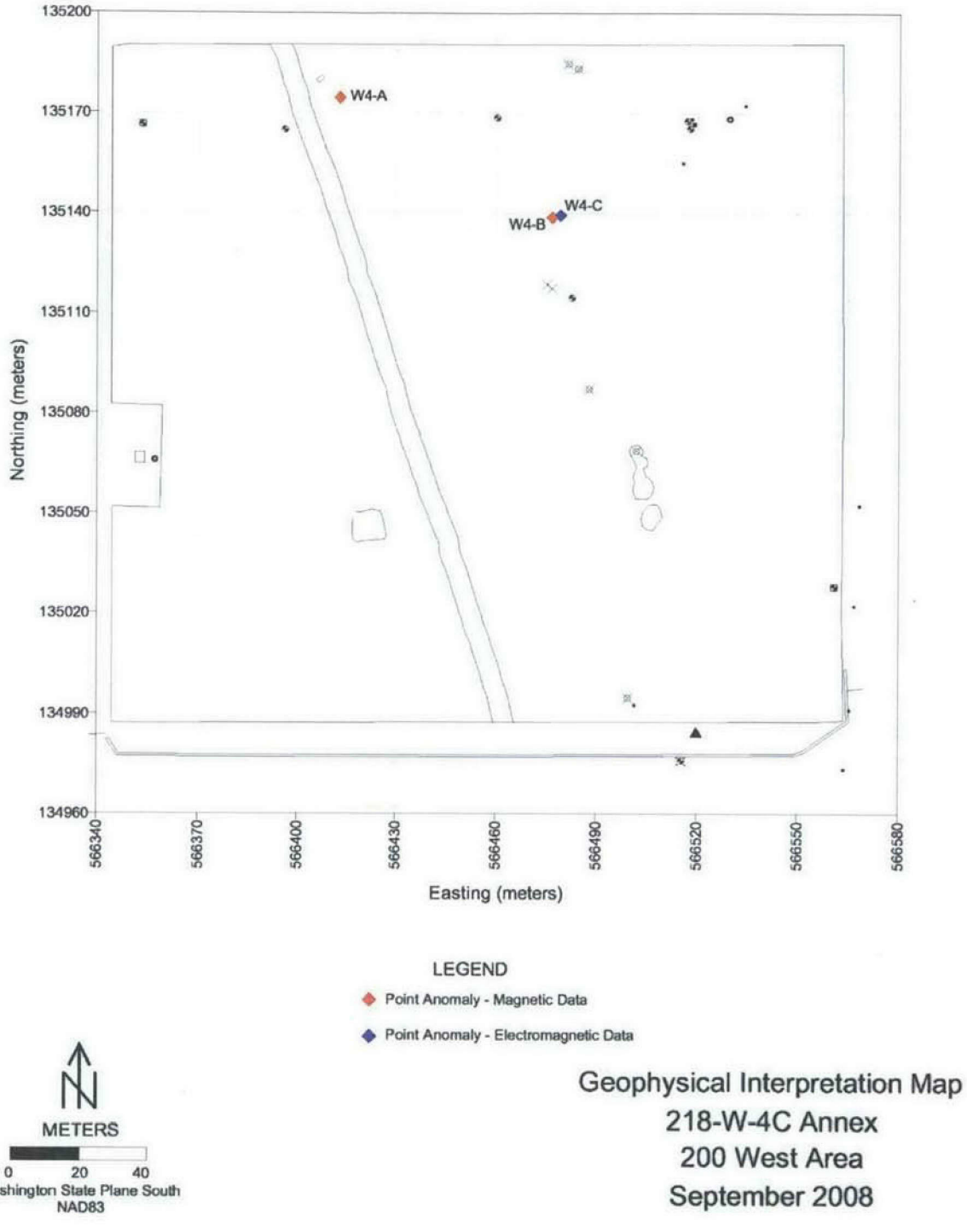

Figure D4. Geophysical Interpretation Map, 218-W-4C Annex, 200 West Area, September 2008

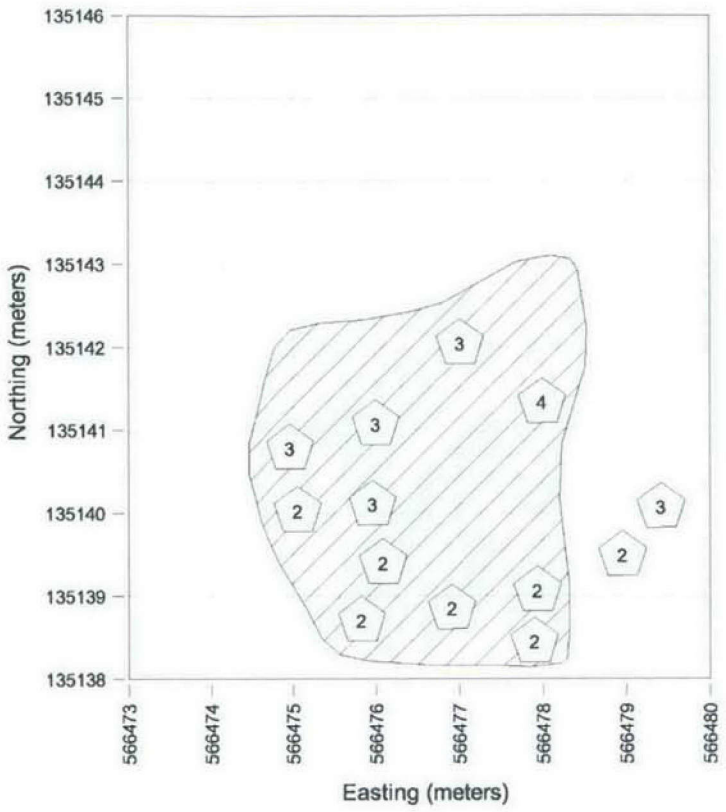

Figure D5. Ground-Penetrating Radar Interpretation Map, 218-W-4C Annex Detail Area, 200 West Area, September 2008

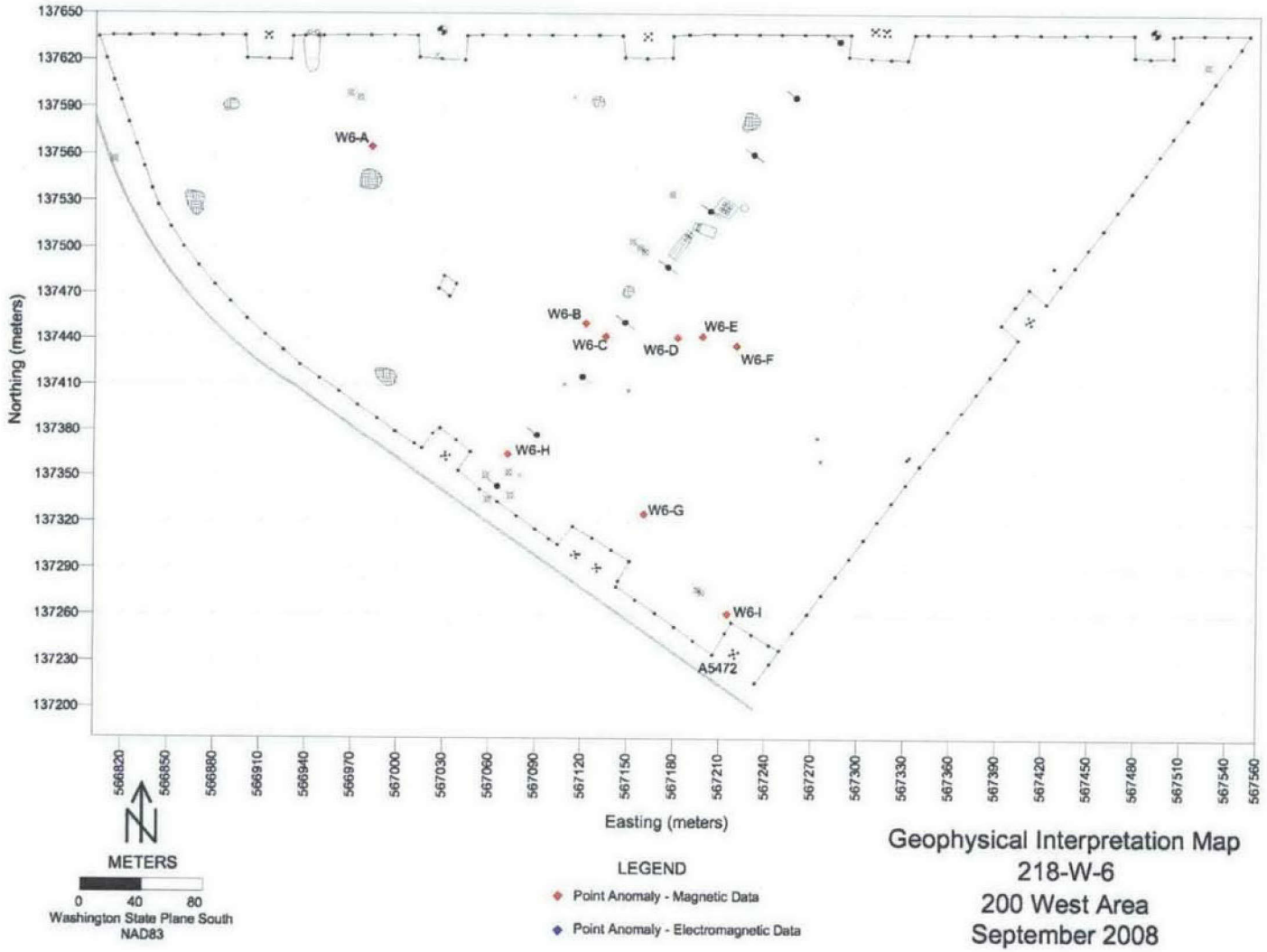

Figure D6. Geophysical Interpretation Map, 218-W-6, 200 West Area, September 2008

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 often interpreted in GPR data, the discretion of the interpreter is used to decide which anomalies are transferred to the computer-aided drafting and design drawing to indicate the important information about the site.

D3.2 General Discussion of Results

The geophysical surveys were reconnaissance-type surveys that were aimed at verifying the unused status of the landfill areas. Geophysical methods, profile spacing, and profile orientation were selected to support this goal. At all four sites, the EM, and magnetic field data generally exhibit very low amplitude character. To illustrate the predominately quiet/anomaly free nature of the survey areas, the anomalies that do dominate most of the magnetic field/vertical gradient data are associated with T-posts and metal survey pin flags, or can be correlated with visible surface features such as well casings. In the event that unexplained anomalous areas were identified within the survey boundaries, additional characterization was attempted using ground-penetrating radar and/or more detailed visual field checking for correlations.

D3.2.1 Reliability/Accuracy of the Results

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. 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 many factors that affect the reliability of the results and can provide a level of confidence in the reliability of the results.

Given the reconnaissance nature of the surveys, interpretations were performed with the intent of determining the boundaries of a given anomaly and representative information about its content and depth. The interpretation figures do not show all detected anomalies. Locations of objects detected in the data (i.e., position in the horizontal plane) have a nominal accuracy of +/-1.0 m (3 ft). Where depth to the top of the anomaly is presented, its accuracy is nominally +/-0.3 m (1 ft).

D3.3 218-E-10 Annex

Numerous small, discrete magnetic anomalies are scattered throughout the data, but most of these appear to be associated with basalt cobbles/boulders observed on the surface and occasionally attributed to miscellaneous small pieces of metal scattered throughout the survey area (Figure D1). The EMI apparent ground conductivity and in-phase data also indicate an overall quiet background for the entire site.

The notable exception to the otherwise benign character of the site is a subsurface anomaly, centered at about N137700 and E572990. GPR data were collected around this area for further characterization. The GPR data indicate this area likely contains shallow, scattered anomalous debris from 0.3 to 1.0 m (1 to 3 ft) below the surface over an area 10 to 20 m (33 to 66 ft) across (Figure D2).

D3.4 218-E-12B (Western Portion)

Numerous small, discrete magnetic anomalies are scattered throughout the data, but most of these appear to be associated with basalt cobbles/boulders observed on the surface and occasionally to miscellaneous small pieces of metal scattered throughout the survey area (Figure D3). The EMI apparent ground

conductivity and in-phase data also indicate an overall quiet background for the entire site. No buried drum or trench-like features were observed in the data.

D3.5 218-W-4C Annex

Several small, discrete magnetic anomalies are scattered throughout the data, but most correlate with visible surface features/debris (Figure D4). The EMI apparent ground conductivity and in-phase data also indicate an overall quiet background for the entire site.

The notable exception to the otherwise benign character of the site is an anomalous area, observed in both the magnetic and EM data, centered at about N135140 and E566480. GPR data were collected around this area for further characterization. The GPR data indicate this area contains a few shallow, scattered pieces of debris, from 0.3 to 1.0 m (1 to 3 ft) below the surface, confined laterally within a few meters (Figure D5).

No buried drum or trench-like features were observed in the data.

D3.6 218-W-6

Numerous small, discrete magnetic anomalies are scattered throughout the data, but many of these appear to be associated with basalt cobbles/boulders observed on the surface and to miscellaneous small pieces of metal, wire rope, etc. scattered throughout the survey area (Figure D6). The "anomalous" signature along the southwestern edge of the survey area is from a railroad track and the large anomaly, centered at about N137510 and E567195 is the drill pad/rig location. The EMI apparent ground conductivity and in-phase data also indicate an overall quiet background for the entire site. The southern portion of the survey area appears to have the highest amount of surface/near surface metallic debris.

No buried drum or trench-like features were observed in the data.

D4 Software Problem Reporting and Validation and Verification Information

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

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

D4.1 Software Problem and Error Reporting

A WCH-approved internal work process describes identifying, controlling, documenting, and dispositioning nonconforming items or items of indeterminate quality discovered during WCH personnel performance of on-site work activities. This process applies to all WCH activities and personnel.

The primary objective of this process is to prevent the unintended use or further use of products that fail to pass required inspections. Four broad phases used to control a nonconforming item are: (1) identifying and documenting nonconforming items, (2) segregation, (3) dispositioning and implementation of disposition instructions, and (4) closing nonconformance reports.

D4.2 Validation and Verification Information

D4.2.1 Software Information

Title: Surfer[6]	Version: 8.08, October 31, 2007
Manufacturer:	Golden Software, Inc., Golden, Colorado
Function:	Surface Mapping System
Operating System:	Microsoft Windows XP 2002 Professional, Version: 5.1[7]
Calculations Performed:	Calculates and outputs a contoured grid from regularly spaced data values

D4.2.2 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. Attachment D3 presents the entire data file and a brief summary of the test and its outcome.

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

[7] Windows XP 2002 Professional is a trademark of Microsoft Corporation, Redmond, Washington.

D5 References

10 CFR 830, "Nuclear Safety Management," Subpart A, "Quality Assurance Requirements," *Code of Federal Regulations*. Available at: http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr&rgn=div6&view=text&node=10:4.0.2.5.26.1&idno=10.

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Attachment D1

Geophysical Grid Staking Survey Data Reports

Information is provided on the primary grid node staking that was used for location control.

218-E-12B (Western Portion) Geophysical Grid Staking Survey Data Report

SURVEY DATA REPORT				Request No. 084-410		
Project No.	Title: 218-E-12B Geophysical Grid Staking			File No. 2EWA-061		
Job No. MEIINF123470 - 0010-CA10	Prepared By N.P. Fastabend	Date 8/21/08	Reviewer Jamy Henke			Page 1 of 10

DESCRIPTION OF WORK	DISTRIBUTION	SDR	PLOT	DWG
Staked 30 meter grid at coordinates provided over west portion of 218-E-12B Burial Ground. Set 3/8" x 1 1/2" x 48" Wood Lath with painted orange tops or paint mark on asphalt road and marked with coordinates. Horizontal Coordinate System: WCS83S/91 (Meters) Equipment Used: Trimble GPS 5800 RTK	Survey File	OR		
	B.A. Atkinson	1		
	G.T. Berlin	1		
	J.W. Cammann	1		
	T.H. Mitchell	1		

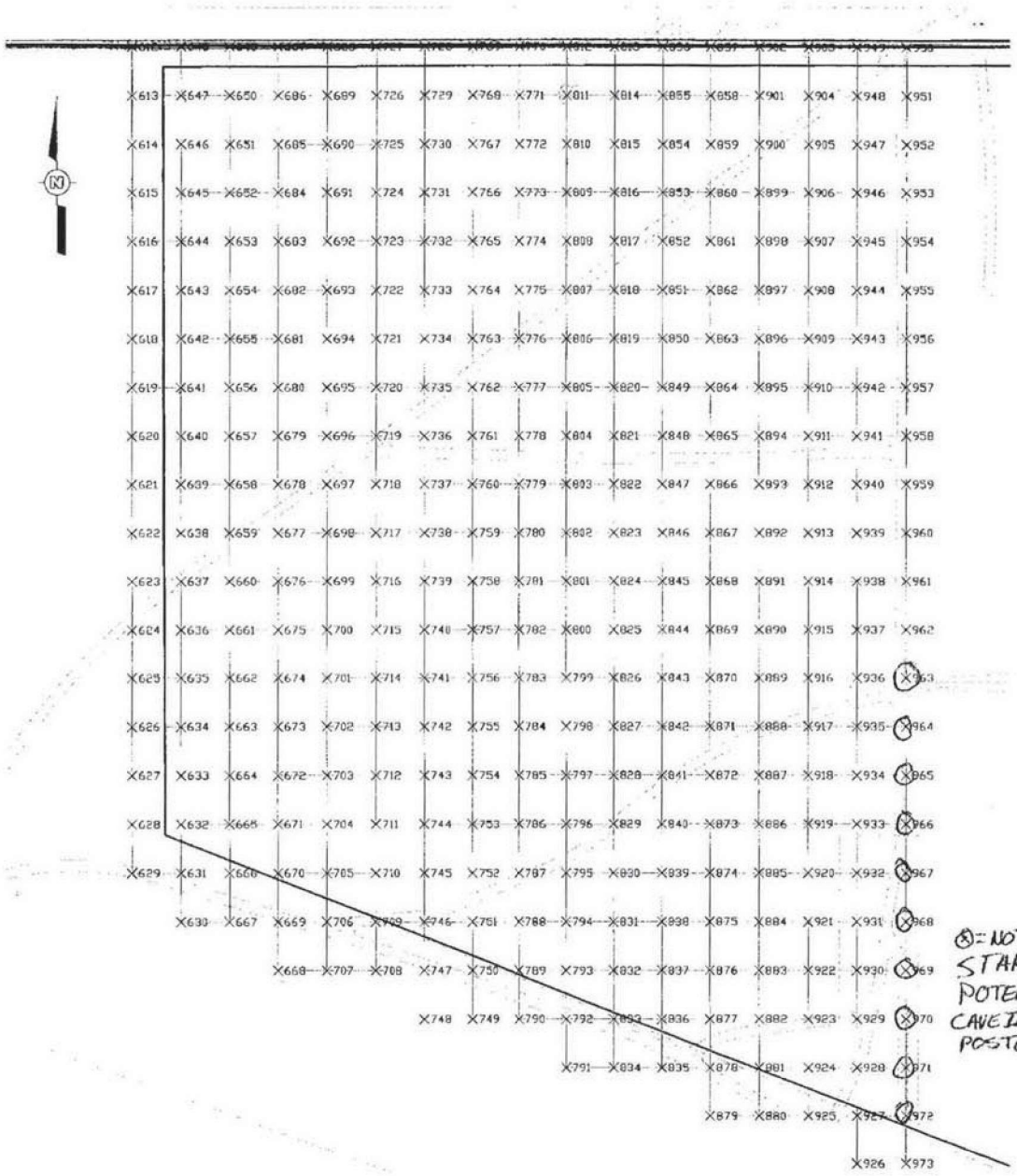
SURVEY RESULTS AND COMMENTS

See Attached Grid Sketch and Coordinate List

NOTE: This Survey was performed under the supervision of a Licensed Professional Land Surveyor registered in the State of Washington.

E-NW-246 (09/04)

218-E-12B



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846	574510	137450	218-W-12B
847	574510	137480	218-W-12B
848	574510	137510	218-W-12B
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853	574510	137660	218-W-12B
854	574510	137690	218-W-12B
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856	574510	137750	218-W-12B
857	574540	137750	218-W-12B
858	574540	137720	218-W-12B
859	574540	137690	218-W-12B

860	574540	137660	218-W-12B
861	574540	137630	218-W-12B
862	574540	137600	218-W-12B
863	574540	137570	218-W-12B
864	574540	137540	218-W-12B
865	574540	137510	218-W-12B
866	574540	137480	218-W-12B
867	574540	137450	218-W-12B
868	574540	137420	218-W-12B
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897	574570	137600	218-W-12B
898	574570	137630	218-W-12B
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903	574600	137750	218-W-12B
904	574600	137720	218-W-12B
905	574600	137690	218-W-12B
906	574600	137660	218-W-12B
907	574600	137630	218-W-12B
908	574600	137600	218-W-12B
909	574600	137570	218-W-12B

910	574600	137540	218-W-12B
911	574600	137510	218-W-12B
912	574600	137480	218-W-12B
913	574600	137450	218-W-12B
914	574600	137420	218-W-12B
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922	574600	137180	218-W-12B
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925	574600	137090	218-W-12B
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933	574630	137270	218-W-12B
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936	574630	137360	218-W-12B
937	574630	137390	218-W-12B
938	574630	137420	218-W-12B
939	574630	137450	218-W-12B
940	574630	137480	218-W-12B
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942	574630	137540	218-W-12B
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949	574630	137750	218-W-12B
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958	574660	137510	218-W-12B
959	574660	137480	218-W-12B

960	574660	137450		218-W-12B
961	574660	137420		218-W-12B
962	574660	137390		218-W-12B
963	574660	137360	Unable to Set	218-W-12B
964	574660	137330	Unable to Set	218-W-12B
965	574660	137300	Unable to Set	218-W-12B
966	574660	137270	Unable to Set	218-W-12B
967	574660	137240	Unable to Set	218-W-12B
968	574660	137210	Unable to Set	218-W-12B
969	574660	137180	Unable to Set	218-W-12B
970	574660	137150	Unable to Set	218-W-12B
971	574660	137120	Unable to Set	218-W-12B
972	574660	137090	Unable to Set	218-W-12B
973	574660	137060		218-W-12B

218-W-4C Annex Geophysical Grid Staking Survey Data Report

SURVEY DATA REPORT				Request No. 084-410	
Project No.	Title: 218-W-4C Geophysical Grid Staking			File No. 2EWA-061	
Job No. MEIIINF123470 - 0010-CA10	Prepared By N.P. Fastabend	Date 7/25/08	Reviewer Terry Horton		Page 1 of 4

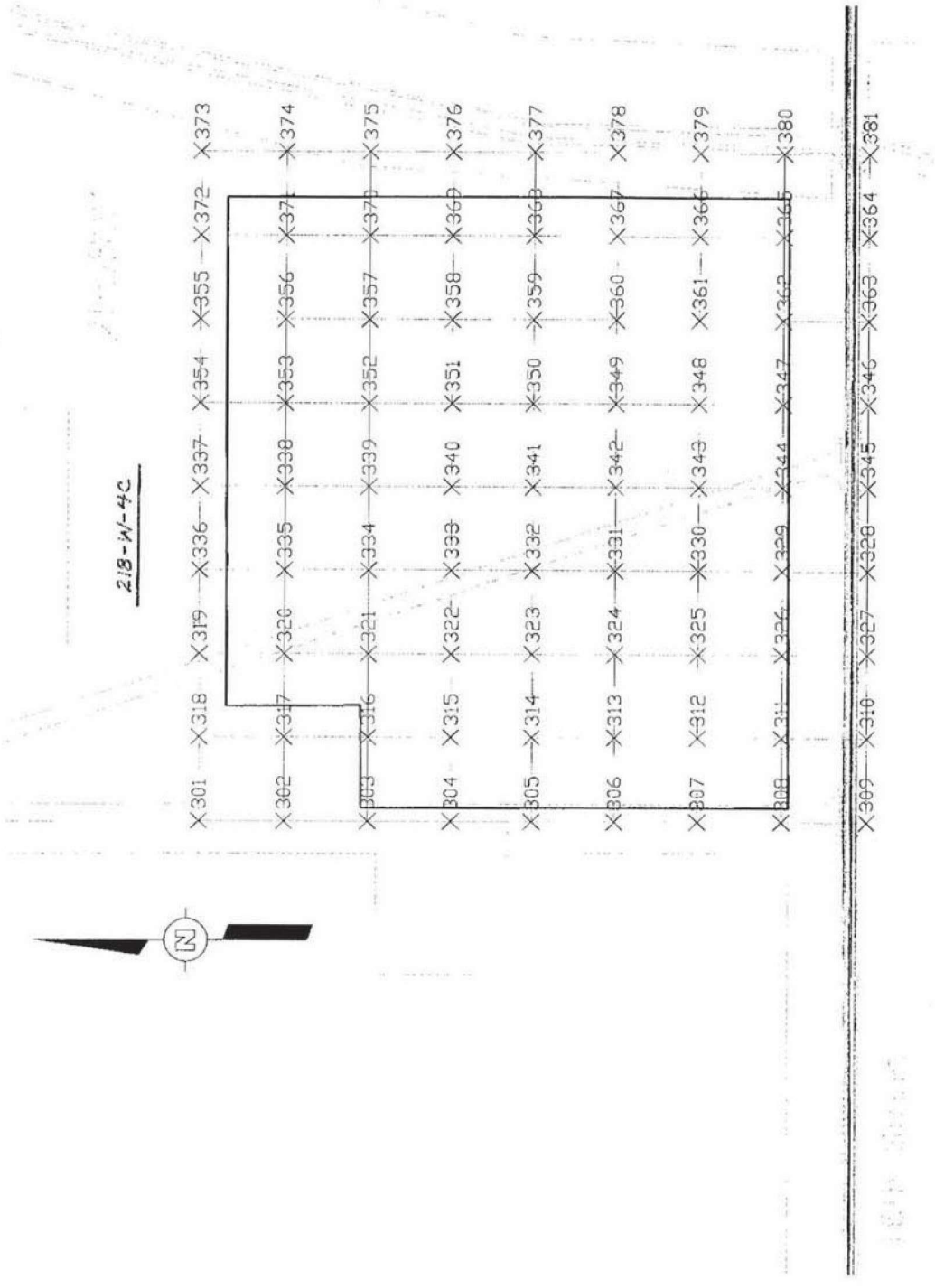
DESCRIPTION OF WORK	DISTRIBUTION	SDR	PLOT	DWG
Staked 30 meter grid at coordinates provided over section of 218-W-4C Burial Ground. Set 3/8" x 1 1/2" x 48" Wood Lath with painted orange tops and marked with coordinates. Horizontal Coordinate System: WCS83S/91 (Meters) Equipment Used: Trimble GPS 5800 RTK	Survey File	OR		
	B.A. Atkinson	1		
	G.T. Berlin	1		
	J.W. Cammann	1		
	T.J. Mitchell	1		

SURVEY RESULTS AND COMMENTS

See Attached Grid Sketch and Coordinate List

NOTE: This Survey was performed under the supervision of a Licensed Professional Land Surveyor registered in the State of Washington.

E-NW-246 (09/04)


218-W-4C
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Pt.No.	Easting	Northing	Site
301	566340	135200	218-W-4C
302	566340	135170	218-W-4C
303	566340	135140	218-W-4C
304	566340	135110	218-W-4C
305	566340	135080	218-W-4C
306	566340	135050	218-W-4C
307	566340	135020	218-W-4C
308	566340	134990	218-W-4C
309	566340	134960	218-W-4C
310	566370	134960	218-W-4C
311	566370	134990	218-W-4C
312	566370	135020	218-W-4C
313	566370	135050	218-W-4C
314	566370	135080	218-W-4C
315	566370	135110	218-W-4C
316	566370	135140	218-W-4C
317	566370	135170	218-W-4C
318	566370	135200	218-W-4C
319	566400	135200	218-W-4C
320	566400	135170	218-W-4C
321	566400	135140	218-W-4C
322	566400	135110	218-W-4C
323	566400	135080	218-W-4C
324	566400	135050	218-W-4C
325	566400	135020	218-W-4C
326	566400	134990	218-W-4C
327	566400	134960	218-W-4C
328	566430	134960	218-W-4C
329	566430	134990	218-W-4C
330	566430	135020	218-W-4C
331	566430	135050	218-W-4C
332	566430	135080	218-W-4C
333	566430	135110	218-W-4C
334	566430	135140	218-W-4C
335	566430	135170	218-W-4C
336	566430	135200	218-W-4C
337	566460	135200	218-W-4C
338	566460	135170	218-W-4C
339	566460	135140	218-W-4C
340	566460	135110	218-W-4C
341	566460	135080	218-W-4C
342	566460	135050	218-W-4C
343	566460	135020	218-W-4C
344	566460	134990	218-W-4C
345	566460	134960	218-W-4C
346	566490	134960	218-W-4C
347	566490	134990	218-W-4C
348	566490	135020	218-W-4C

349	566490	135050	218-W-4C
350	566490	135080	218-W-4C
351	566490	135110	218-W-4C
352	566490	135140	218-W-4C
353	566490	135170	218-W-4C
354	566490	135200	218-W-4C
355	566520	135200	218-W-4C
356	566520	135170	218-W-4C
357	566520	135140	218-W-4C
358	566520	135110	218-W-4C
359	566520	135080	218-W-4C
360	566520	135050	218-W-4C
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365	566550	134990	218-W-4C
366	566550	135020	218-W-4C
367	566550	135050	218-W-4C
368	566550	135080	218-W-4C
369	566550	135110	218-W-4C
370	566550	135140	218-W-4C
371	566550	135170	218-W-4C
372	566550	135200	218-W-4C
373	566580	135200	218-W-4C
374	566580	135170	218-W-4C
375	566580	135140	218-W-4C
376	566580	135110	218-W-4C
377	566580	135080	218-W-4C
378	566580	135050	218-W-4C
379	566580	135020	218-W-4C
380	566580	134990	218-W-4C
381	566580	134960	218-W-4C

218-W-6 Geophysical Grid Staking Survey Data Report

SURVEY DATA REPORT				Request No. 084-410		
Project No.	Title: 218-W-6 Geophysical Grid Staking			File No. 2EWA-061		
Job No. MEH1NF123470 - 0010-CA10	Prepared By N.P. Fastabend	Date 8/15/08	Reviewer Barry Hanlon			Page 1 of 8

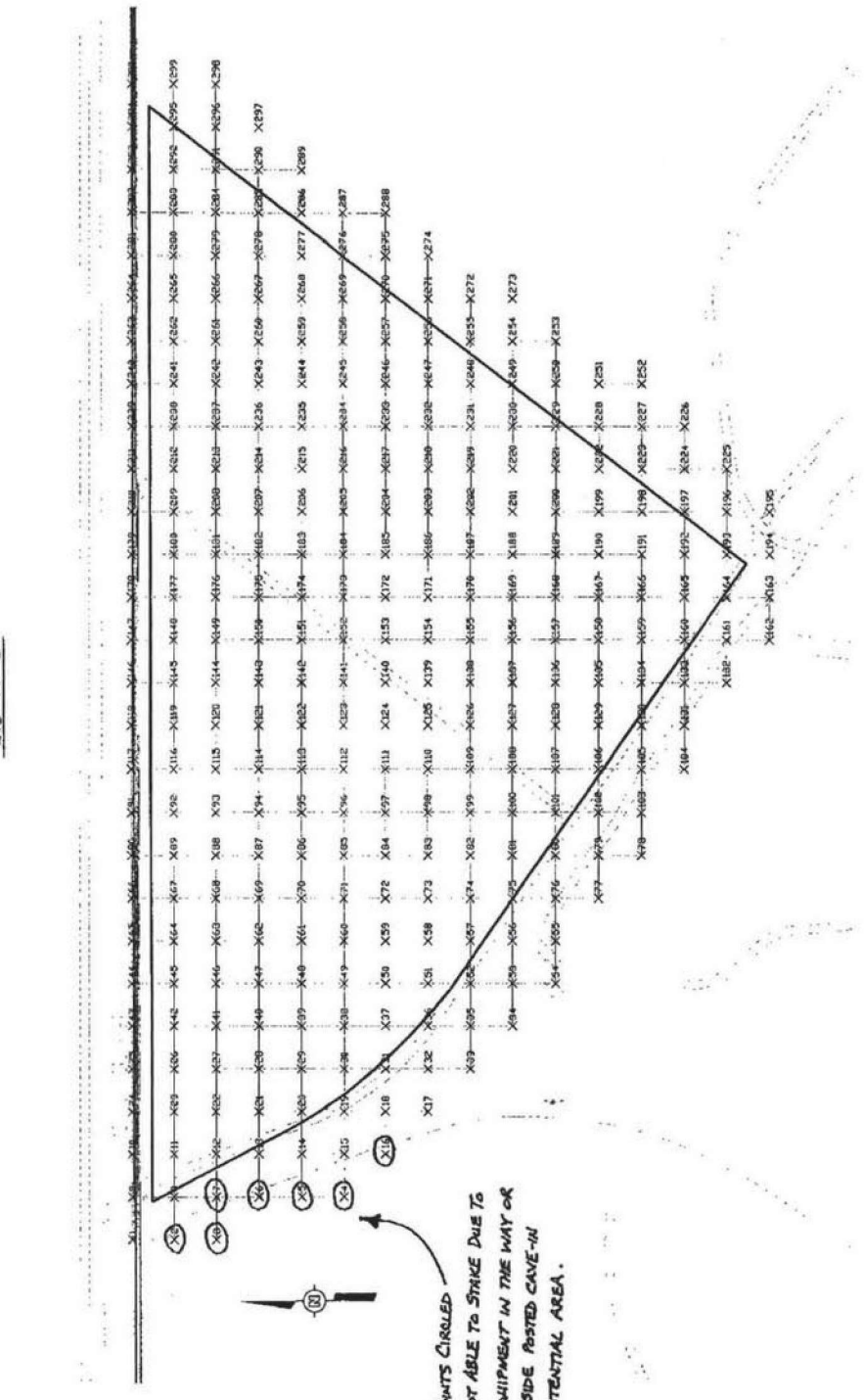
DESCRIPTION OF WORK	DISTRIBUTION	SDR	PLOT	DWG
Staked 30 meter grid at coordinates provided over 218-W-6 Burial Ground. Set 3/8" x 1 1/2" x 48" Wood Lath with painted orange tops or paint mark on asphalt road and marked with coordinates. Horizontal Coordinate System: WCS83S/91 (Meters) Equipment Used: Trimble GPS 5800 RTK	Survey File	OR		
	B.A. Atkinson	1		
	G.T. Berlin	1		
	I.W. Cammann	1		
	T.H. Mitchell	1		

SURVEY RESULTS AND COMMENTS

See Attached Grid Sketch and Coordinate List

NOTE: This Survey was performed under the supervision of a Licensed Professional Land Surveyor registered in the State of Washington.

H-NW-246 (09/04)


218-W-6
POINTS CIRCLED NOT ABLE TO STAKE DUE TO EQUIPMENT IN THE WAY OR INSIDE POSTED CAVE-IN POTENTIAL AREA.

Pt. No.	Easting	Northing		Site
1	566760	137650		218-W-6
2	566760	137620	Unable to Set	218-W-6
3	566760	137590	Unable to Set	218-W-6
4	566790	137500	Unable to Set	218-W-6
5	566790	137530	Unable to Set	218-W-6
6	566790	137560	Unable to Set	218-W-6
7	566790	137590	Unable to Set	218-W-6
8	566790	137620		218-W-6
9	566790	137650		218-W-6
10	566820	137650		218-W-6
11	566820	137620		218-W-6
12	566820	137590		218-W-6
13	566820	137560		218-W-6
14	566820	137530		218-W-6
15	566820	137500		218-W-6
16	566820	137470	Unable to Set	218-W-6
17	566850	137440		218-W-6
18	566850	137470		218-W-6
19	566850	137500		218-W-6
20	566850	137530		218-W-6
21	566850	137560		218-W-6
22	566850	137590		218-W-6
23	566850	137620		218-W-6
24	566850	137650		218-W-6
25	566880	137650		218-W-6
26	566880	137620		218-W-6
27	566880	137590		218-W-6
28	566880	137560		218-W-6
29	566880	137530		218-W-6
30	566880	137500		218-W-6
31	566880	137470		218-W-6
32	566880	137440		218-W-6
33	566880	137410		218-W-6
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49	566940	137500		218-W-6

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51	566940	137440	218-W-6
52	566940	137410	218-W-6
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111	567090	137470	218-W-6
112	567090	137500	218-W-6
113	567090	137530	218-W-6
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122	567120	137530	218-W-6
123	567120	137500	218-W-6
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127	567120	137380	218-W-6
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145	567150	137620	218-W-6
146	567150	137650	218-W-6
147	567180	137650	218-W-6
148	567180	137620	218-W-6
149	567180	137590	218-W-6

150	567180	137560	218-W-6
151	567180	137530	218-W-6
152	567180	137500	218-W-6
153	567180	137470	218-W-6
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183	567240	137530	218-W-6
184	567240	137500	218-W-6
185	567240	137470	218-W-6
186	567240	137440	218-W-6
187	567240	137410	218-W-6
188	567240	137380	218-W-6
189	567240	137350	218-W-6
190	567240	137320	218-W-6
191	567240	137290	218-W-6
192	567240	137260	218-W-6
193	567240	137230	218-W-6
194	567240	137200	218-W-6
195	567270	137200	218-W-6
196	567270	137230	218-W-6
197	567270	137260	218-W-6
198	567270	137290	218-W-6
199	567270	137320	218-W-6

200	567270	137350	218-W-6
201	567270	137380	218-W-6
202	567270	137410	218-W-6
203	567270	137440	218-W-6
204	567270	137470	218-W-6
205	567270	137500	218-W-6
206	567270	137530	218-W-6
207	567270	137560	218-W-6
208	567270	137590	218-W-6
209	567270	137620	218-W-6
210	567270	137650	218-W-6
211	567300	137650	218-W-6
212	567300	137620	218-W-6
213	567300	137590	218-W-6
214	567300	137560	218-W-6
215	567300	137530	218-W-6
216	567300	137500	218-W-6
217	567300	137470	218-W-6
218	567300	137440	218-W-6
219	567300	137410	218-W-6
220	567300	137380	218-W-6
221	567300	137350	218-W-6
222	567300	137320	218-W-6
223	567300	137290	218-W-6
224	567300	137260	218-W-6
225	567300	137230	218-W-6
226	567330	137260	218-W-6
227	567330	137290	218-W-6
228	567330	137320	218-W-6
229	567330	137350	218-W-6
230	567330	137380	218-W-6
231	567330	137410	218-W-6
232	567330	137440	218-W-6
233	567330	137470	218-W-6
234	567330	137500	218-W-6
235	567330	137530	218-W-6
236	567330	137560	218-W-6
237	567330	137590	218-W-6
238	567330	137620	218-W-6
239	567330	137650	218-W-6
240	567360	137650	218-W-6
241	567360	137620	218-W-6
242	567360	137590	218-W-6
243	567360	137560	218-W-6
244	567360	137530	218-W-6
245	567360	137500	218-W-6
246	567360	137470	218-W-6
247	567360	137440	218-W-6
248	567360	137410	218-W-6
249	567360	137380	218-W-6

250	567360	137350	218-W-6
251	567360	137320	218-W-6
252	567360	137290	218-W-6
253	567390	137350	218-W-6
254	567390	137380	218-W-6
255	567390	137410	218-W-6
256	567390	137440	218-W-6
257	567390	137470	218-W-6
258	567390	137500	218-W-6
259	567390	137530	218-W-6
260	567390	137560	218-W-6
261	567390	137590	218-W-6
262	567390	137620	218-W-6
263	567390	137650	218-W-6
264	567420	137650	218-W-6
265	567420	137620	218-W-6
266	567420	137590	218-W-6
267	567420	137560	218-W-6
268	567420	137530	218-W-6
269	567420	137500	218-W-6
270	567420	137470	218-W-6
271	567420	137440	218-W-6
272	567420	137410	218-W-6
273	567420	137380	218-W-6
274	567450	137440	218-W-6
275	567450	137470	218-W-6
276	567450	137500	218-W-6
277	567450	137530	218-W-6
278	567450	137560	218-W-6
279	567450	137590	218-W-6
280	567450	137620	218-W-6
281	567450	137650	218-W-6
282	567480	137650	218-W-6
283	567480	137620	218-W-6
284	567480	137590	218-W-6
285	567480	137560	218-W-6
286	567480	137530	218-W-6
287	567480	137500	218-W-6
288	567480	137470	218-W-6
289	567510	137530	218-W-6
290	567510	137560	218-W-6
291	567510	137590	218-W-6
292	567510	137620	218-W-6
293	567510	137650	218-W-6
294	567540	137650	218-W-6
295	567540	137620	218-W-6
296	567540	137590	218-W-6
297	567540	137560	218-W-6
298	567570	137590	218-W-6
299	567570	137620	218-W-6
300	567570	137650	218-W-6

Attachment D2

Site Investigation Details, Data Plots, and Overlays

Contents

Figures

Tables

Terms

DGPS	differential global positioning system
EM	electromagnetic
EMI	electromagnetic induction
GPR	ground penetrating radar
GPS	global positioning system
PC	personal computer
WCH	Washington Closure Hanford
WIDS	Waste Information Data System

D2-1 Site Investigation Details, Data Plots, and Overlays

Information is provided on the ground-penetrating radar (GPR), electromagnetic induction (EMI), and magnetic data collected, along with details of the investigation, for each "burial ground" discussed in this document. This attachment also presents an overlay of the geophysical results with mapped surface features for each site investigation.

D2-2 218-E-10 Annex Geophysical Investigation Summary and Data Plots

Geophysical Investigation Summary Sheet	
Site Name	218-E-10 Annex
Location	200 East Area
Approximate Size	210 m (689 ft) × 615 m (2,017 ft) (about 14 ha [35 ac])
Burial Ground Information	No documented use
Terrain	Generally flat
Vegetation/Ground Cover	Bunch grass, Russian thistle, other grasses and weeds
Hydrological Properties	Surface dry at time of data collection
Limitations/ Obstacles	None
Overall Assessment for Geophysical Investigation	EMI, magnetic methods, and GPR effective at meeting project objectives
Equipment	
GPR	SIR-10A[1] GPR system with 200 MHz antenna
EMI	Frequency domain EMI: Geonics EM31[2] Ground Conductivity Meter and data logger. Trimble DGPS for navigation and positioning.
Total Magnetic Field	G-858/G Cesium Vapor Magnetometer/Gradiometer[3]
Data Collection and Processing Parameters	

[1] SIR-10A (GPR system) is a registered trademark of Geophysical Survey Systems, Inc., North Salem, New Hampshire.

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

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

Geophysical Investigation Summary Sheet	
Grid Location Control and Data Collection Lines	Fluor personnel staked grid nodes at 30 m (98 ft) centers using a Trimble GPS 5800 RTK[4] system and coordinates supplied by WCH, based on WIDS documentation. The 30 m (98 ft) node base grid was 270 m (886 ft) north-south, 660 m (2,165 ft) east-west; data collection lines were flagged at 6 m (19 ft) intervals in the east-west direction along grid nodes.
SIR-10A	Data were collected at specific sites with the antenna pulled by hand. Marks were placed in the data as the instrument passed position marks tied to the base grid nodes, painted on the ground at 2 m (6 ft) intervals. Data were stacked (two 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.
EM31	Data were collected at hip height in the vertical dipole mode with samples recorded every 0.5 seconds (nominal 0.5 m [1.6 ft] data spacing along line). Data were collected on 6 m (19 ft) line spacing in both the north-south and east-west directions. For the east-west profiles, DGPS was used for navigation and positioning. Data were downloaded from the field PC and written to a .xyz data file. The data was then reviewed using standard spreadsheets such as Excel[5]. For north-south lines, data positioning relied on survey marks/pin flags. Data were downloaded from the data logger to a PC using DAT31.exe and then converted to DAT31W[6] format. Corrections of position errors during data collection (if any) were made. Data were gridded and plotted using Surfer[7]. Grid cell size for data plots is nominally 6 m (19 ft) (cross line) × 2 m (6 ft) (down line) and the nearest neighbor algorithm was used for contouring.
G-858/G	Data were collected with sensors 0.5 and 1.25 m (1.6 and 4 ft) above the ground in continuous sampling mode with samples recorded every 0.3 seconds (nominal 0.3 m [1 ft] data spacing), and fiducial positioning marks placed every 30 m (98 ft), on lines spaced 3 m (10 ft) 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 MagMapper2000.exe[8]. Data were gridded and plotted using Surfer. Grid cell size for the data plots is nominally 3 m (10 ft) (cross line) × 1 m (3 ft) (down line) and the nearest neighbor algorithm was used for contouring. Profile spacing, contour thresholds, and intervals were aggressively chosen in order to maximize the ability to detect anomalies that could be attributed to drum size or even smaller objects.
Equipment Functional Check Location	

[4] GPS 5800 RTK is a trademark of Trimble Navigation Limited, Sunnyvale, California.

[5] Excel is a trademark of Microsoft Corporation, Redmond, Washington.

[6] DAT31.exe and DAT31W are trademarks of Geonics Limited, Mississauga, Ontario, Canada.

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

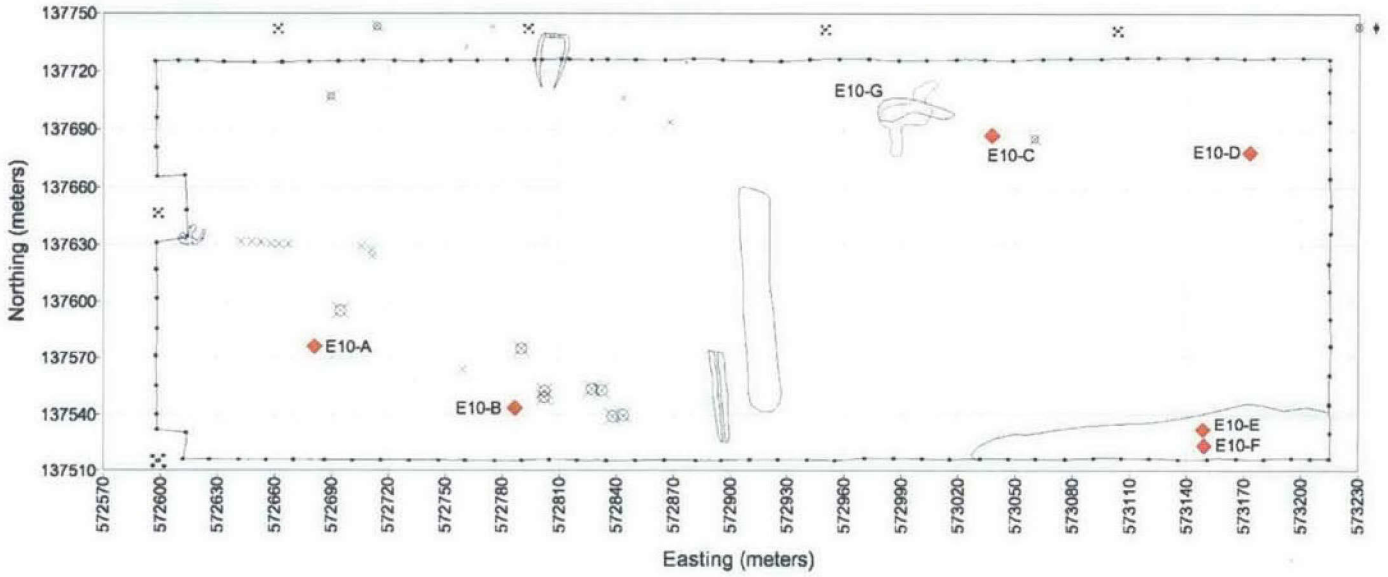
[8] MagMapper2000.exe is a trademark of Geometrics, Inc., San Jose, California.

Geophysical Investigation Summary Sheet	
Results	
Data Discussion/ Interpretation	Refer to data plots D2-1 through D2-11 and Table D2-1 during the following discussion: To illustrate the predominately quiet and anomaly-free nature of the survey area, the anomalies that dominate most of the magnetic field/vertical gradient data are associated with T-posts and metal survey pin flags or can be correlated with visible surface features such as well casings. T-posts support a small chain surrounding the 218-E-10 Annex and the pin flags were placed at 6 m (19 ft) intervals along N137540, N137600, N137660, and N137720. Numerous small, discrete magnetic anomalies are also scattered throughout the data, but most of these appear to be associated with basalt cobbles/boulders observed on the surface and occasionally to miscellaneous small pieces of metal scattered throughout the survey area. The EMI apparent ground conductivity and in-phase data also indicate an overall quiet background for the entire site. The notable exception to the otherwise benign character of the site is an anomalous area that might represent significant buried debris, centered at about N137700 and E572990. GPR data were collected around this area for further characterization. The GPR data indicate this area likely contains shallow, scattered debris buried from 0.3 to 1.0 m (1 to 3 ft) below the surface over an area 10 to 20 m (33 to 66 ft) across.
Lessons Learned	Given the objective of characterizing the site with the intent not to miss a pickup size area of debris or a minimum target size equal to a 55-gallon drum, the profile spacing for the magnetic field data is appropriate. It might be argued that EMI data collected only in one direction, still spaced at 6 m (19 ft) intervals, would be adequate. However, having EM data collected in two directions greatly improves the possibility of detecting an unknown liquid or non-ferrous material filled trench, if they were present.

Table D2-1. Summary of Results from 218-E-10 Annex

Target ID	Easting	Northing	Target Description
E10-A	572681.17	137576.19	Single low-amplitude magnetic target
E10-B	572786.72	137543.58	Multiple low-amplitude magnetic targets
E10-C	573037.54	137687.07	Single low-amplitude magnetic target
E10-D	573172.73	137678.18	Single low-amplitude magnetic target
E10-E	573148.42	137532.31	Single low-amplitude magnetic target
E10-F	573149.01	137524.01	Single low-amplitude magnetic target
E10-G	572990.00	137700.00	Area magnetic and EM target

Note: Target IDs are posted on the Geophysical Interpretation Map Coordinates in Washington State Plane Meters/NAD83



LEGEND

- Point Anomaly - Magnetic Data
- Point Anomaly - Electromagnetic Data
- Area Anomaly - Magnetic Data
- Area Anomaly - Electromagnetic Data

N

METERS

0 40 80

Washington State Plane South
NAD83

Geophysical Interpretation Map
218-E-10 Annex
200 East Area
September 2008

Figure D2-1. Geophysical Interpretation Map, 218-E-10 Annex, 200 East Area, September 2008

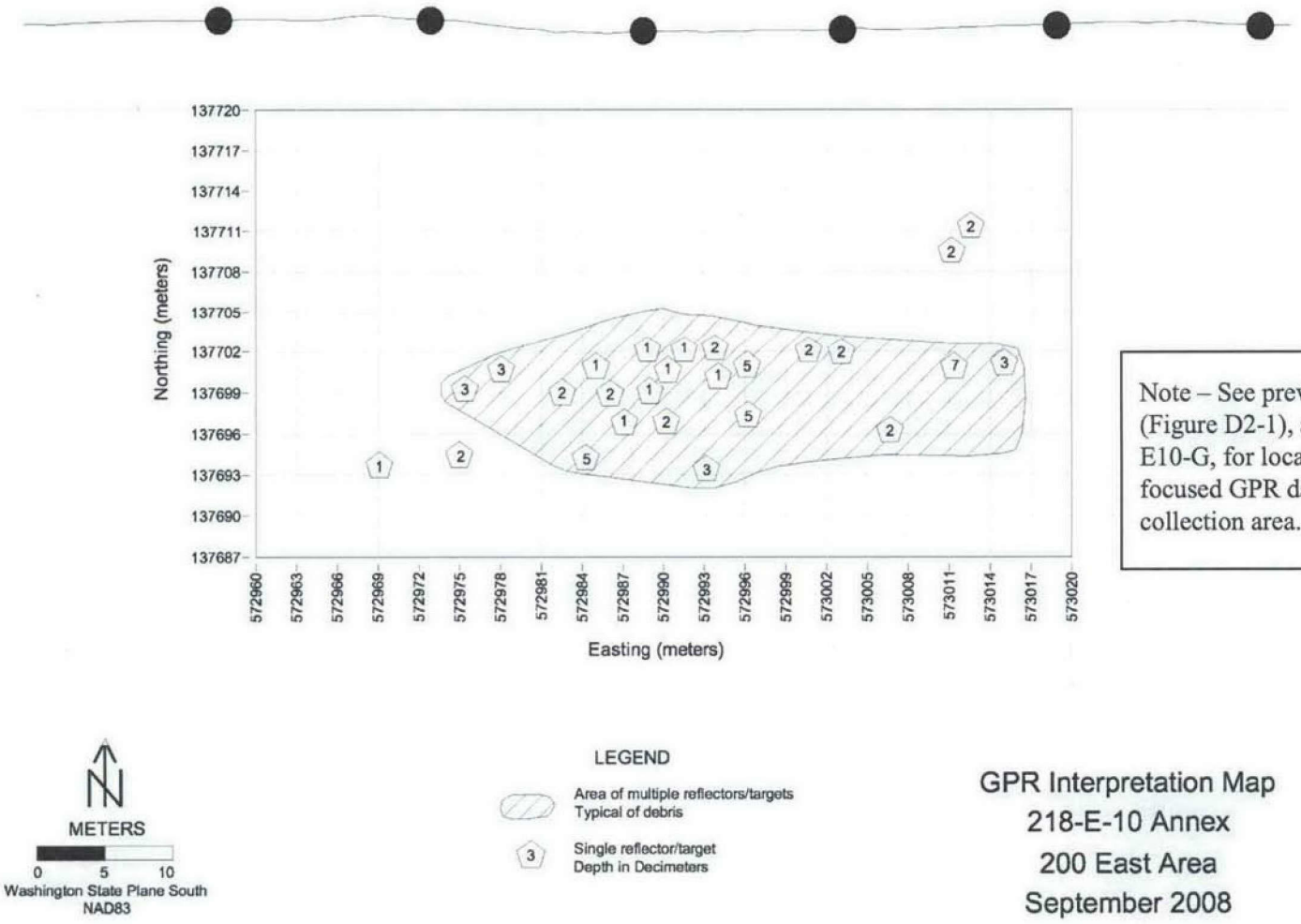
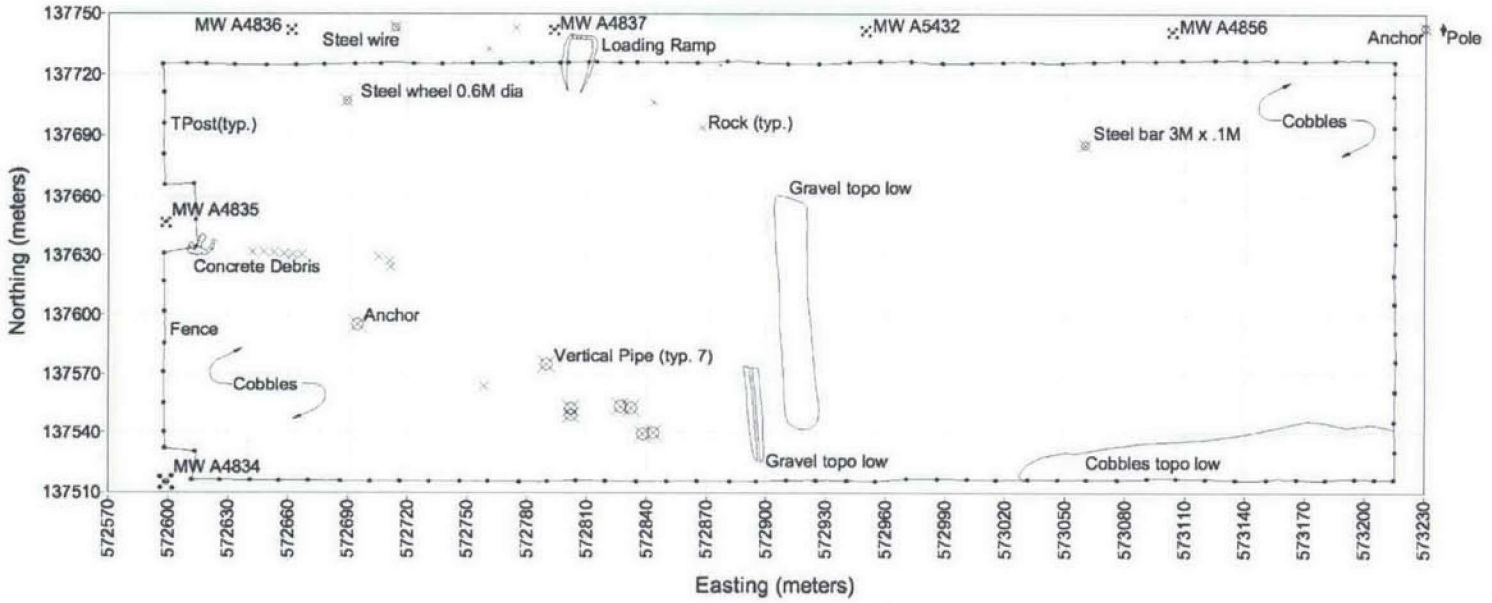
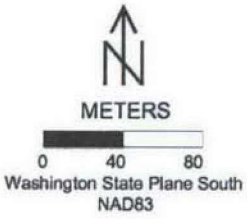


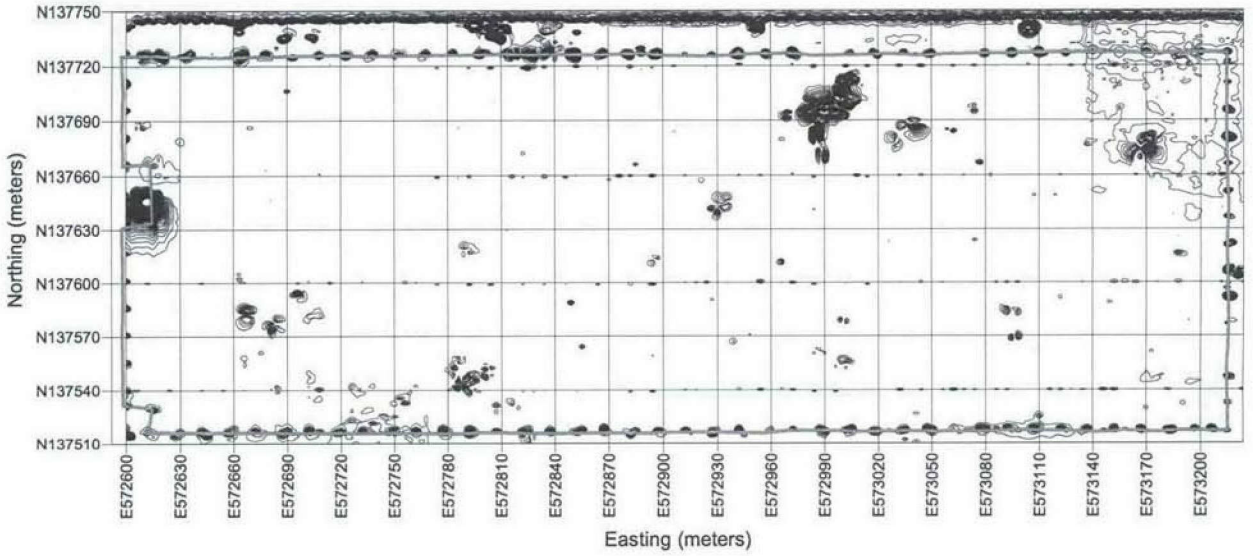
Figure D2-2. Ground-Penetrating Radar Interpretation Map, 218-E-10 Annex Detail Area, 200 East Area, September 2008





Surface Features Base Map
218-E-10 Annex
200 East Area
September 2008

Figure D2-3. Surface Features Base Map, 218-E-10 Annex, 200 East Area, September 2008



Top Residual (-54580 nT)
Contour Interval: 25 nT
Contour Threshold: 50 nT

LEGEND

Fence

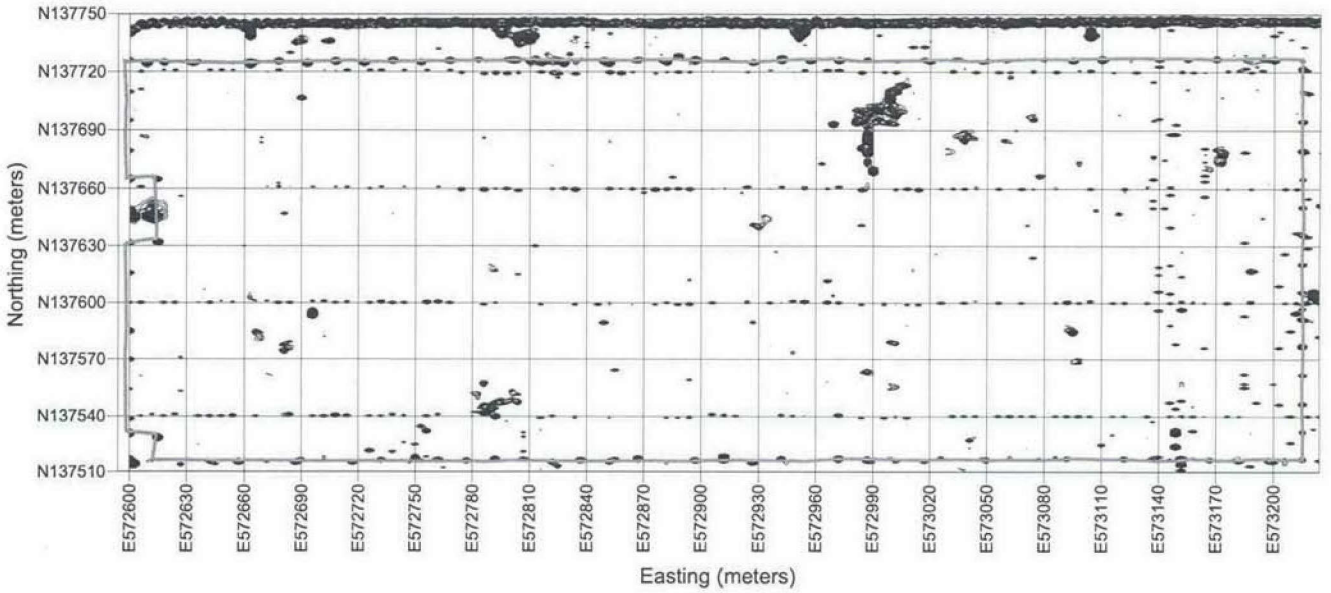
Meters

0 30 60

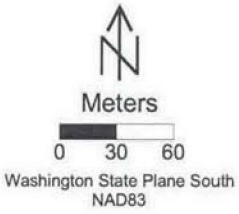
Washington State Plane South
NAD83

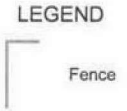
Residual Magnetic Field (G858/G)
218-E-10 Annex
200 East Area
September 2008

Figure D2-4. Residual Magnetic Field (G-858/G) Data, 218-E-10 Annex, 200 East Area, September 2008



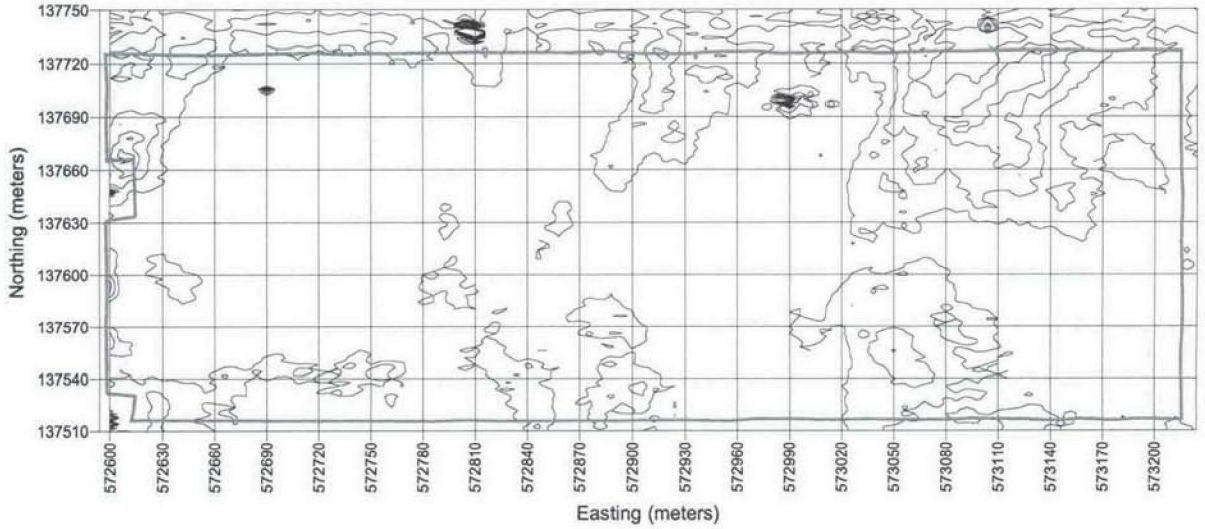
Vertical Magnetic Gradient (absolute value)
Contour Interval: 25 nT
Minimum Contour Level: 75 nT





Vertical Magnetic Gradient (G858/G)
218-E-10 Annex
200 East Area
September 2008

Figure D2-5. Vertical Magnetic Gradient (G-858/G) Data, 218-E-10 Annex, 200 East Area, September 2008



Ground Conductivity
Contour Interval : 1.0 mS/m

LEGEND

Fence

N

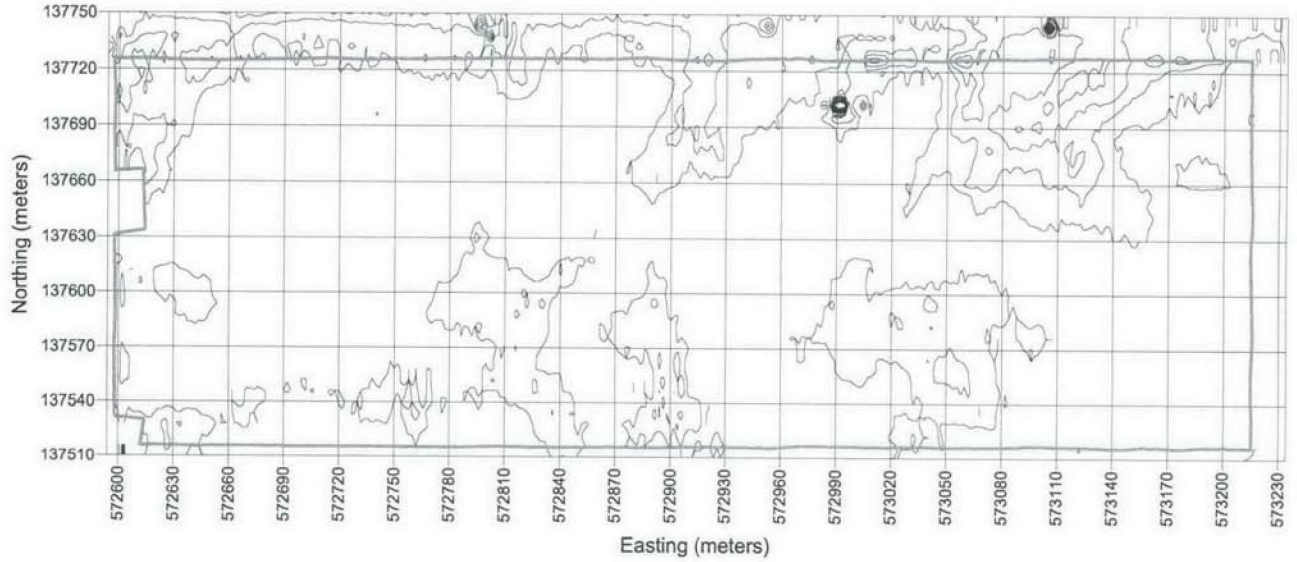
METERS

0 40 80

Washington State Plane South
NAD83

Electromagnetic Induction (EM31)
North-South Profiles
218-E-10 Annex
200 East Area
September 2008

Figure D2-6. Electromagnetic Induction (EM31) Apparent Ground Conductivity Data, North-South Profiles, 218-E-10 Annex, 200 East Area, September 2008



Ground Conductivity
Contour Interval : 1.0 mS/m

LEGEND

Fence

N

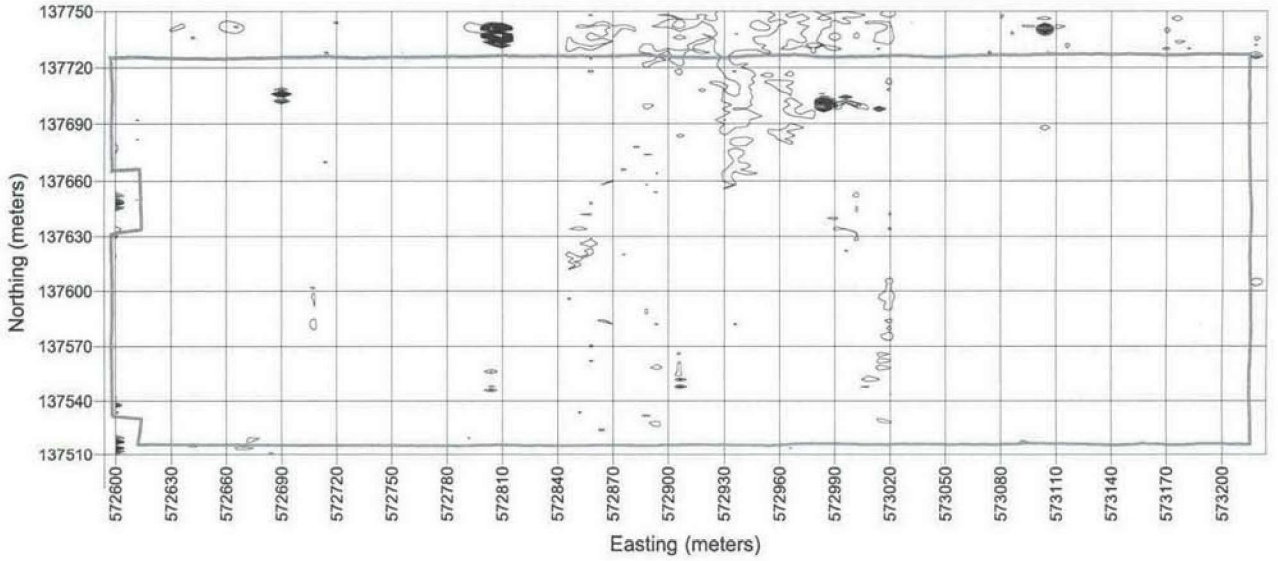
METERS

0 40 80

Washington State Plane South
NAD83

Electromagnetic Induction (EM31)
East - West Profiles
218-E-10 Annex
200 East Area
September 2008

Figure D2-7. Electromagnetic Induction (EM31) Apparent Ground Conductivity Data, East-West Profiles, 218-E-10 Annex, 200 East Area, September 2008



In-Phase Response
Contour Interval : 0.5 ppt

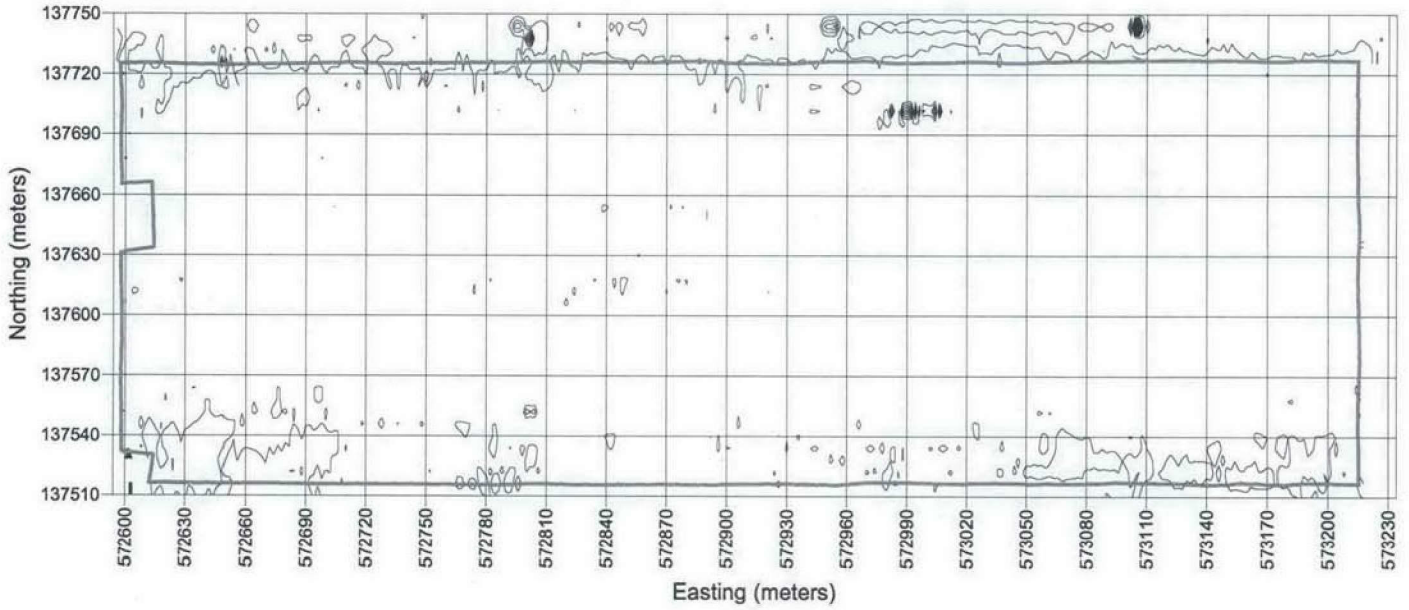
LEGEND

Fence

METERS
0 40 80
Washington State Plane South
NAD83

Electromagnetic Induction (EM31)
North-South Profiles
218-E-10 Annex
200 East Area
September 2008

Figure D2-8. Electromagnetic Induction (EM31) In-Phase Data, North-South Profiles, 218-E-10 Annex, 200 East Area, September 2008



In-Phase Response
Contour Interval : 0.5 ppt

LEGEND

Fence

N

METERS

0 40 80

Washington State Plane South
NAD83

Electromagnetic Induction (EM31)
East - West Profiles
218-E-10 Annex
200 East Area
September 2008

Figure D2-9. Electromagnetic Induction (EM31) In-Phase Data, East-West Profiles, 218-E-10 Annex, 200 East Area, September 2008

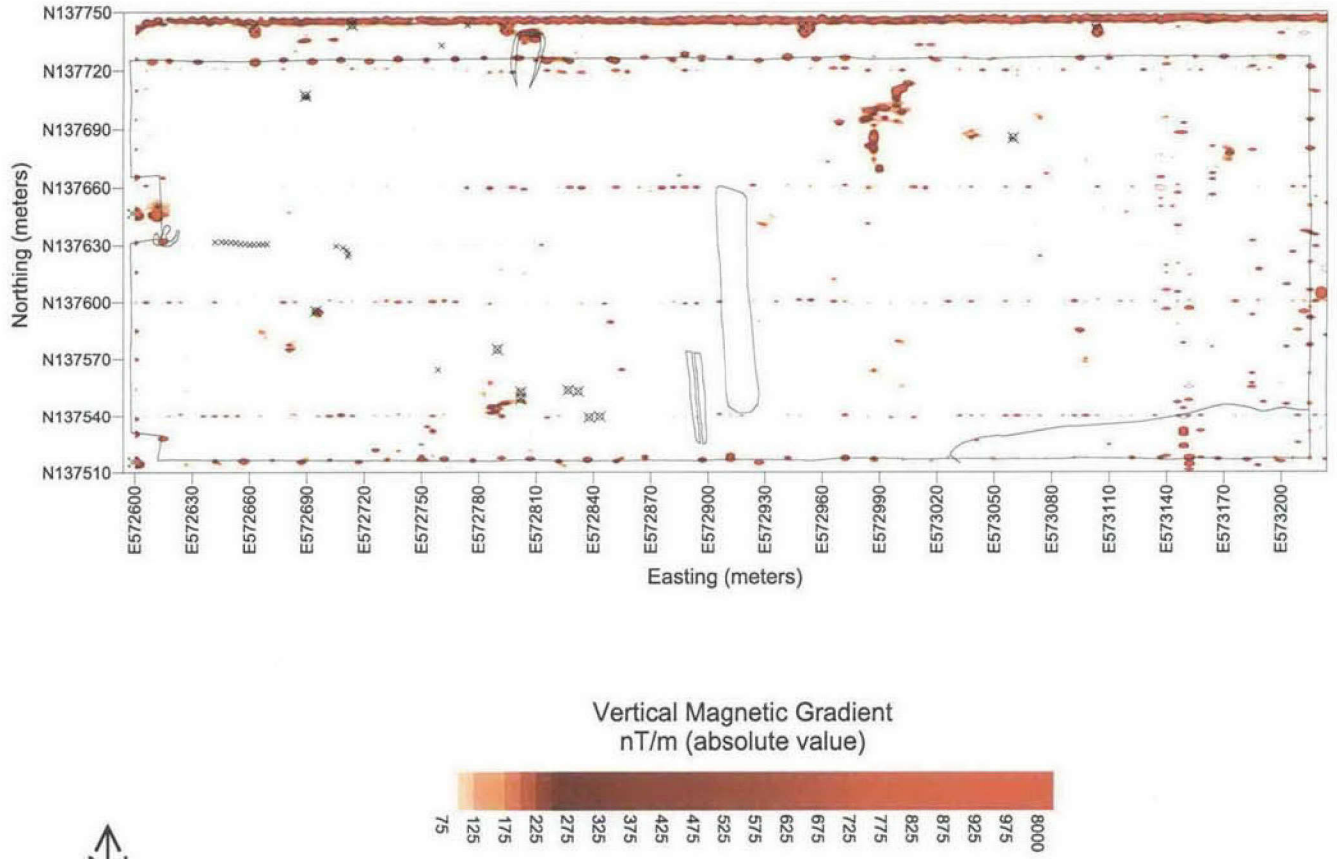
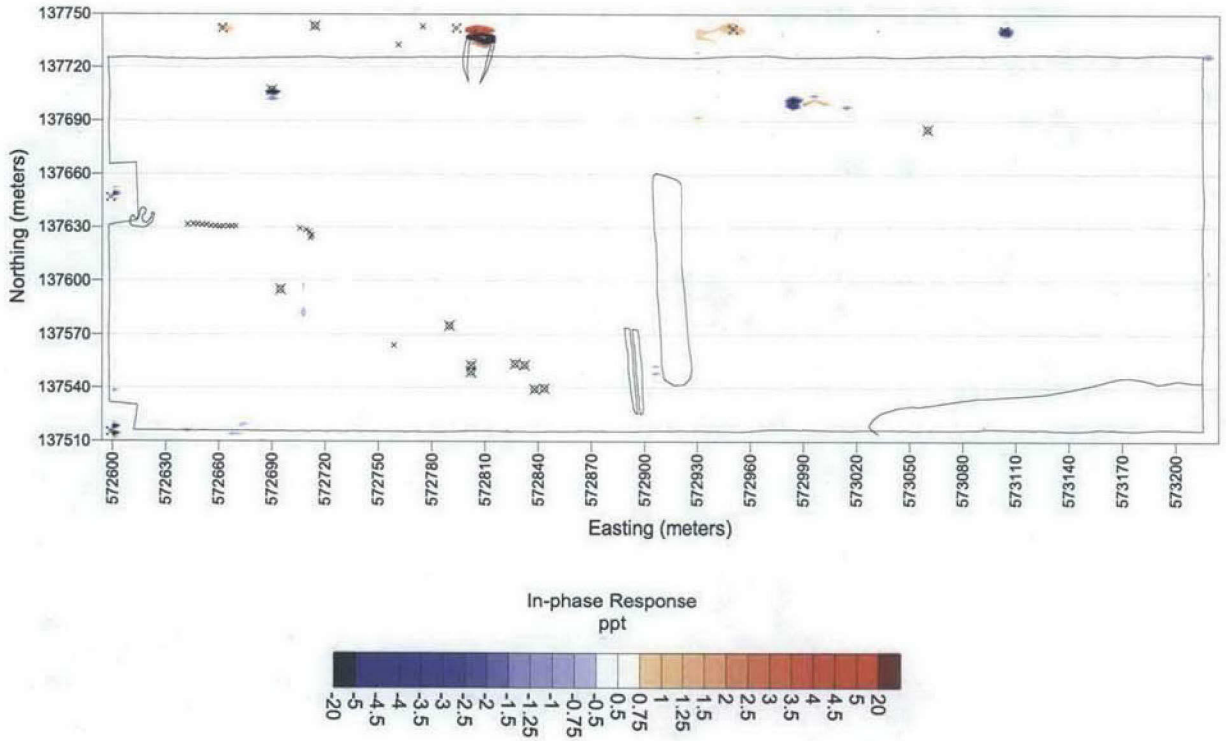
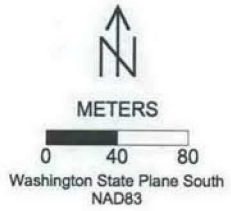


Figure D2-10. Overlay: Vertical Magnetic Gradient Data and Surface Features, 218-E-10 Annex, 200 East Area, September 2008





Electromagnetic Induction (EM31) Overlay
North-South Profiles
218-E-10 Annex
200 East Area
September 2008

Figure D2-11. Overlay: Electromagnetic Induction In-Phase Data and Surface Features, 218-E-10 Annex, 200 East Area, September 2008

D2-3 218-E-12B (Western Portion) Geophysical Investigation Summary and Data Plots

Geophysical Investigation Summary Sheet	
Site Name	218-E-12B (Western Portion)
Location	200 East Area
Approximate Size	Trapezoid with an angled southern base, measuring roughly 460 m (1,509 ft) across by 650 m (2,132 ft) north-south (about 24 ha [60 ac])
Burial Ground Information	No documented use
Terrain	Generally flat
Vegetation/Ground Cover	Bunch grass, Russian thistle, other grasses and weeds
Hydrological Properties	Surface dry at time of data collection
Limitations/Obstacles	None
Overall Assessment for Geophysical Investigation	EMI and magnetic methods effective at meeting project objectives
Equipment	
EMI	Frequency domain EMI: Geonics EM31 Ground Conductivity Meter with a data logger. Trimble DGPS for navigation and positioning.
Total Magnetic Field	G-858/G Cesium Vapor Magnetometer/Gradiometer
Data Collection and Processing Parameters	
Grid Location Control and Data Collection Lines	Fluor personnel staked grid nodes at 30 m (98 ft) centers using a Trimble GPS 5800 RTK system and coordinates supplied by WCH, based on WIDS documentation. The 30 m (98 ft) node base grid was 690 m (2,263 ft) north-south, 480 m (1,574 ft) east-west data collection lines were flagged at 6 m (19 ft) intervals in the east-west and north-south direction along grid nodes.
EM31	Data were collected at hip height in the vertical dipole mode with samples recorded every 0.5 seconds (nominal 0.5 m [1.6 ft] data spacing along line). Data were collected on 6 m (19 ft) line spacing in both the north-south and east-west directions. For both the east-west and north-south lines, data were downloaded from the data logger to a PC using DAT31.exe. and converted to DAT31W format. The data were then reviewed using standard spreadsheets such as Excel, and corrections of position errors during data collection (if any) were made. Data were gridded and plotted using Surfer. Grid cell size for data plots is nominally 6 m (19 ft) (cross line) × 2 m (6 ft) (down line) and the nearest neighbor algorithm was used for contouring.

Geophysical Investigation Summary Sheet	
G-858/G	Data were collected with sensors 0.5 and 1.25 m (1.6 and 4 ft) above the ground in continuous sampling mode with samples recorded every 0.3 seconds (nominal 0.3 m [1 ft] data spacing), and fiducial positioning marks placed every 30 m (98 ft), on lines spaced 3 m (10 ft) 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 (10 ft) (cross line) × 1 m (3 ft) (down line) and the nearest neighbor algorithm was used for contouring. Profile spacing, contour thresholds and intervals were aggressively chosen in order to maximize the ability to detect anomalies that could be attributed to drum size or even smaller objects.
Equipment Functional Check Location	
Results	
Data Discussion/ Interpretation	Refer to data plots D2-12 through D2-21 and Table D2-2 during the following discussion: To illustrate the predominately quiet and anomaly-free nature of the survey area, the anomalies that dominate most of the magnetic field/vertical gradient data are associated with T-posts and metal survey pin flags or can be correlated with visible surface features. T-posts support a small chain surrounding the 218-E-12BB (Western Portion) and the pin flags were placed at 6 m (19 ft) intervals along N137120, N137180, N137240, N137300, N137360, N137420, N137480, N137540, N137600, N137660, N137720, and also along north-south node lines spaced typically 60 m (197 ft) apart. Numerous small, discrete magnetic anomalies are also scattered throughout the data, but most of these appear to be associated with basalt cobbles/boulders observed on the surface and occasionally to miscellaneous small pieces of metal scattered throughout the survey area. The EMI apparent ground conductivity and in-phase data also indicate an overall quiet background for the entire site. No buried drum or trench-like features were observed in the data.
Lessons Learned	Given the objective of characterizing the site with the intent not to miss a pickup size area of debris or a minimum target size equal to a 55-gallon drum, the profile spacing for the magnetic field data is appropriate. It might be argued that EMI data collected only in one direction, still spaced at 6 m (19 ft) intervals, would be adequate. But, having EM data collected in two directions greatly improves the possibility of detecting an unknown liquid or non-ferrous material filled trench, if they were present.

Table D2-2. Summary of Results from 218-E-12B (Western Portion)

Target ID	Easting	Northing	Target Description
E12-A	574263.7	137277.6	Multiple low amplitude magnetic targets
E12-B	574275.7	137275.6	Multiple low-amplitude magnetic targets
E12-C	574251.8	137472.1	Single low-amplitude magnetic target
E12-D	574332.6	137669.6	Single low-amplitude magnetic target
E12-E	574464.2	137655.6	Single low-amplitude magnetic target
E12-F	574557	137642.7	Single low-amplitude magnetic target
E12-G	574549	137525	Single low-amplitude magnetic target
E12-H	574364.5	137353.4	Single low-amplitude magnetic target

Note: Target IDs are posted on the Geophysical Interpretation Map Coordinates in Washington State Plane Meters/NAD83.

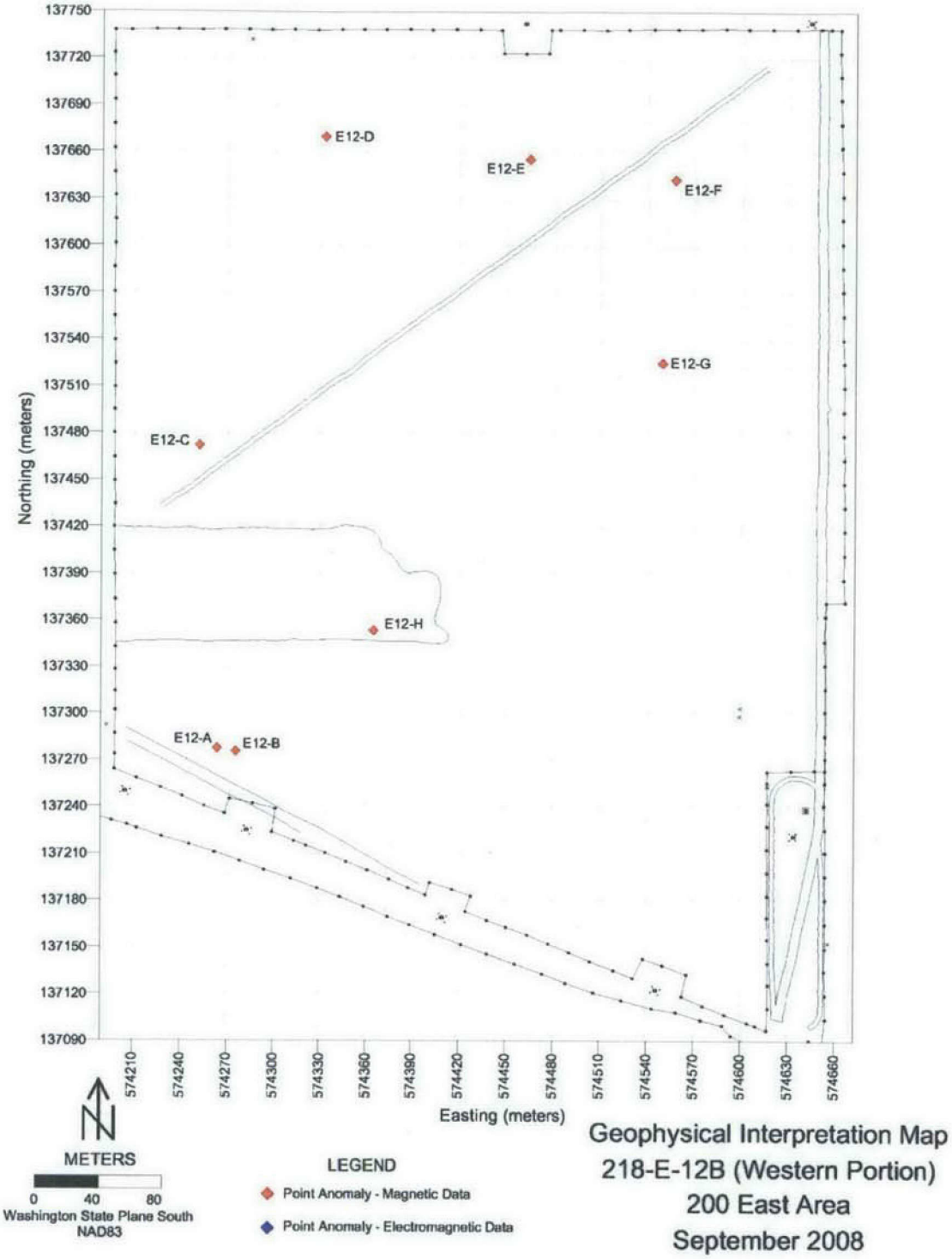


Figure D2-12. Geophysical Interpretation Map, 218-E-12B (Western Portion), 200 East Area, September 2008

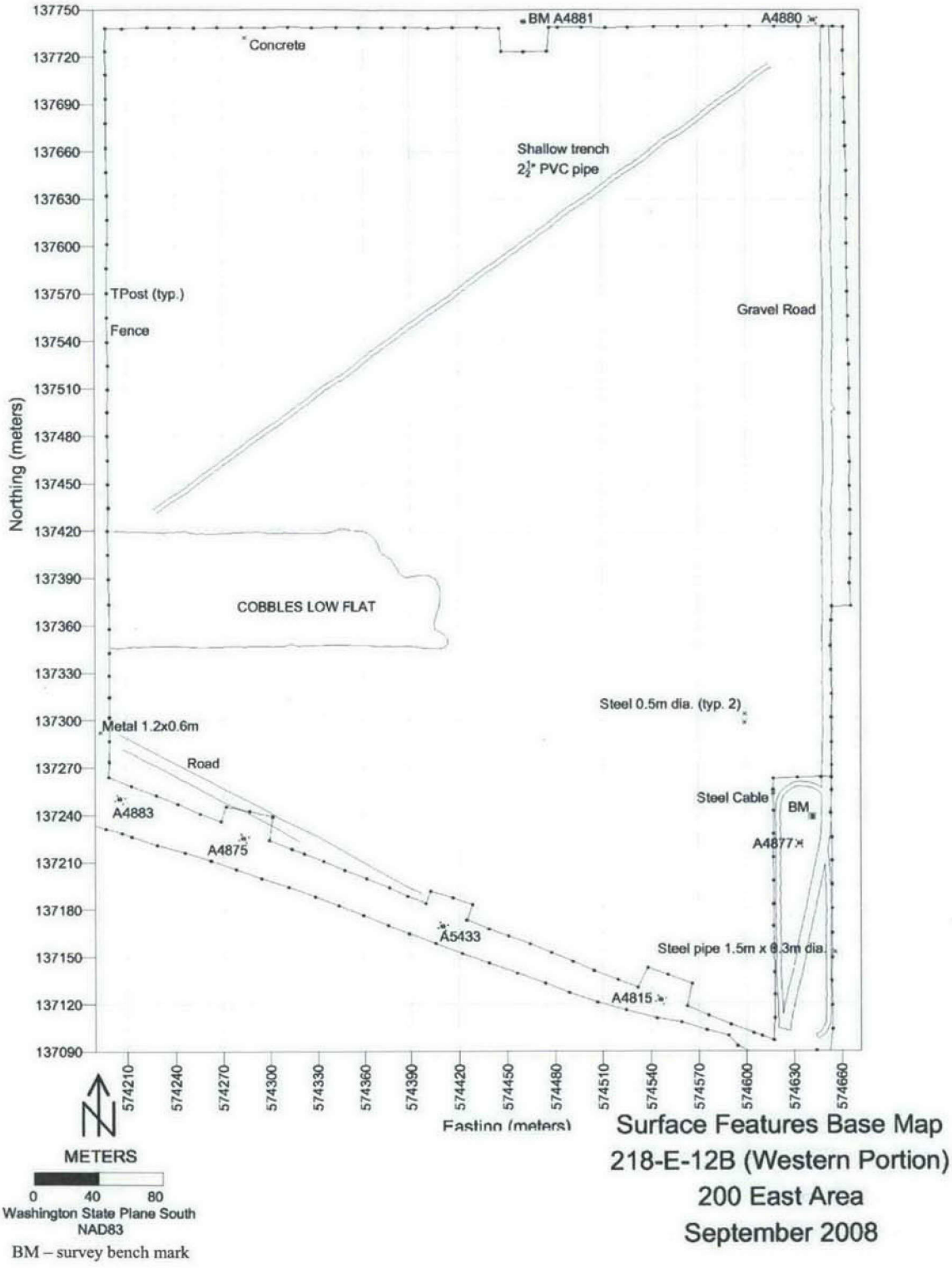


Figure D2-13. Surface Features Base Map, 218-E-12B (Western Portion), 200 East Area, September 2008

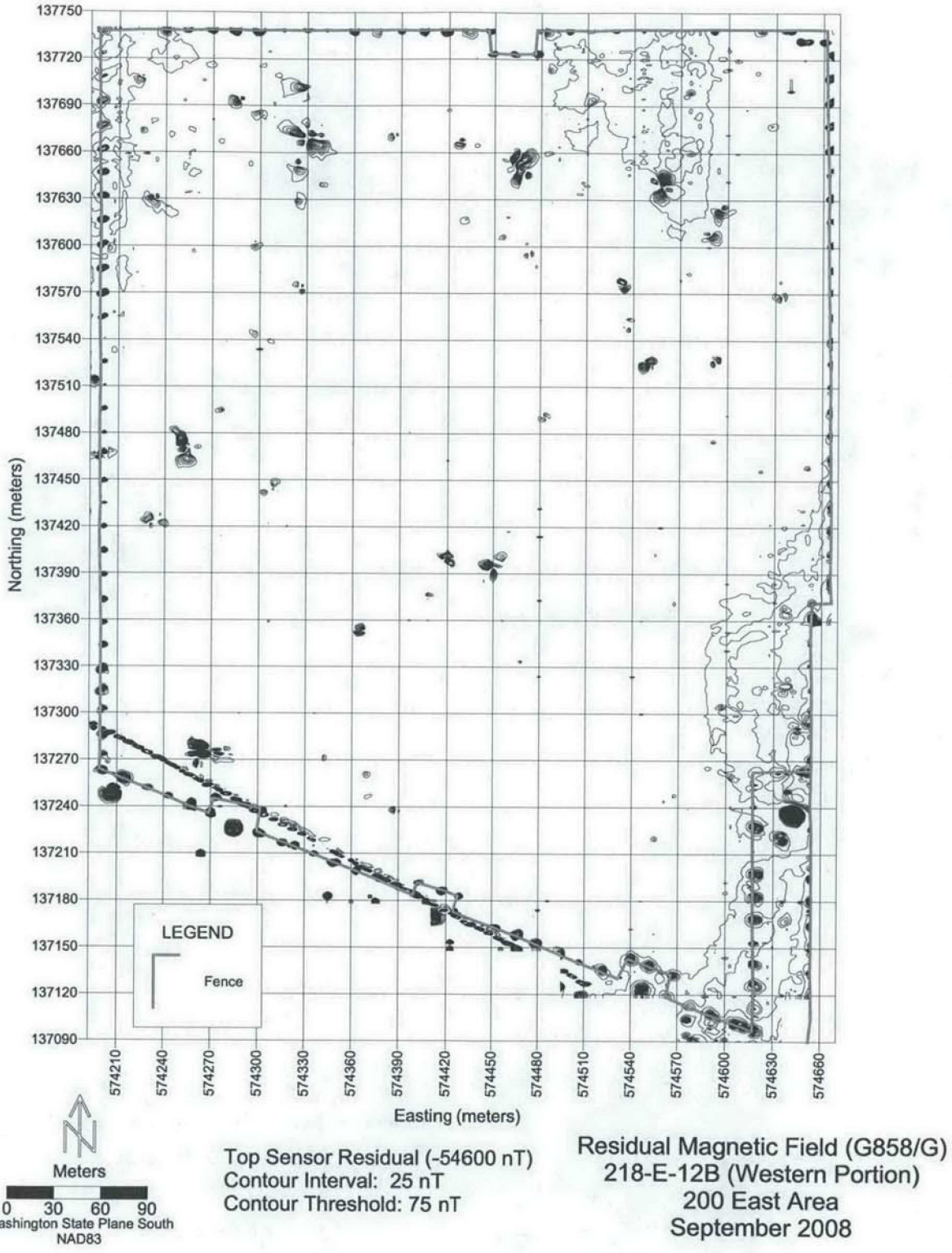


Figure D2-14. Residual Magnetic Field (G-858/G) Data, 218-E-12B (Western Portion), 200 East Area, September 2008

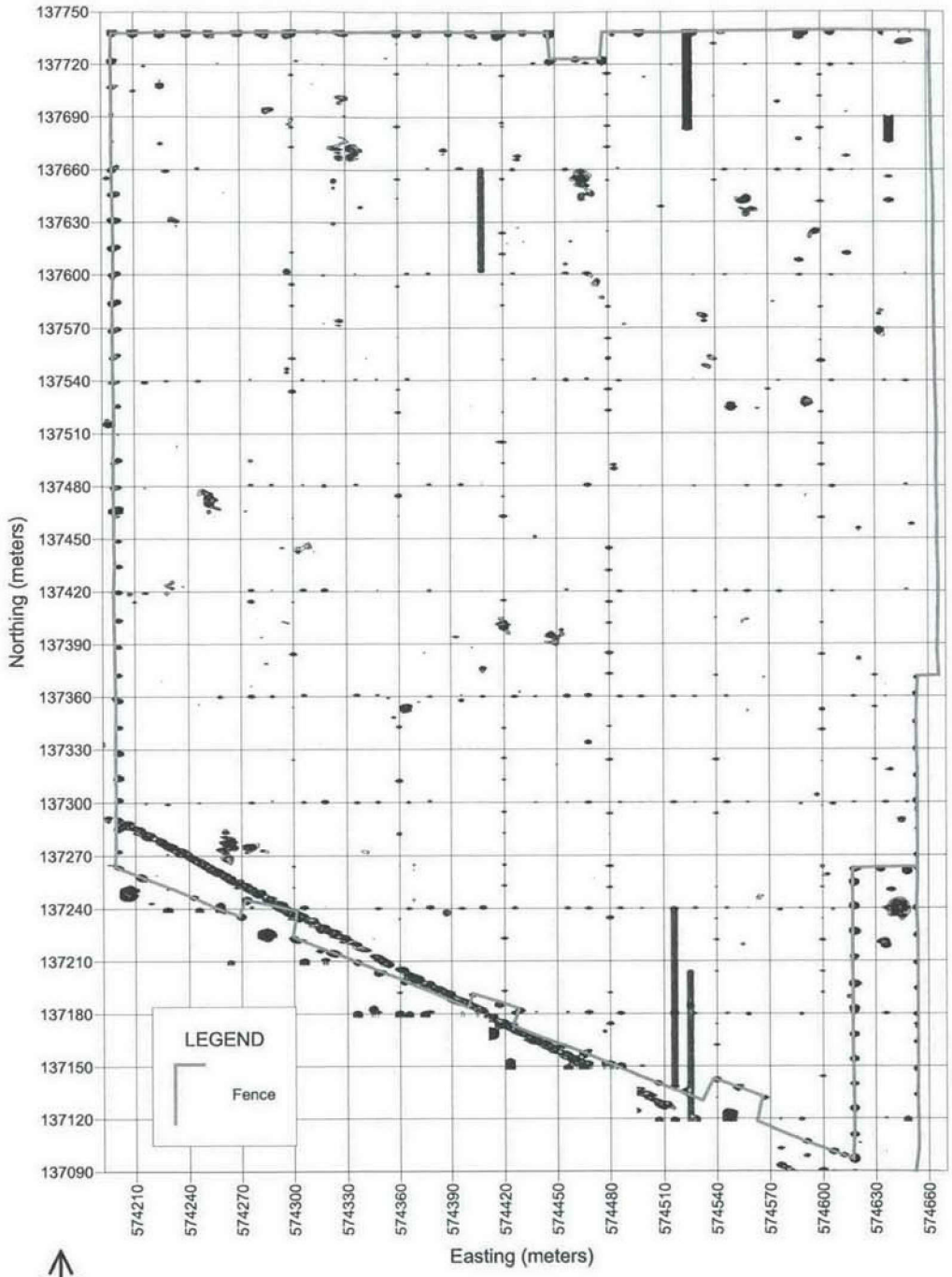


Figure D2-15. Vertical Magnetic Gradient (G-858/G) Data, 218-E-12B (Western Portion), 200 East Area, September 2008

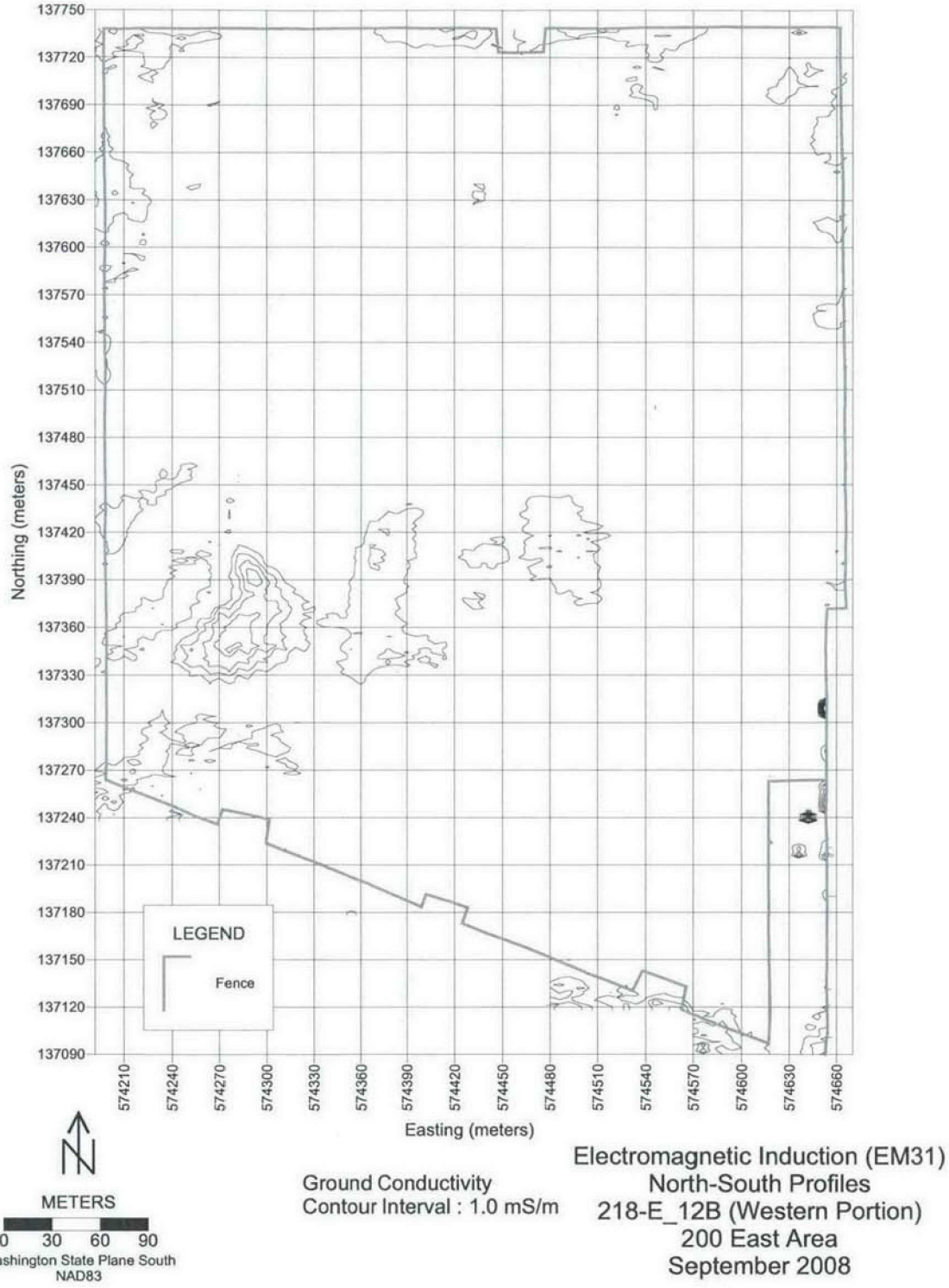


Figure D2-16. Electromagnetic Induction (EM31) Apparent Ground Conductivity Data, North-South Profiles, 218-E-12B (Western Portion), 200 West Area, September 2008

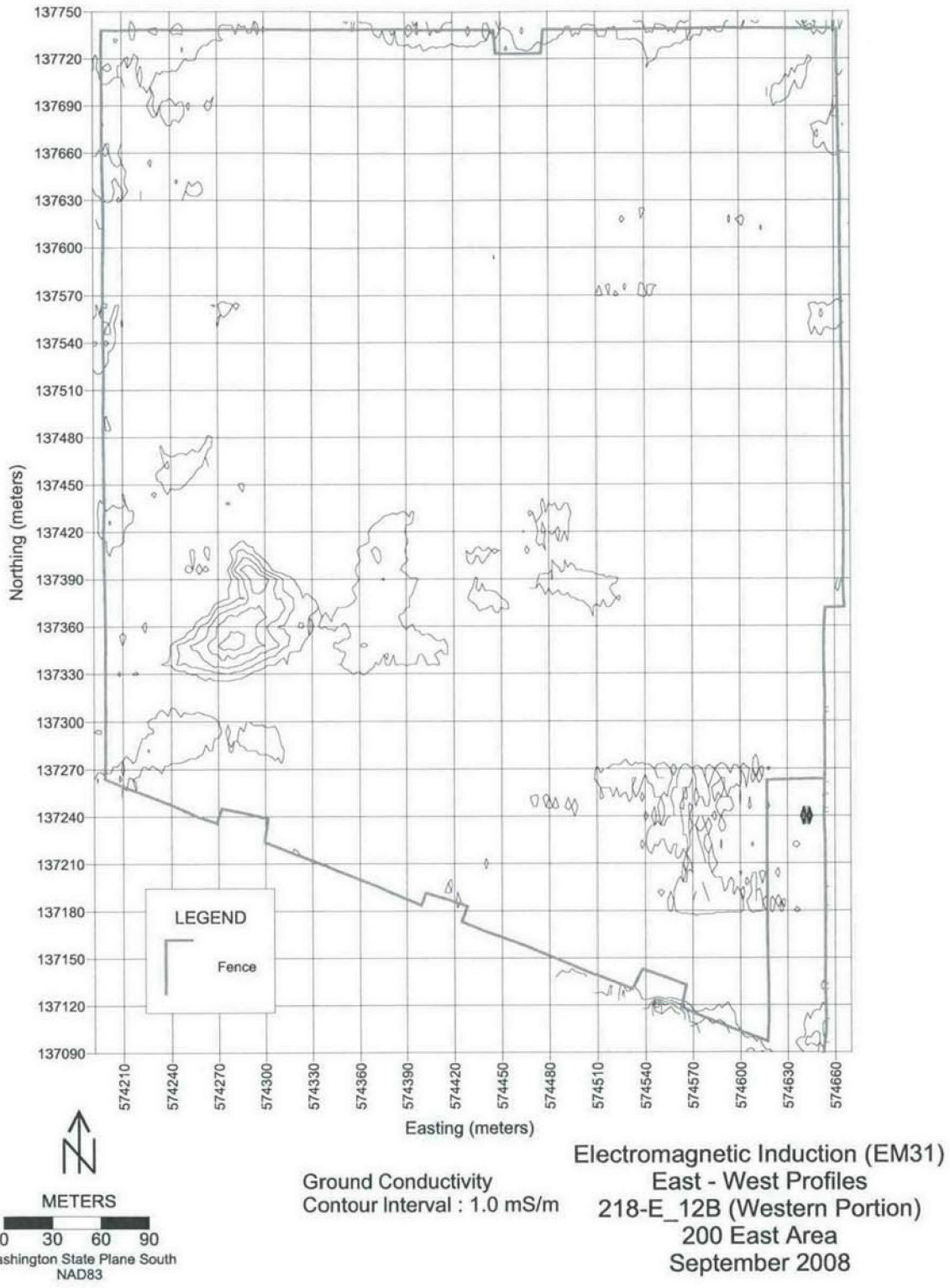


Figure D2-17. Electromagnetic Induction (EM31) Apparent Ground Conductivity Data, East-West Profiles, 218-E-12B (Western Portion), 200 East Area, September 2008

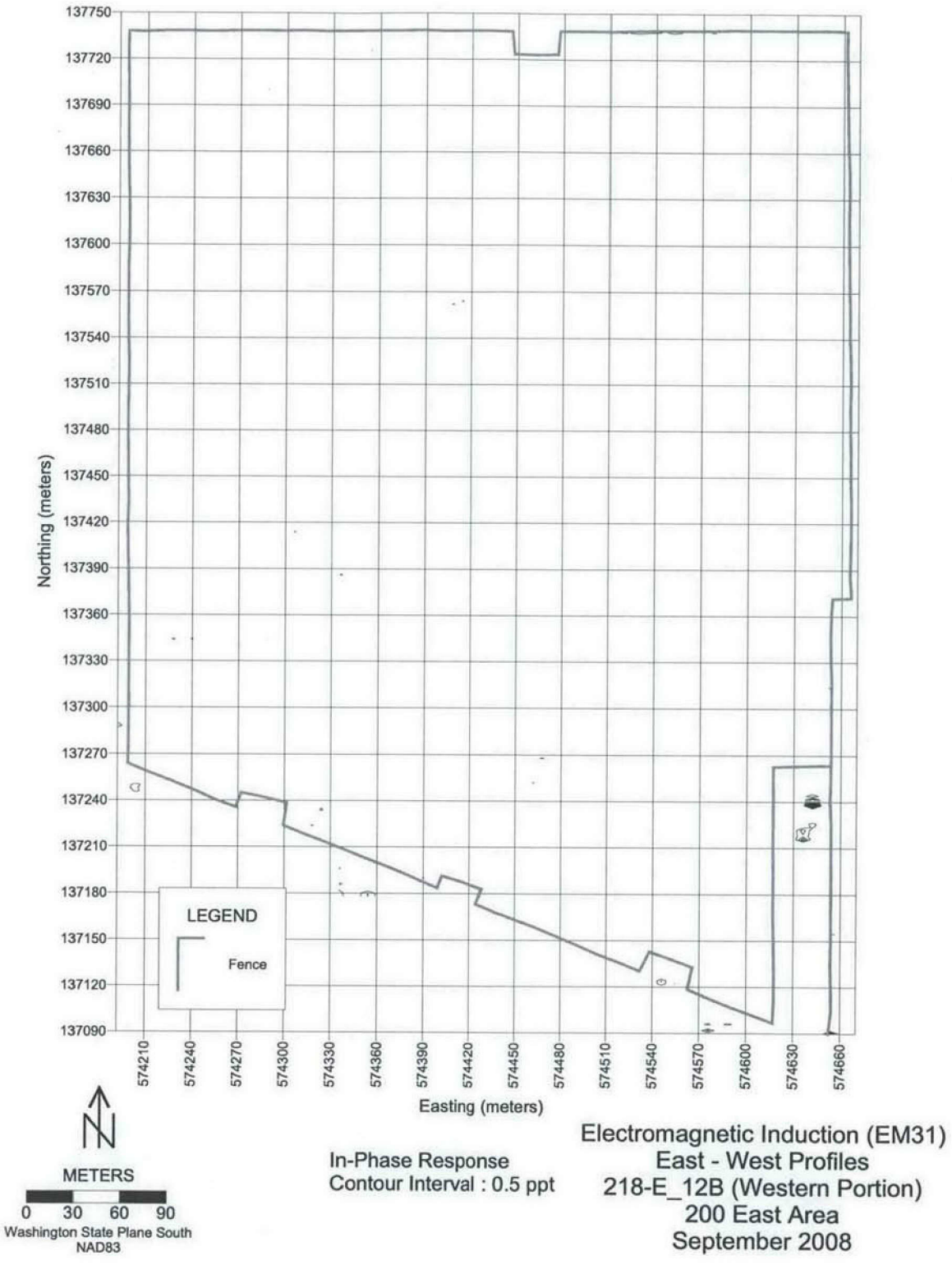


Figure D2-18. Electromagnetic Induction (EM31) In-Phase Data, North-South Profiles, 218-E-12B (Western Portion), 200 East Area, September 2008

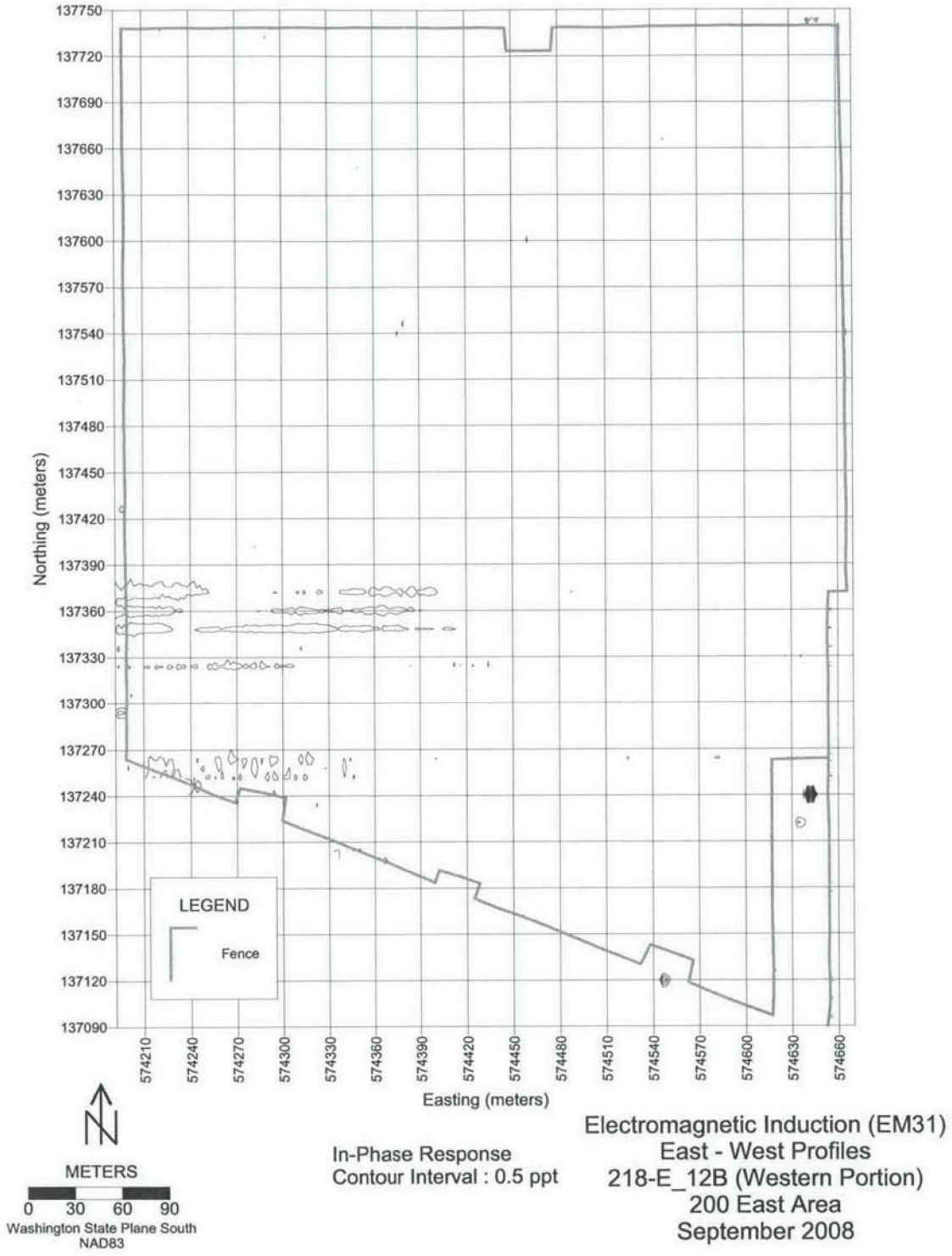


Figure D2-19. Electromagnetic Induction (EM31) In-Phase Data, East-West Profiles, 218-E-12B (Western Portion), 200 East Area, September 2008

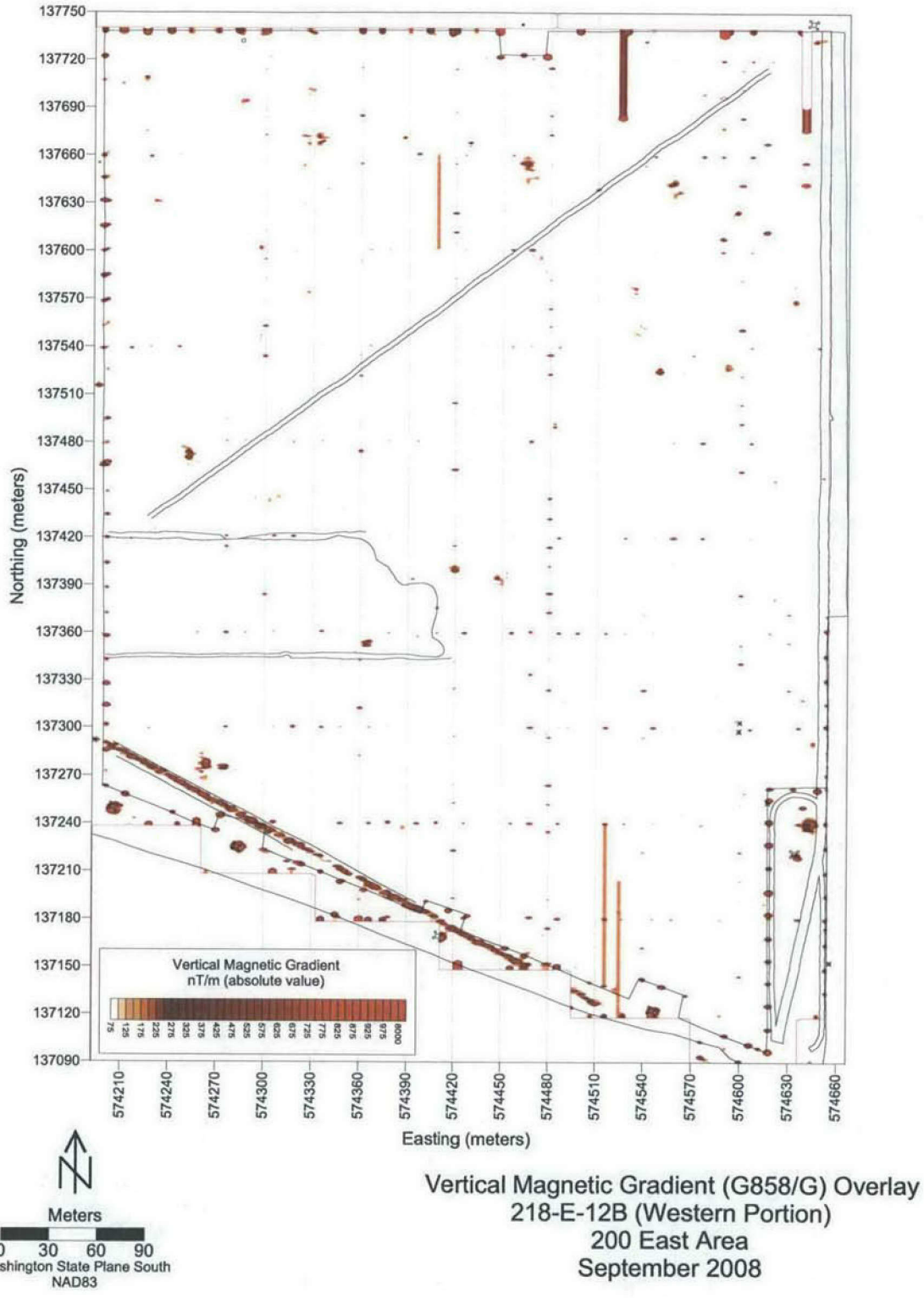


Figure D2-20. Overlay: Vertical Magnetic Gradient Data and Surface Features, 218-E-12B (Western Portion), 200 East Area, September 2008

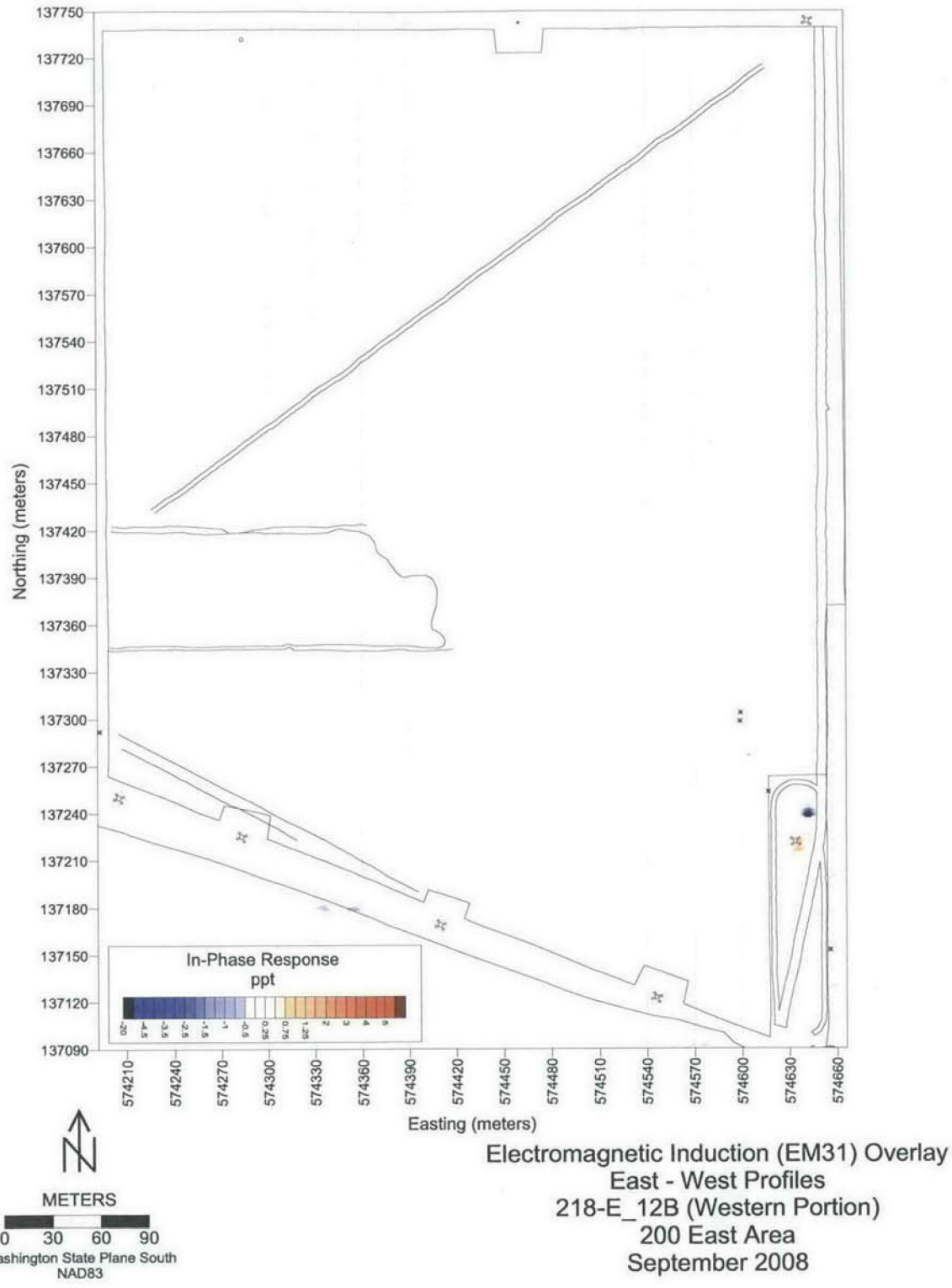


Figure D2-21. Overlay: Electromagnetic Induction In-Phase Data and Surface Features, 218-E-12B (Western Portion), 200 East Area, September 2008

D2-4 218-W-4C Annex Geophysical Investigation Summary and Data Plots

Geophysical Investigation Summary Sheet	
Site Name	218-W-4C Annex
Location	200 West Area
Approximate Size	230 m (754 ft) × 210 m (689 ft) (about 4 ha [10 ac])
Burial Ground Information	No documented use
Terrain	Generally flat
Vegetation/Ground Cover	Bunch grass, Russian thistle, and other grasses and weeds in the eastern third and older growth sagebrush in the western portion of the site.
Hydrological Properties	Surface dry at time of data collection
Limitations/Obstacles	None
Overall Assessment for Geophysical Investigation	EMI, magnetic methods, and GPR effective at meeting project objectives
Equipment	
GPR	SIR-10A GPR system with 200 MHz antenna
EMI	Frequency domain EMI: Geonics EM31 Ground Conductivity Meter with a data logger. Trimble DGPS for navigation and positioning.
Total Magnetic Field	G-858/G Cesium Vapor Magnetometer/Gradiometer
Data Collection and Processing Parameters	
Grid Location Control and Data Collection Lines	Fluor personnel staked grid nodes at 30 m (98 ft) centers using a Trimble GPS 5800 RTK system and coordinates supplied by WCH, based on WIDS documentation. The 30 m (98 ft) node base grid was 240 m (787 ft) north-south, 240 m (787 ft) east-west; data collection lines were flagged at 6 m (19 ft) intervals in the east-west direction along the eastern grid nodes (out of the older growth sage).
SIR-10A	Data were collected at a specific site with the antenna pulled by hand. Marks were placed in the data as the instrument passed position marks tied to the base grid nodes, painted on the ground at 1 m (3 ft) intervals. Data were stacked (two 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.
EM31	Data were collected at hip height in the vertical dipole mode with samples recorded every 0.5 seconds (nominal 0.5 m [1.6 ft] data spacing along line). Data were collected on 6 m (19 ft) line spacing in both the north-south and east-west directions. DGPS was used for navigation and positioning for both the north-south and east-west profiles. Data were downloaded from the field PC and written to a .xyz data file. The data were then reviewed using standard spreadsheets such as Excel. Data were gridded and plotted using Surfer. Grid cell size for data plots is nominally 6 m (19 ft) (cross line) × 2 m (6 ft) (down line) and the nearest neighbor algorithm was used for contouring.

Geophysical Investigation Summary Sheet	
G-858/G	Data were collected with sensors 0.5 and 1.25 m (1.6 and 4 ft) above the ground in continuous sampling mode with samples recorded every 0.3 seconds (nominal 0.3 m [1 ft] data spacing), and fiducial positioning marks placed every 30 m (98 ft), on lines spaced 3 m (10 ft) apart. DGPS was used for navigation and positioning in the older growth sage brush areas. All 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 MagMapper2000.exe. Data were gridded and plotted using Surfer. Grid cell size for the data plots is nominally 3 m (10 ft) (cross line) × 1 m (3 ft) (down line) and the nearest neighbor algorithm was used for contouring. Profile spacing, contour thresholds, and intervals were aggressively chosen in order to maximize the ability to detect anomalies that could be attributed to drum size or even smaller objects.
Equipment Functional Check Location	
Results	
Data Discussion/ Interpretation	Refer to data plots D2-22 through D2-32 and Table D2-3 during the following discussion. To illustrate the predominately quiet and anomaly-free nature of the survey area, the anomalies that dominate most of the magnetic field/vertical gradient data are associated with T-posts and metal survey pin flags or can be correlated with visible surface features such as air monitors or miscellaneous metal debris. T-posts support a small chain surrounding the 218-W-4C Annex and are visible in the data. Pin flags were placed at 6 m (19 ft) intervals along N135050, N135110, N135170, and N135200, only in the eastern 60 m (197 ft) of the survey area. These pin flags are also visible in the data. Several small, discrete magnetic anomalies are scattered throughout the data, but most correlate with visible surface features/debris. The EMI apparent ground conductivity and in-phase data also indicate an overall quiet background for the entire site. The notable exception to the otherwise benign character of the site is an anomalous area, observed in both the magnetic and EM data, centered at about N135140 and E566480. GPR data were collected around this area for further characterization. The GPR data indicate this area contains a few shallow, scattered pieces of debris, buried from 0.3 to 1.0 m (1 to 3 ft) below the surface, confined laterally within a few meters. No buried drum or trench-like features were observed in the data.
Lessons Learned	Given the objective of characterizing the site with the intent not to miss a pickup size area of debris or a minimum target size equal to a 55-gallon drum, the profile spacing for the magnetic field data is appropriate. It might be argued that EMI data collected only in one direction, still spaced at 6 m (19 ft) intervals, would be adequate. However, having EM data collected in two directions greatly improves the possibility of detecting an unknown liquid or non-ferrous material filled trench, if they were present.

Table D2-3. Summary of Results from 218-W-4C Annex

Target ID	Easting	Northing	Target Description
W4C-A	566412.4	135174.5	Single low-amplitude magnetic target
W4C-B	566476.7	135138.6	Multiple high-amplitude magnetic target
W4C-C	566479.1	135139.3	Single high-amplitude EM target

Note: Target IDs are posted on the Geophysical Interpretation Map Coordinates in Washington State Plane Meters/NAD83

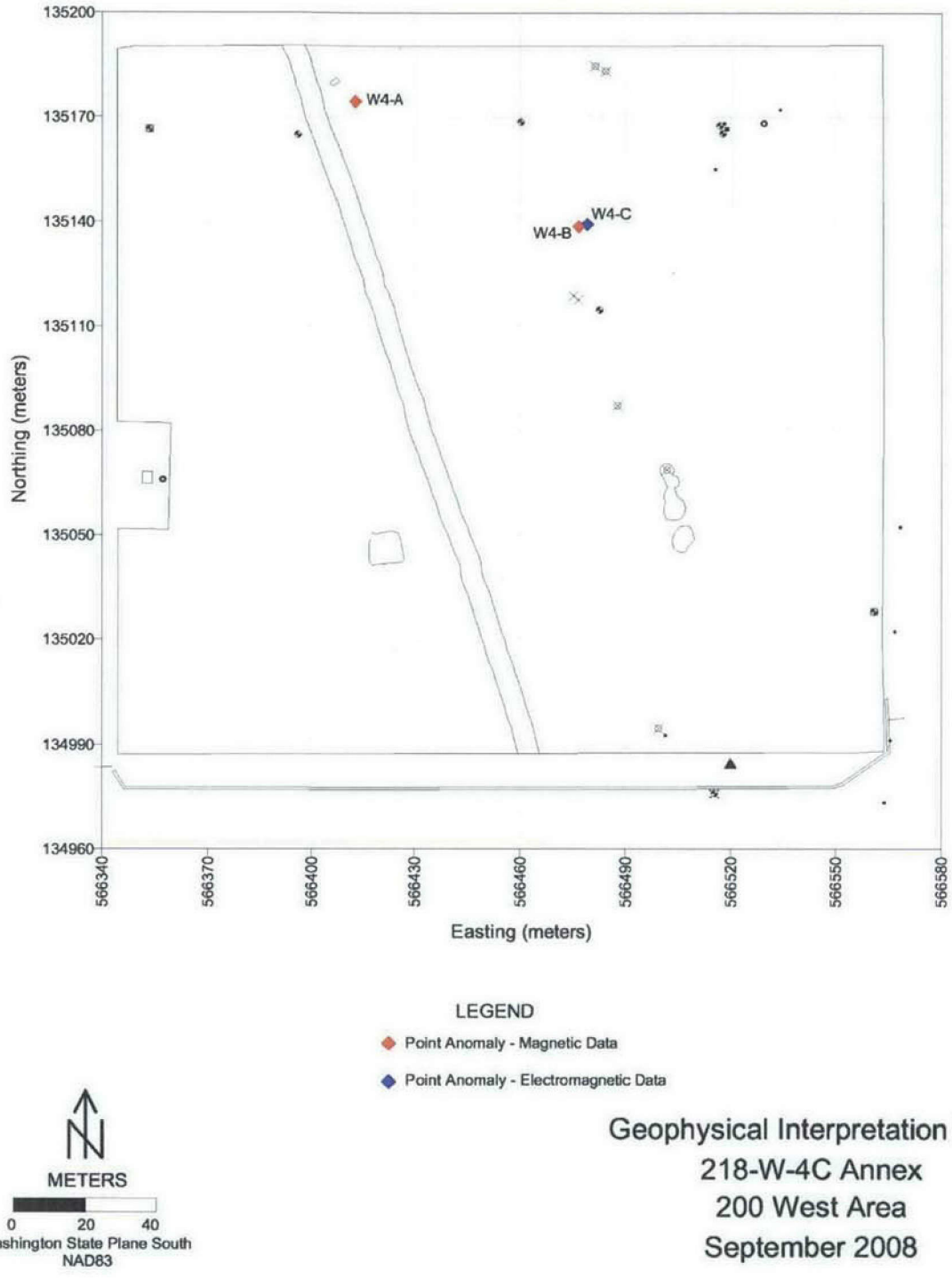
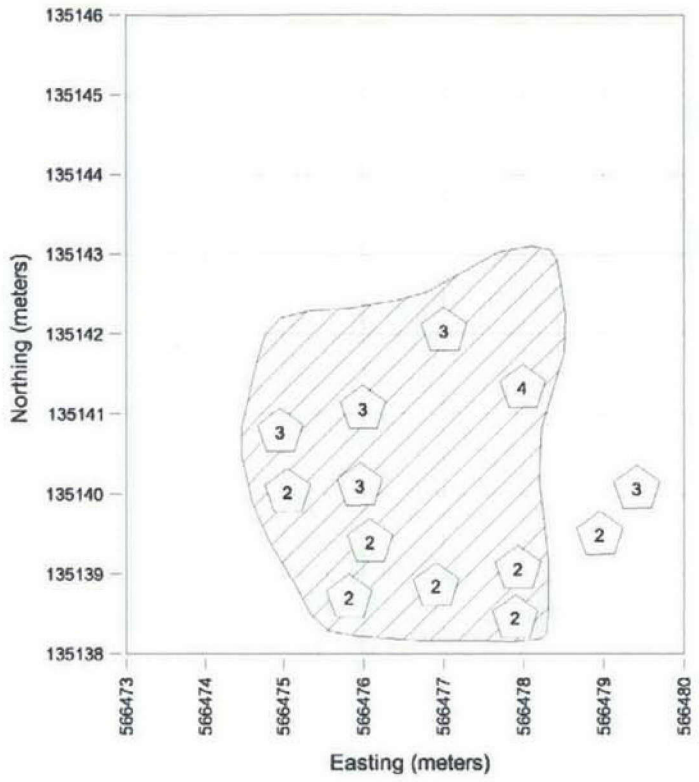


Figure D2-22. Geophysical Interpretation Map, 218-W-4C Annex, 200 West Area, September 2008



LEGEND

Area of multiple reflectors/targets
Typical of debris

3 Single reflector/target
Depth in Decimeters

Note – See Figure D2-22 and D2-32 for general location of this focused GPR data collection area.

N

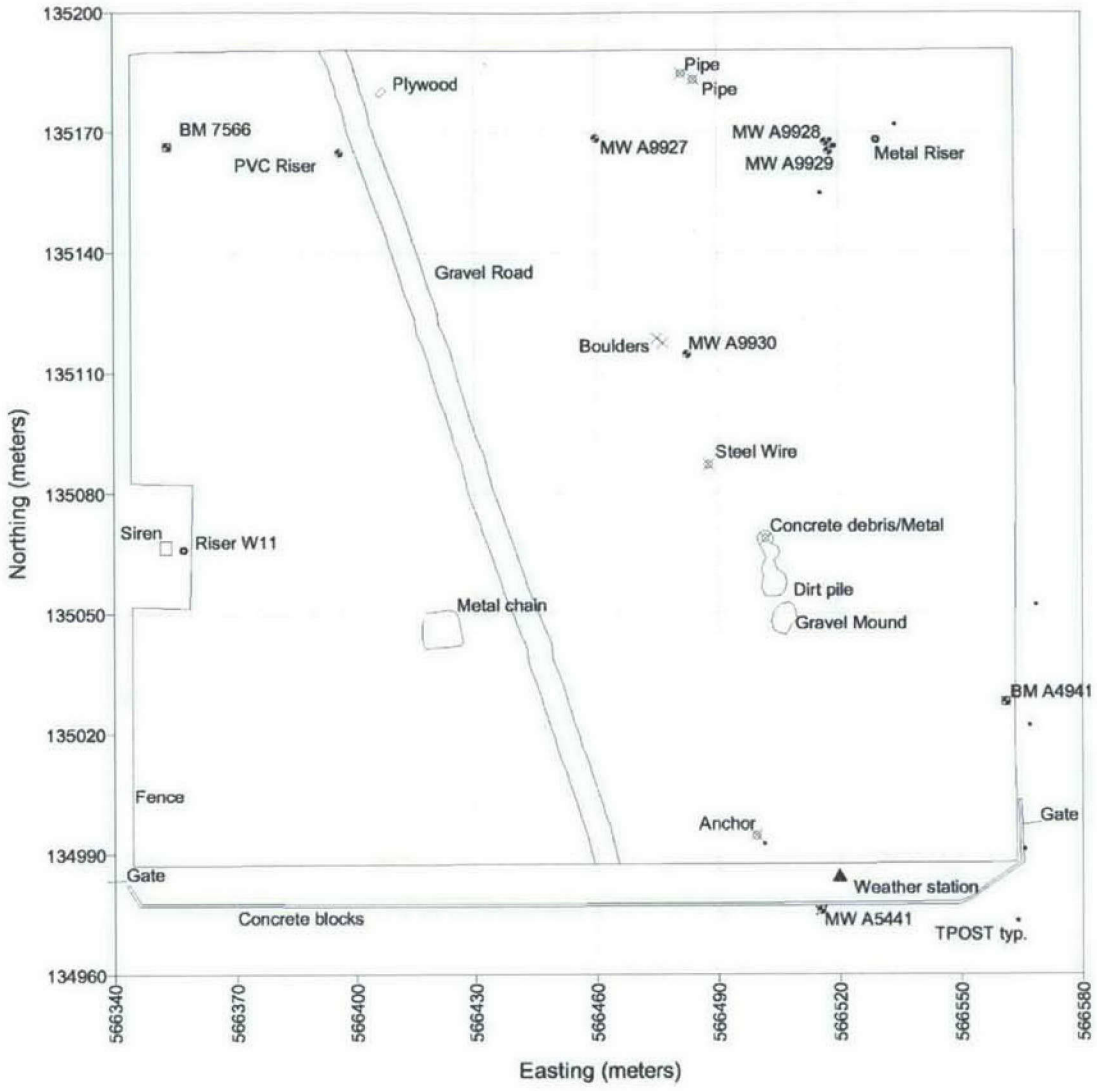
METERS

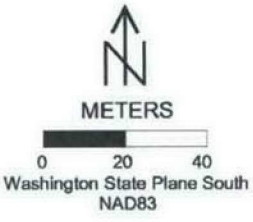
0 1 2

Washington State Plane South
NAD83

GPR Interpretation Map
218-W-4C Annex
200 West Area
September 2008

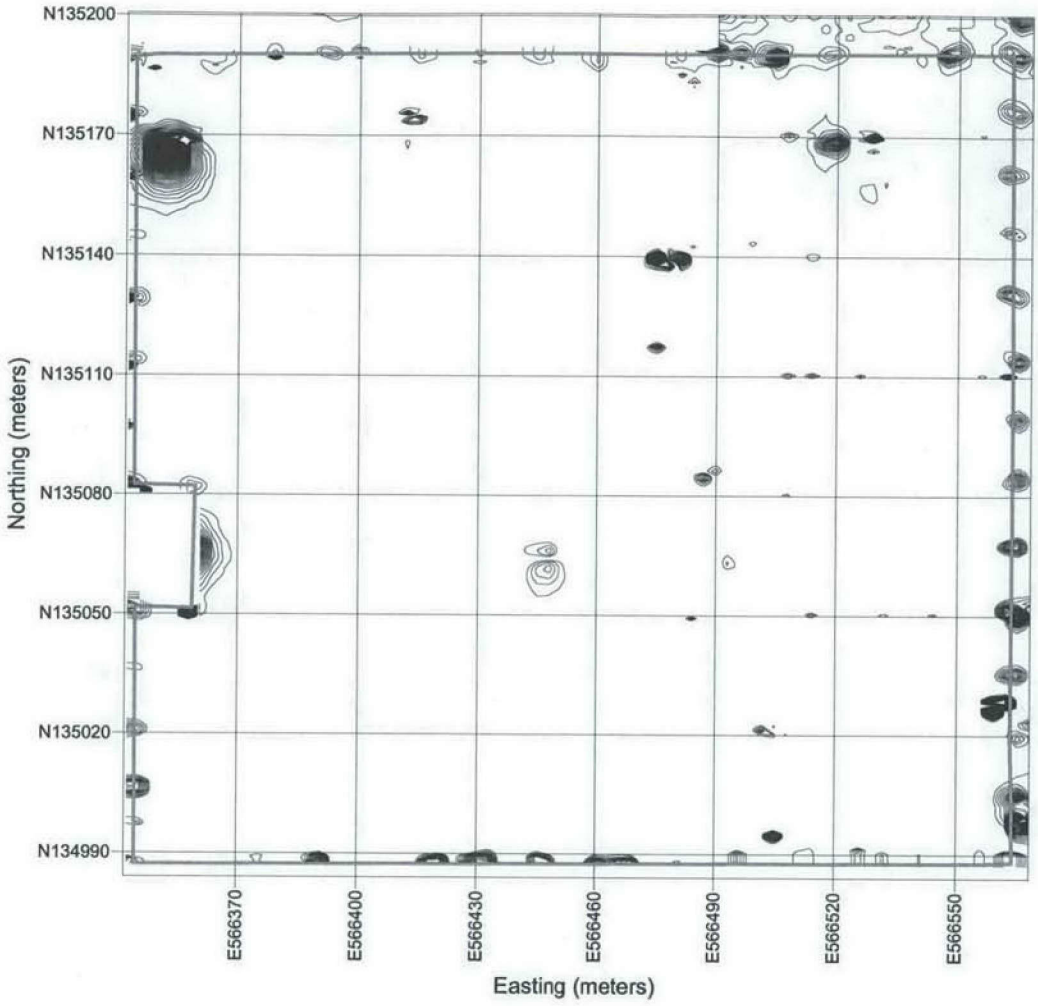
Figure D2-23. Ground-Penetrating Radar Interpretation Map, 218-W-4C Annex Detail Area, 200 West Area, September 2008





Surface Features Base Map
218-W-4C Annex
200 West Area
September 2008

Figure D2-24. Surface Features Base Map, 218-W-4C Annex, 200 West Area, September 2008



Top Residual (-54390 nT)
Contour Interval: 25 nT
Contour Threshold: 50 nT

LEGEND

Fence

N

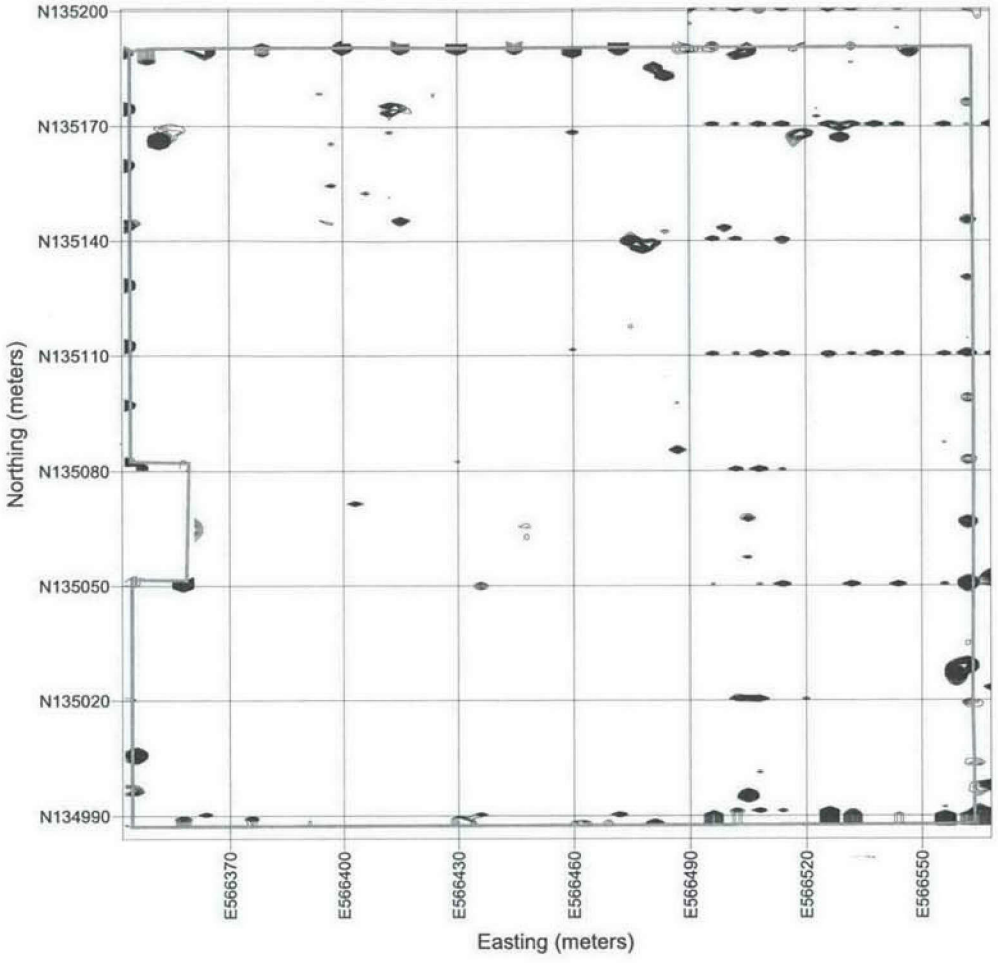
Meters

0 30 60

Washington State Plane South
NAD83

Residual Magnetic Field (G858/G)
218-W-4C Annex
200 West Area
September 2008

Figure D2-25. Residual Magnetic Field (G-858/G) Data, 218-W-4C Annex, 200 West Area, September 2008



Vertical Magnetic Gradient (Absolute Value)
Contour Interval: 25 nT
Minimum Contour Level: 75 nT

LEGEND

Fence

N

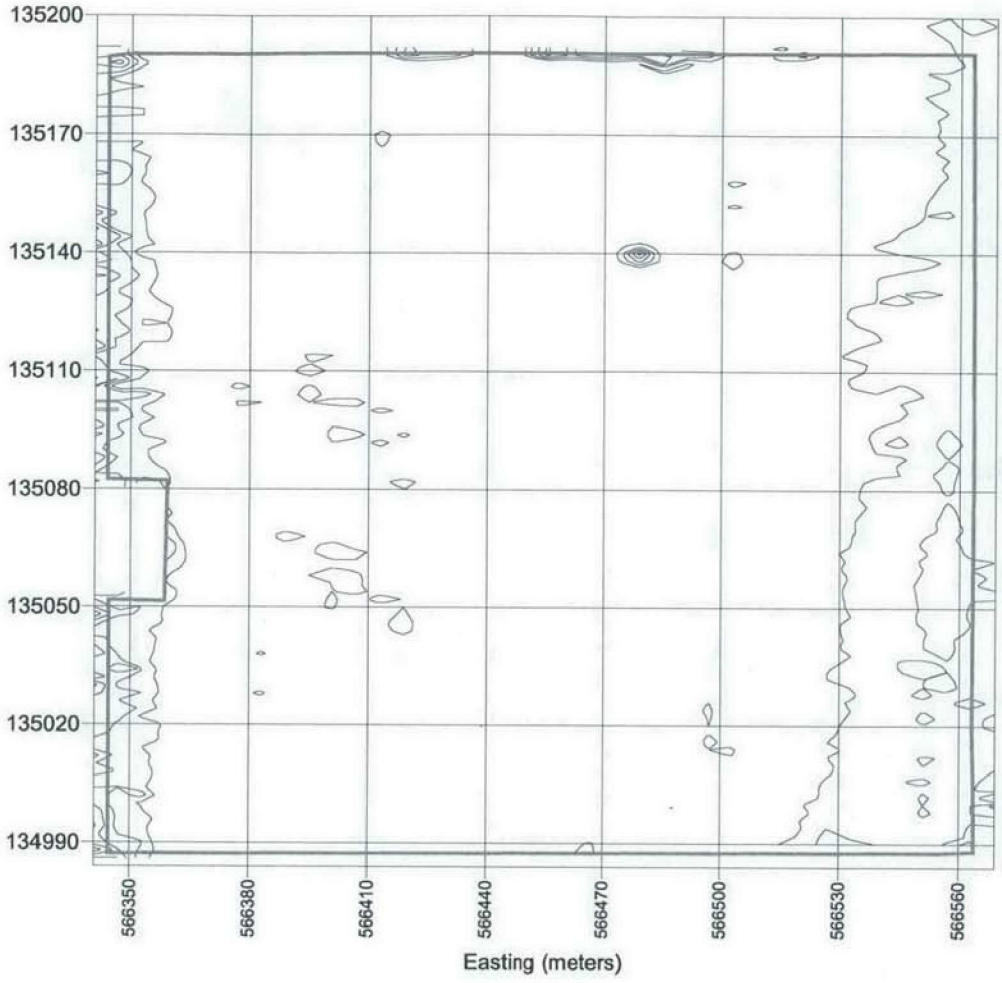
Meters

0 30 60

Washington State Plane South
NAD83

Vertical Magnetic Gradient (G858/G)
218-W-4C Annex
200 West Area
September 2008

Figure D2-26. Vertical Magnetic Gradient (G-858/G) Data, 218-W-4C Annex, 200 West Area, September 2008



Ground Conductivity
Contour Interval : 1.0 mS/m

LEGEND

Fence

N

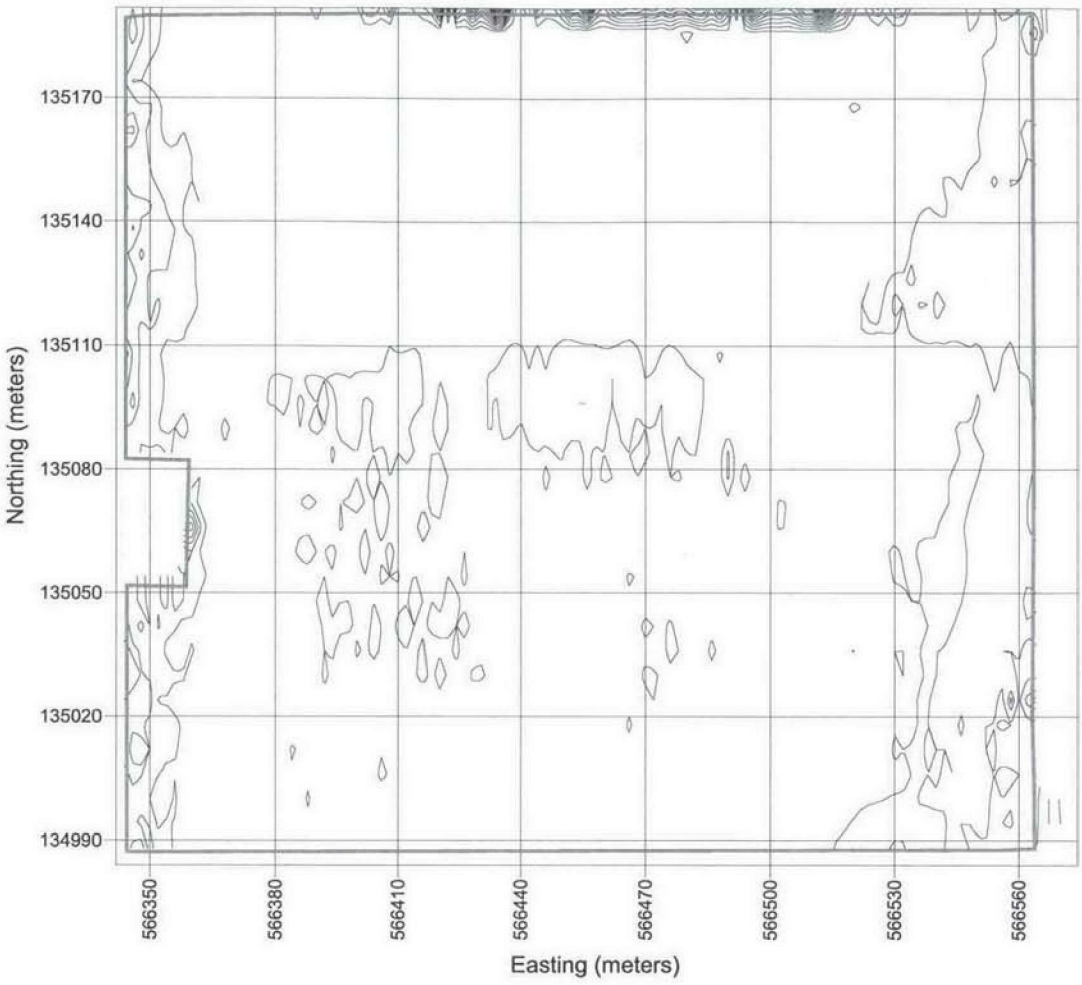
METERS

0 30 60

Washington State Plane South
NAD83

Electromagnetic Induction (EM31)
North - South Profiles
218-W 4C Annex
200 West Area
September 2008

Figure D2-27. Electromagnetic Induction (EM31) Apparent Ground Conductivity Data, North-South Profiles, 218-W-4C Annex, 200 West Area, September 2008



Ground Conductivity
Contour Interval : 1.0 mS/m

LEGEND

Fence

N

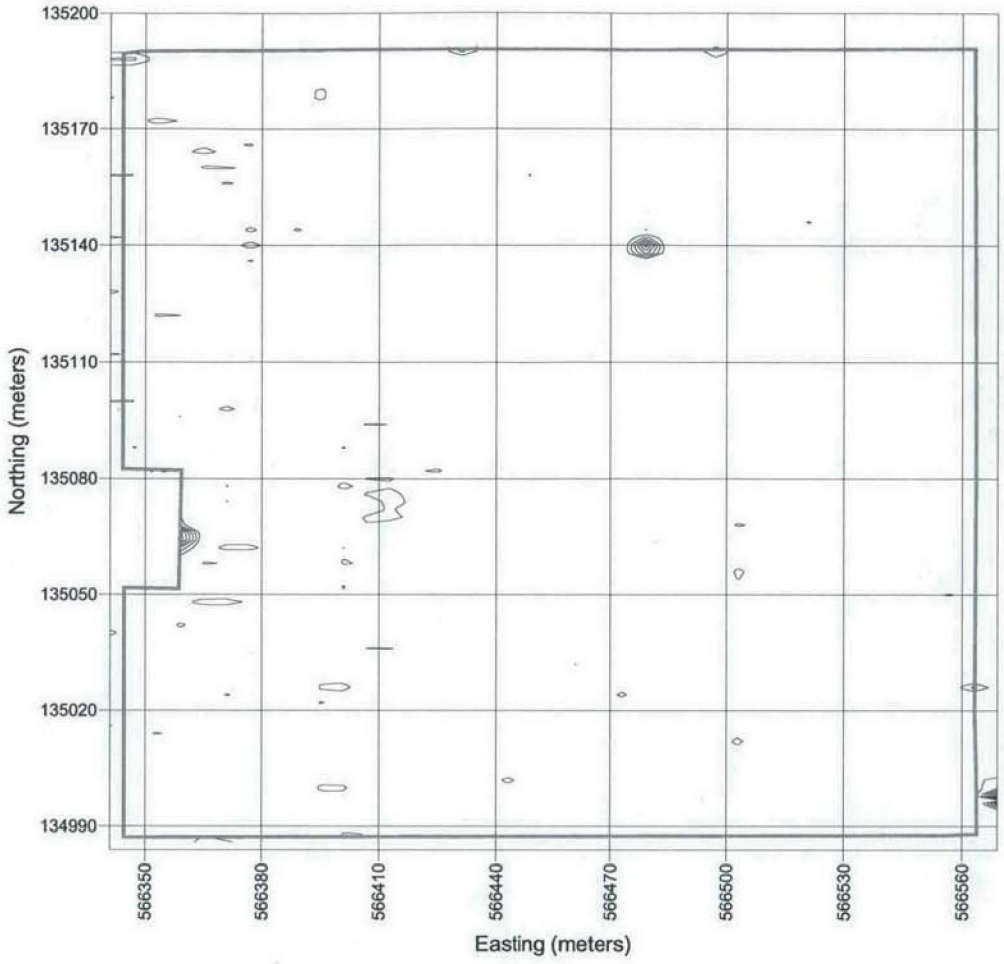
METERS

0 30 60

Washington State Plane South
NAD83

Electromagnetic Induction (EM31)
East - West Profiles
218-W 4C Annex
200 West Area
September 2008

Figure D2-28. Electromagnetic Induction (EM31) Apparent Ground Conductivity Data, East-West Profiles, 218-W-4C Annex, 200 West Area, September 2008



In-Phase Response
Contour Interval : 0.5 ppt

LEGEND

Fence

N

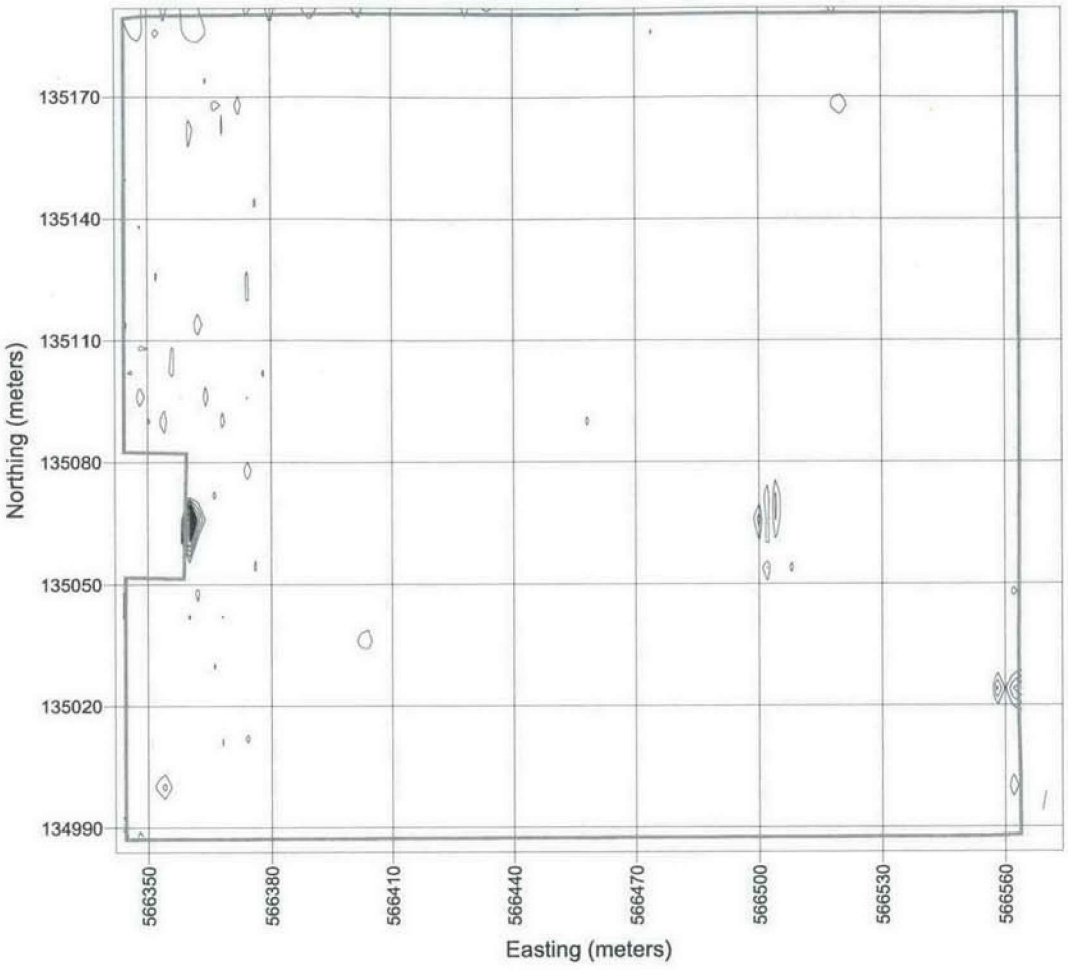
METERS

0 30 60

Washington State Plane South
NAD83

Electromagnetic Induction (EM31)
North - South Profiles
218-W 4C Annex
200 West Area
September 2008

Figure D2-29. Electromagnetic Induction (EM31) In-Phase Data, North-South Profiles, 218-W-4C Annex, 200 West Area, September 2008



In-Phase Response
Contour Interval : 0.5 ppt

LEGEND

Fence

N

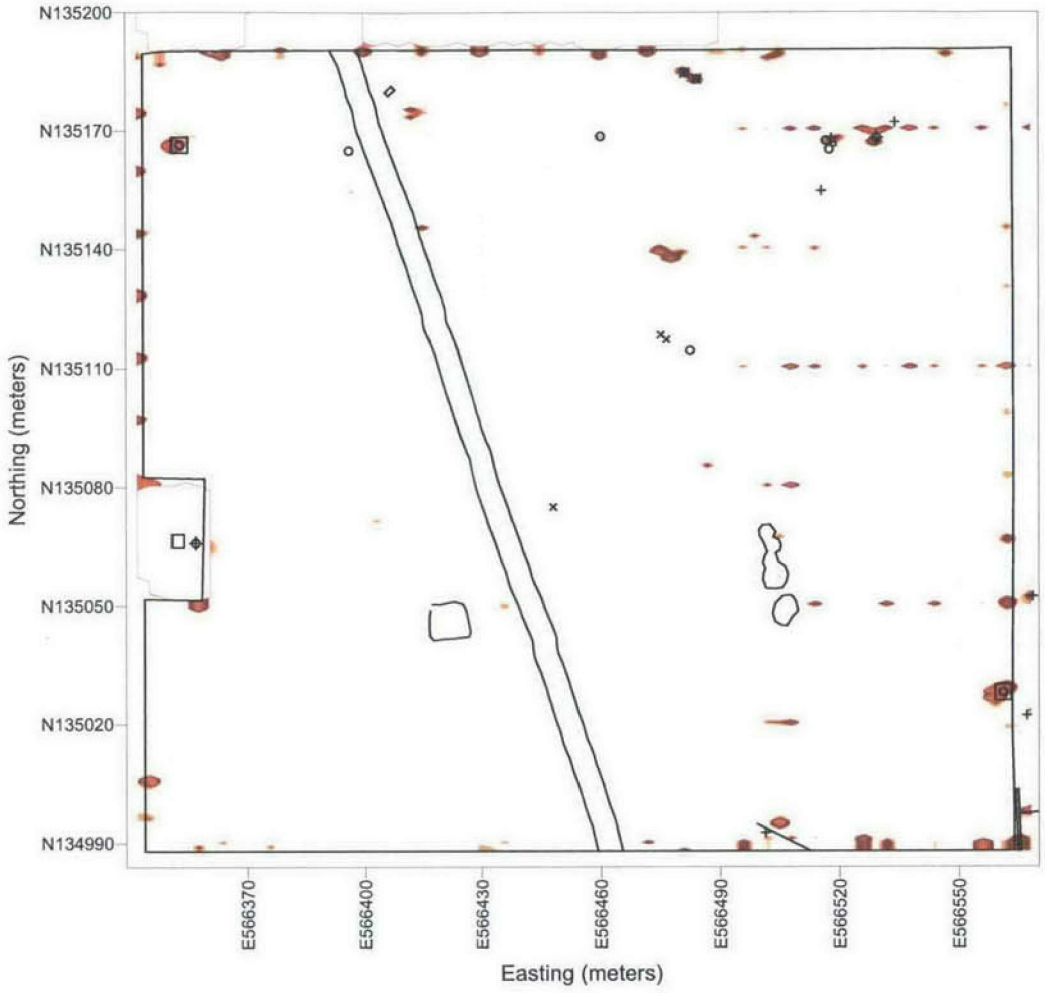
METERS

0 30 60

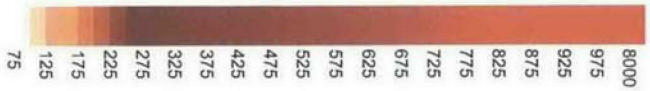
Washington State Plane South
NAD83

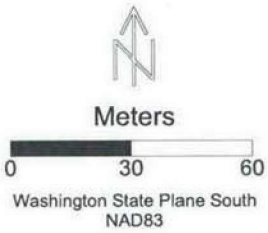
Electromagnetic Induction (EM31)
East - West Profiles
218-W 4C Annex
200 West Area
September 2008

Figure D2-30. Electromagnetic Induction (EM31) In-Phase Data, East-West Profiles, 218-W-4C Annex, 200 West Area, September 2008



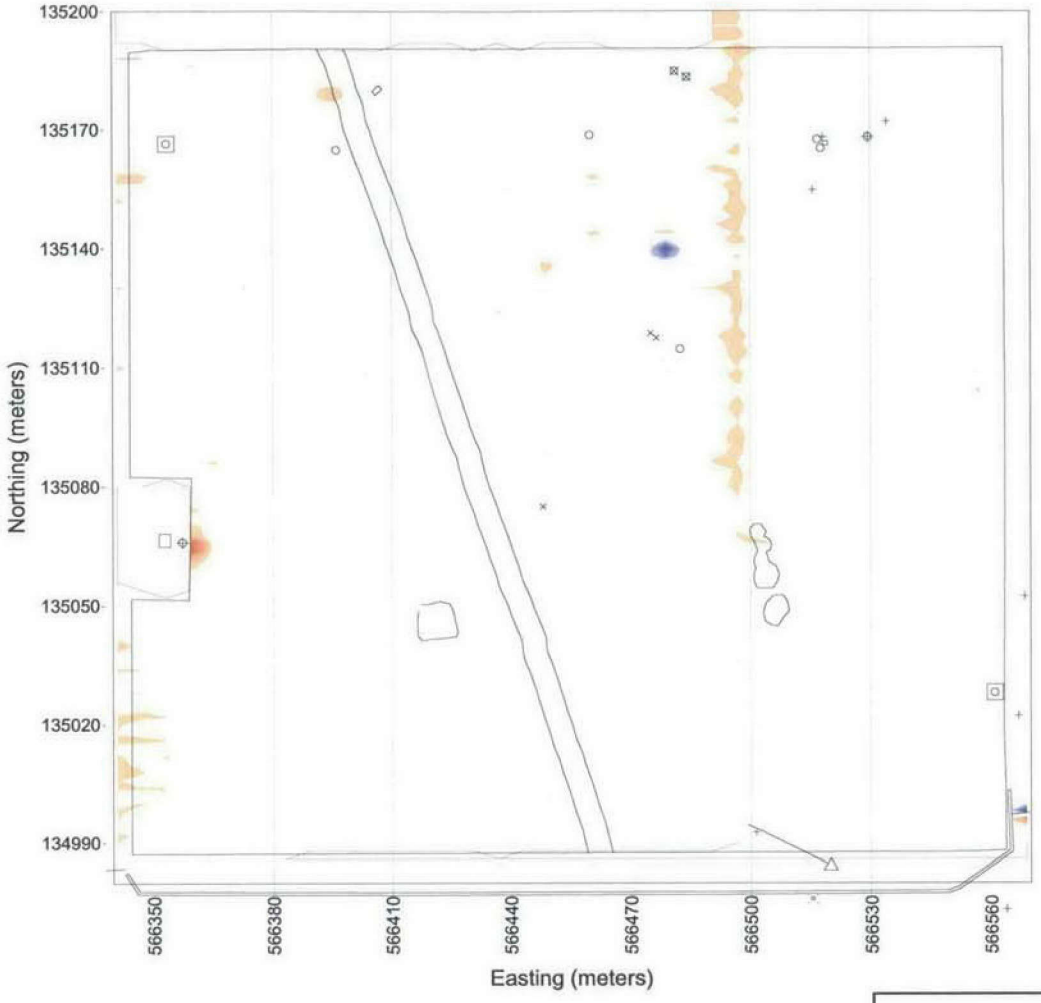
Vertical Magnetic Gradient
nT/m (absolute value)





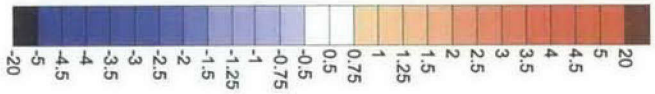
Vertical Magnetic Gradient (G858/G) Overlay
218-W-4C Annex
200 West Area
September 2008

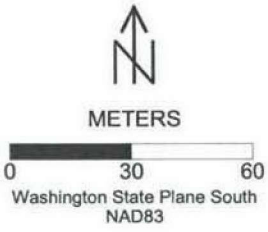
Figure D2-31. Overlay: Vertical Magnetic Gradient Data and Surface Features, 218-W-4C Annex, 200 West Area, September 2008



Note – See Figure D2-22 for general location of this focused GPR data collection area.

In-phase Response
ppt





Electromagnetic Induction (EM31) Overlay
North - South Profiles
218-W 4C Annex
200 West Area
September 2008

Figure D2-32. Overlay: Electromagnetic Induction In-Phase Data and Surface Features, 218-W-4C Annex, 200 West Area, September 2008

D2-5 218-W-6 Geophysical Investigation Summary and Data Plots

Geophysical Investigation Summary Sheet	
Site Name	218-W-6
Location	200 West Area
Approximate Size	Triangular shaped site, measuring roughly 740 m (2,428 ft) across by 430 m (1,410 ft) north-south (about 20 ha [50 ac]), coming to a point at the center of the southern edge
Burial Ground Information	No documented use
Terrain	Generally flat with "windrows" of vegetation debris from some minor surface work
Vegetation/Ground Cover	Bunch grass, Russian thistle, other grasses and weeds
Hydrological Properties	Surface dry at time of data collection
Limitations/Obstacles	A drill pad, including a drill rig, drill pipe, and drum storage in the center of the site. A power line corridor runs roughly north-south through the center of the site.
Overall Assessment for Geophysical Investigation	EMI and magnetic methods effective at meeting project objectives
Equipment	
EMI	Frequency domain EMI: Geonics EM31 Ground Conductivity Meter with a data logger. Trimble DGPS for navigation and positioning.
Total Magnetic Field	G-858/G Cesium Vapor Magnetometer/Gradiometer
Data Collection and Processing Parameters	
Grid Location Control and Data Collection Lines	Fluor personnel staked grid nodes at 30 m (98 ft) centers using a Trimble GPS 5800 RTK system and coordinates supplied by WCH, based on WIDS documentation. The 30 m (98 ft) node base grid was 450 m (1,476 ft) north-south, 810 m (2,657 ft) east-west; data collection lines were flagged at 6 m (19 ft) intervals in the east-west direction along grid nodes.
EM31	Data were collected at hip height in the vertical dipole mode with samples recorded every 0.5 seconds (nominal 0.5 m [1.6 ft] data spacing along line). Data were collected on 6 m (19 ft) line spacing in both the north-south and east-west directions. For the east-west profiles, DGPS was used for navigation and positioning. Data were downloaded from the field PC and written to a .xyz data file. The data were then reviewed using standard spreadsheets such as Excel. For north-south lines, data positioning relied on survey marks/pin flags. Data were downloaded from the data logger to a PC using DAT31.exe. and then converted to DAT31W format. Corrections of position errors during data collection (if any) were made. Data were gridded and plotted using Surfer. Grid cell size for data plots is nominally 6 m (19 ft) (cross line) × 2 m (6 ft) (down line) and the nearest neighbor algorithm was used for contouring.

Geophysical Investigation Summary Sheet	
G-858/G	Data were collected with sensors 0.5 and 1.25 m (1.6 and 4 ft) above the ground in continuous sampling mode with samples recorded every 0.3 seconds (nominal 0.3 m [1 ft] data spacing), and fiducial positioning marks placed every 30 m (98 ft), on lines spaced 3 m (10 ft) 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 MagMapper2000.exe. Data were gridded and plotted using Surfer. Grid cell size for the data plots is nominally 3 m (10 ft) (cross line) × 1 m (3 ft) (down line) and the nearest neighbor algorithm was used for contouring. Profile spacing, contour thresholds and intervals were aggressively chosen in order to maximize the ability to detect anomalies that could be attributed to drum size or even smaller objects.
Equipment Functional Check Location	
Results	
Data Discussion/ Interpretation	Refer to data plots D2-33 through D2-42 and Table D2-4 during the following discussion. To illustrate the predominately quiet and anomaly-free nature of the survey area, the anomalies that dominate most of the magnetic field/vertical gradient data are associated with T-posts and metal survey pin flags or can be correlated with visible surface features. T-posts support a small chain surrounding 218-W-6 and the pin flags were placed at 6 m (19 ft) intervals along N137260, N137320, N137380, N137440, N137500, N137560, and N137620. Numerous small, discrete magnetic anomalies are also scattered throughout the data, but many of these appear to be associated with basalt cobbles/boulders observed on the surface and to miscellaneous small pieces of metal, wire rope, etc. scattered throughout the survey area. The "anomalous" signature along the southwestern edge of the survey area is from a railroad track and the large anomaly, centered at about N137510 and E567195 is the drill pad/rig location. The EMI apparent ground conductivity and in-phase data also indicate an overall quiet background for the entire site. The southern portion of the survey area appears to have the highest amount of surface/near surface metallic debris. No buried drum or trench-like features were observed in the data.
Lessons Learned	Given the objective of characterizing the site with the intent not to miss a pickup size area of debris or a minimum target size equal to a 55-gallon drum, the profile spacing for the magnetic field data is appropriate. It might be argued that EMI data collected only in one direction, still spaced at 6 m (19 ft) intervals, would be adequate. But, having EM data collected in two directions greatly improves the possibility of detecting an unknown liquid or non-ferrous material filled trench, if they were present.

Table D2-4. Summary of Results from 218-W-6

Target ID	Easting	Northing	Target Description
W6-A	566982.4	137564.7	Multiple low-amplitude magnetic targets
W6-B	567122.7	137450.5	Single low-amplitude magnetic target
W6-C	567135.7	137442.1	Single low-amplitude magnetic target
W6-D	567182.5	137441.3	Single low-amplitude magnetic target
W6-E	567198.6	137442.1	Single low-amplitude magnetic target
W6-F	567220.8	137435.9	Single low-amplitude magnetic target
W6-G	567161	137325.5	Single low-amplitude magnetic target
W6-H	567072.1	137363.9	Single low-amplitude magnetic target
W6-I	567215.4	137261.2	Single low-amplitude magnetic target

Note: Target IDs are posted on the Geophysical Interpretation Map Coordinates in Washington State Plane Meters/NAD83

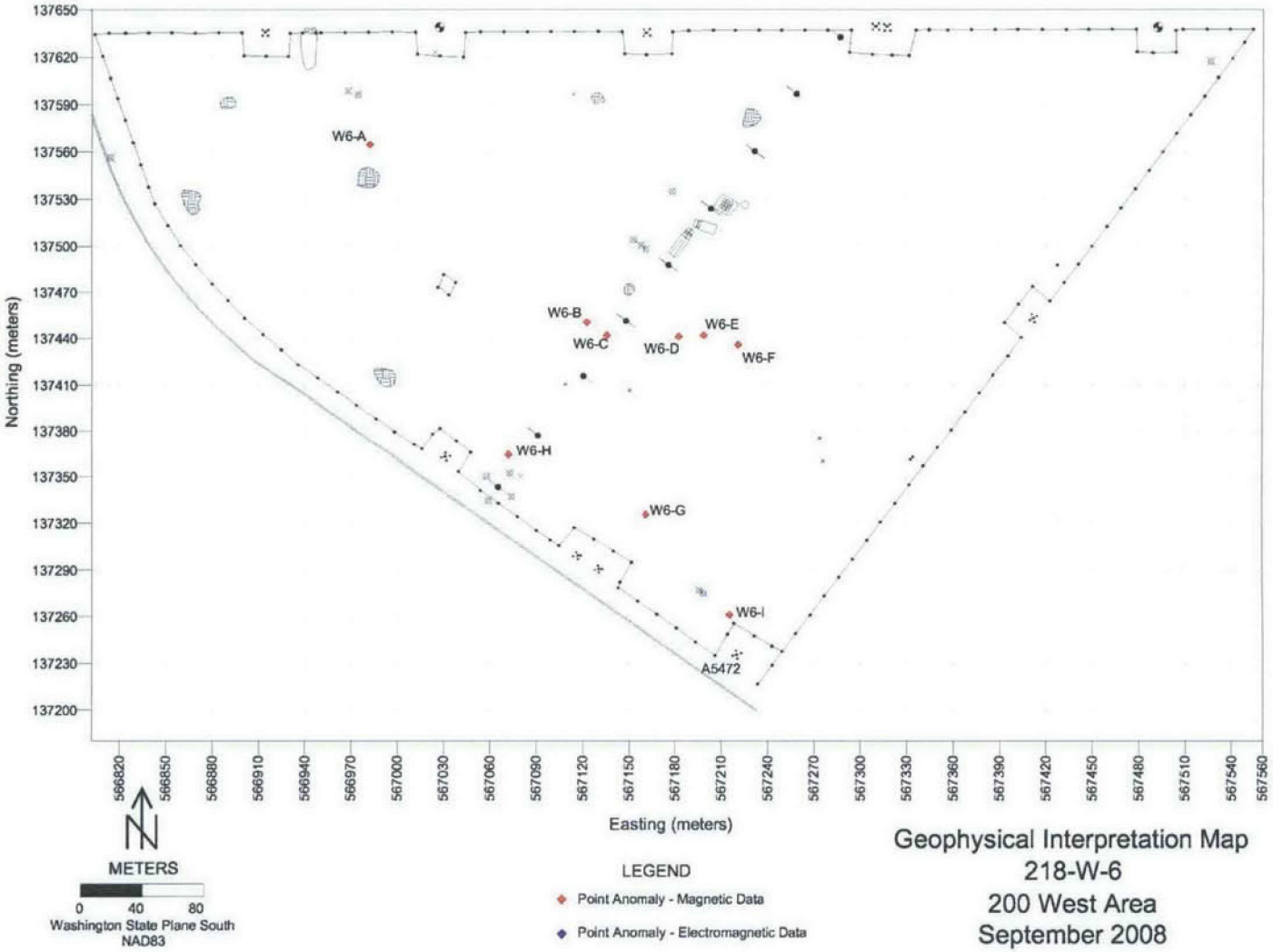


Figure D2-33. Geophysical Interpretation Map, 218-W-6, 200 West Area, September 2008

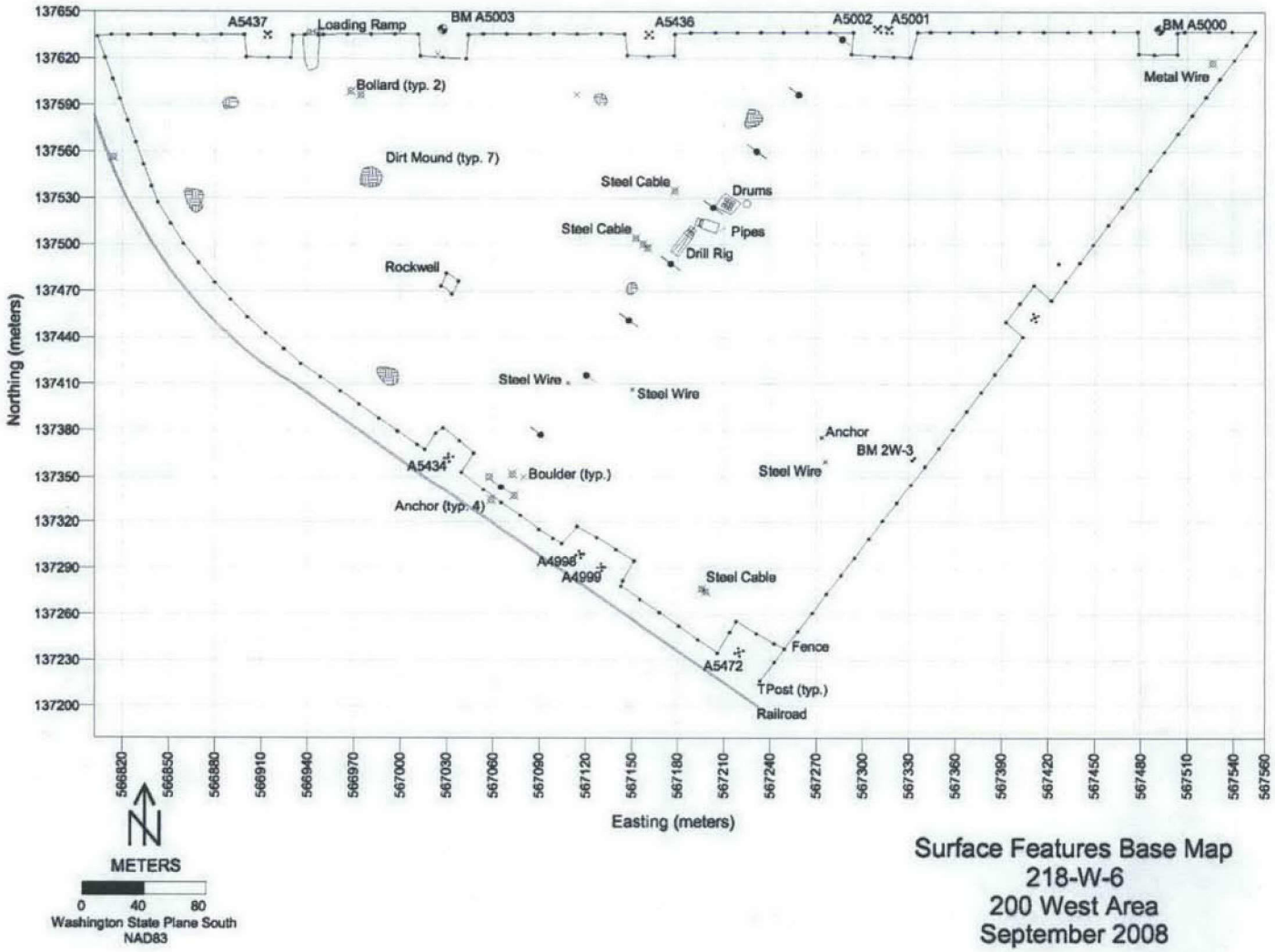


Figure D2-34. Surface Features Base Map, 218-W-6, 200 West Area, September 2008

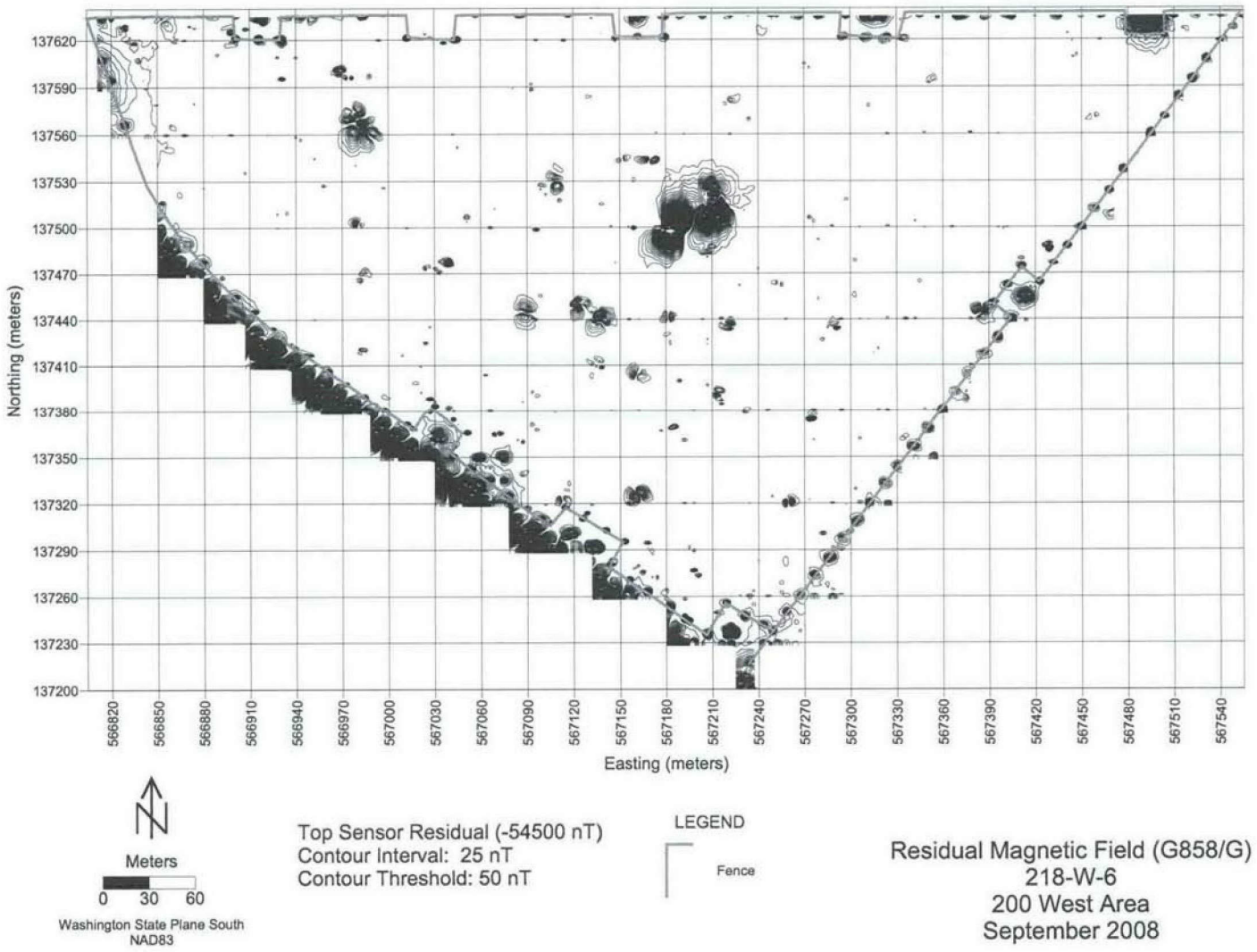


Figure D2-35. Residual Magnetic Field (G-858/G) Data, 218-W-6, 200 West Area, September 2008

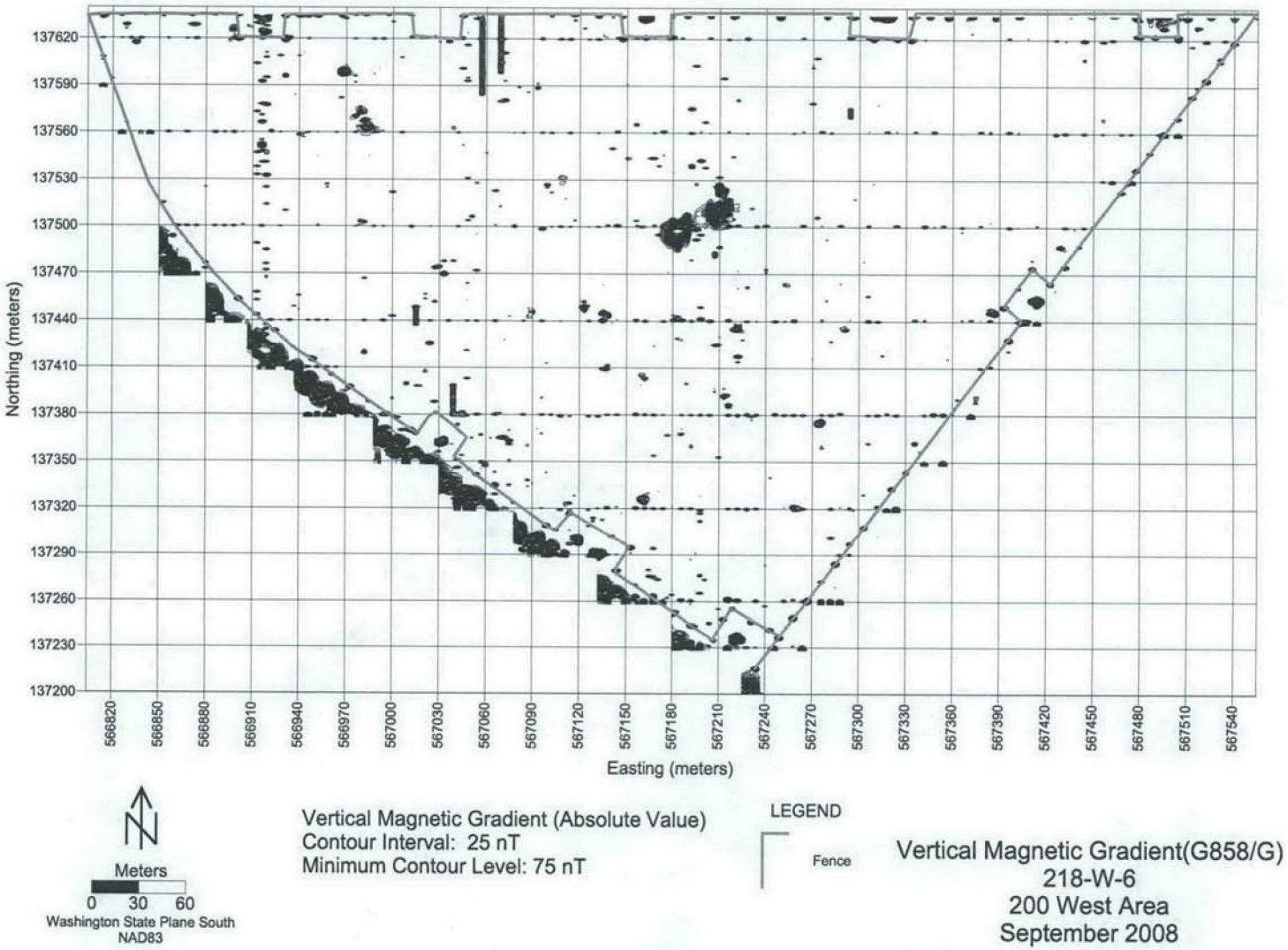


Figure D2-36. Vertical Magnetic Gradient (G-858/G) Data, 218-W-6, 200 West Area, September 2008

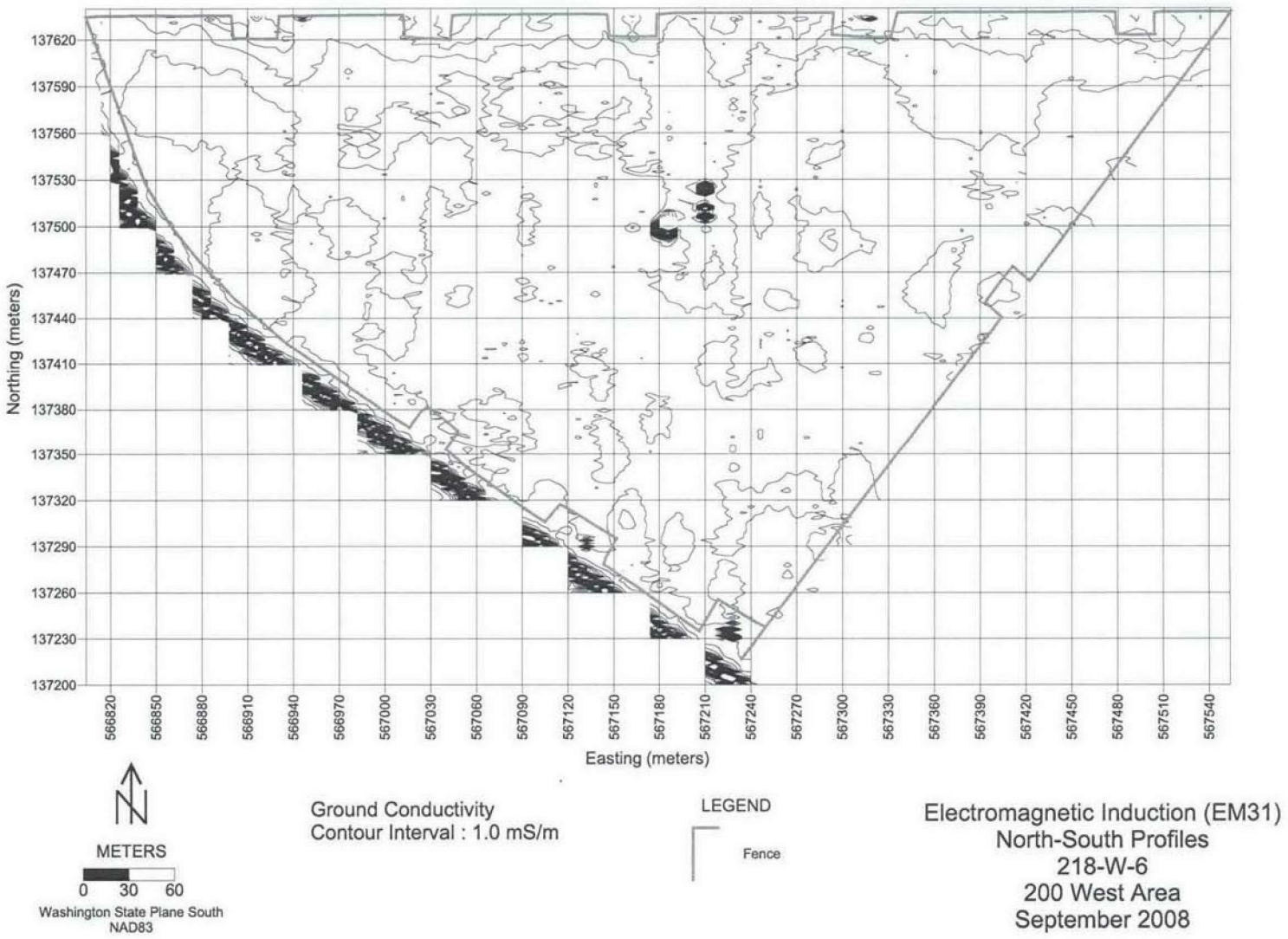


Figure D2-37. Electromagnetic Induction (EM31) Apparent Ground Conductivity Data, North-South Profiles, 218-W-6, 200 West Area, September 2008

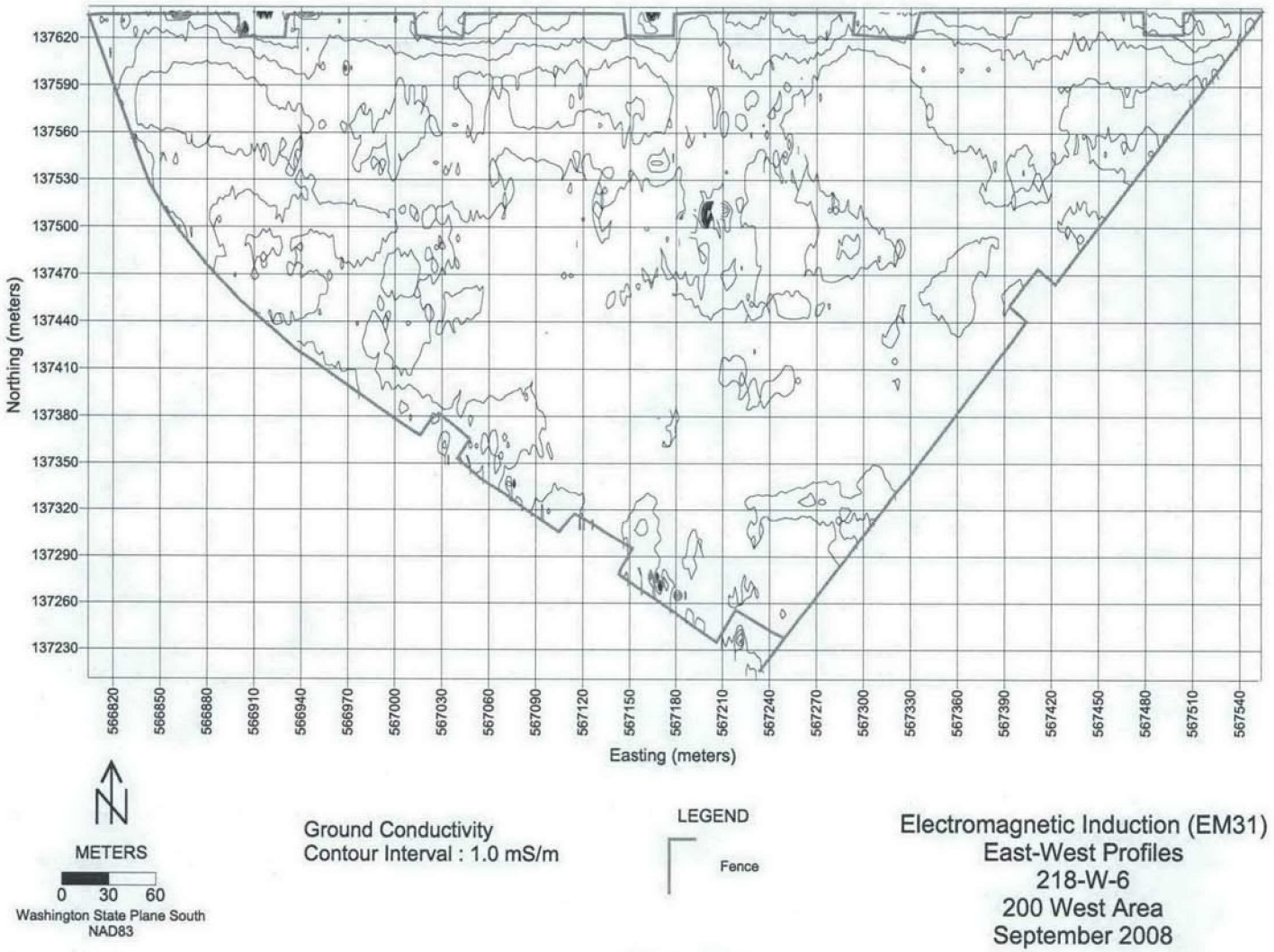


Figure D2-38. Electromagnetic Induction (EM31) Apparent Ground Conductivity Data, East-West Profiles, 218-W-6, 200 West Area, September 2008

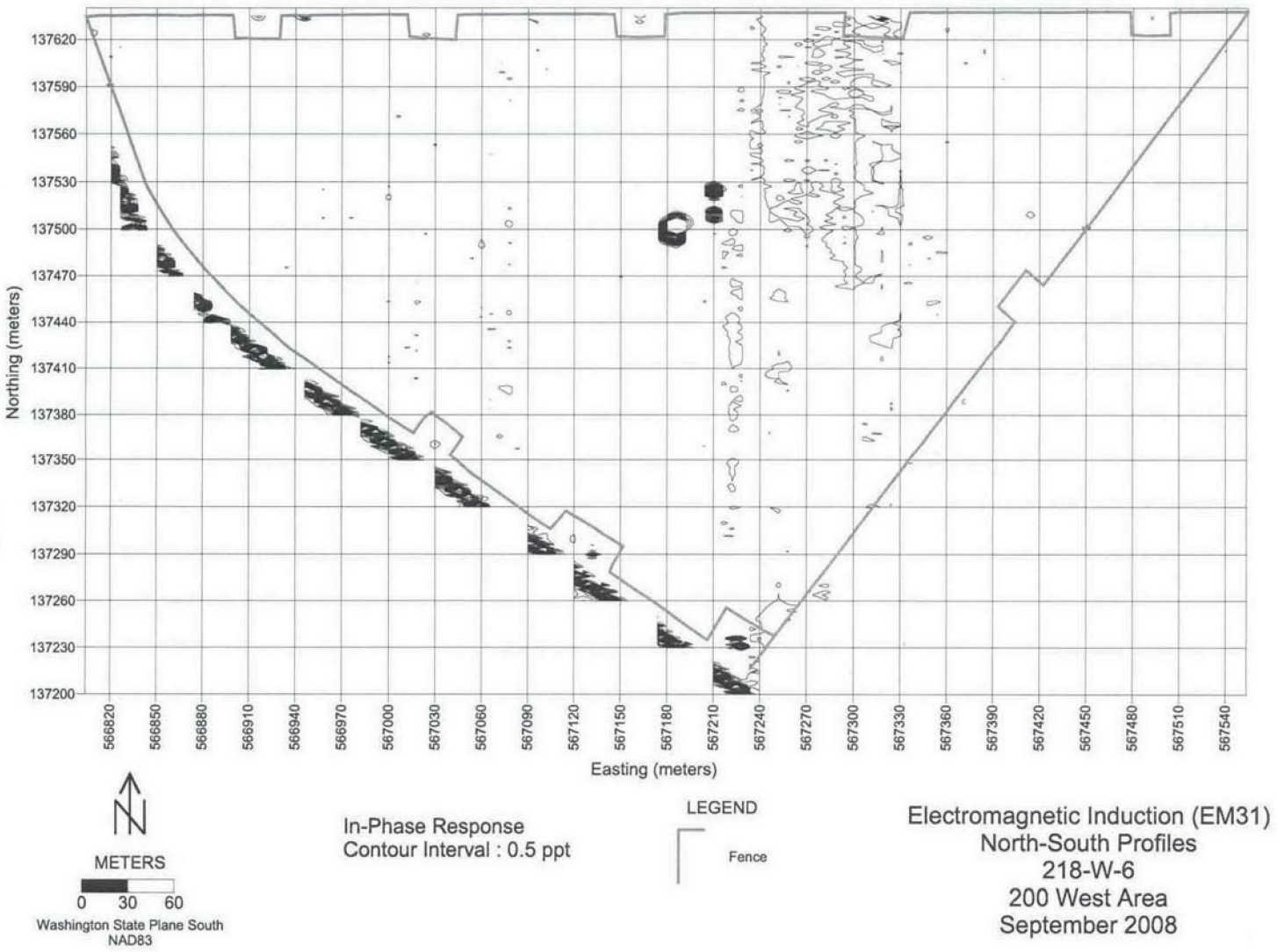


Figure D2-39. Electromagnetic Induction (EM31) In-Phase Data, North-South Profiles, 218-W-6, 200 West Area, September 2008

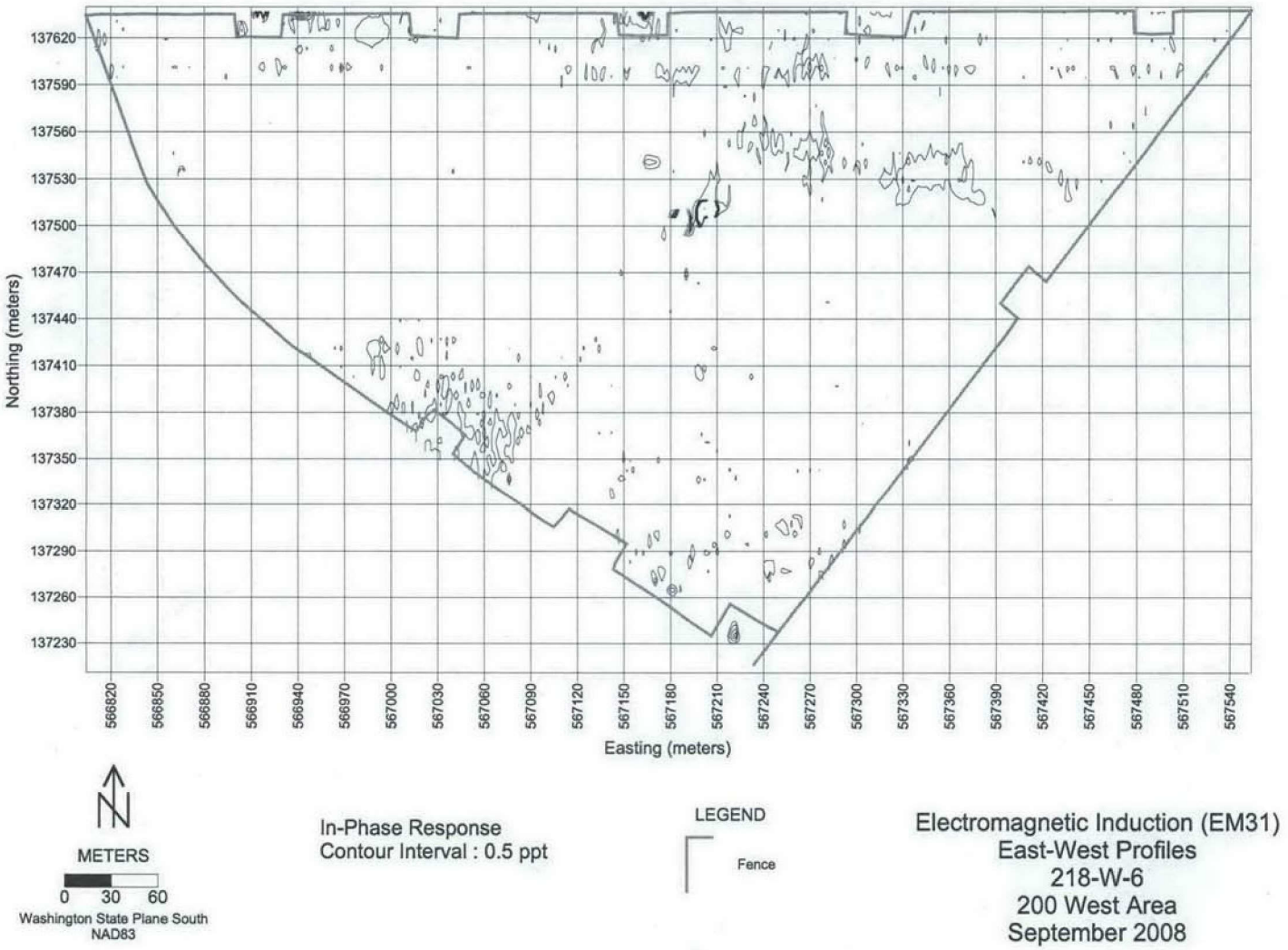


Figure D2-40. Electromagnetic Induction (EM31) In-Phase Data, East-West Profiles, 218-W-6, 200 West Area, September 2008

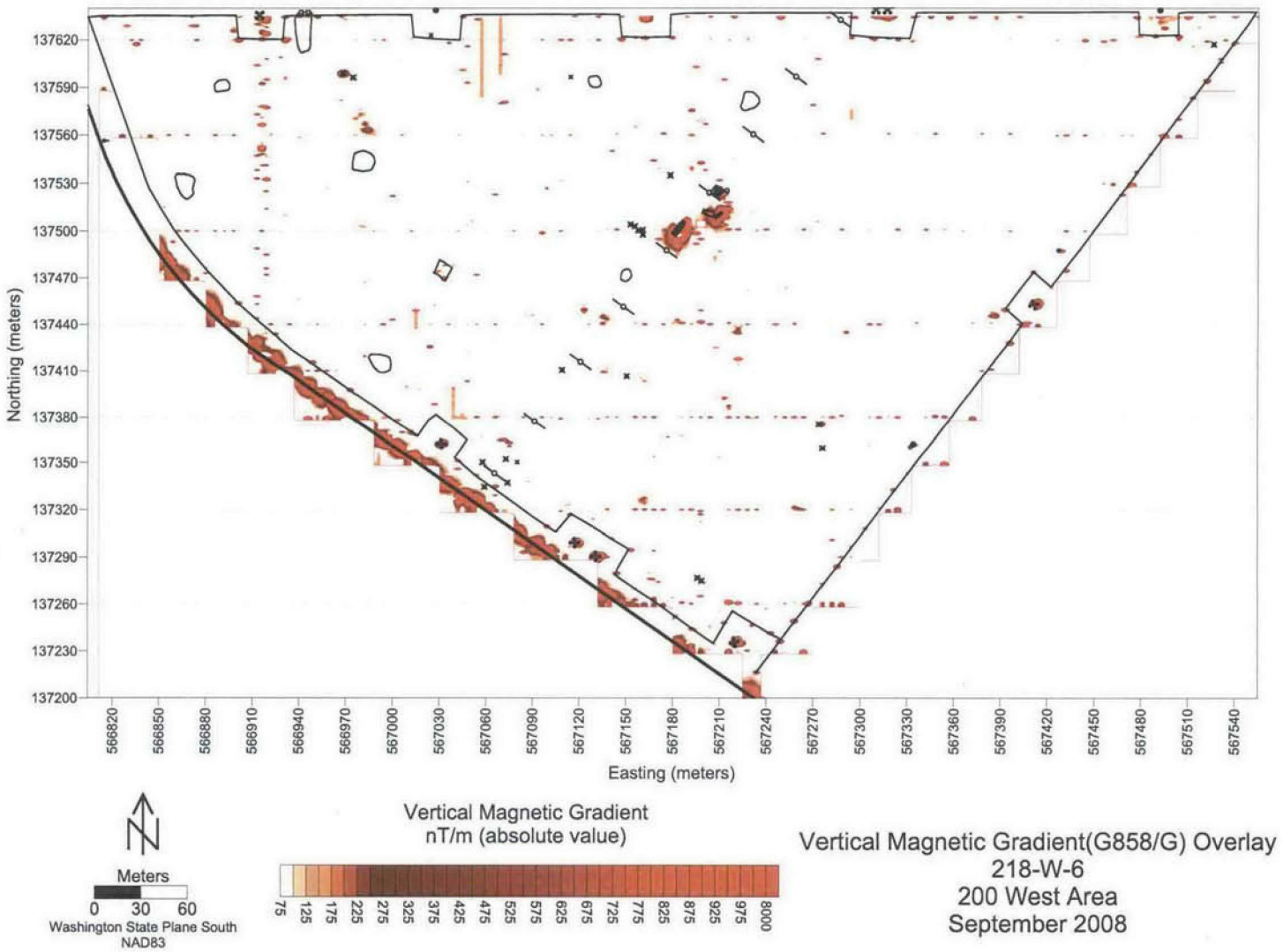


Figure D2-41. Overlay: Vertical Magnetic Gradient Data and Surface Features, 218-W-6, 200 West Area, September 2008

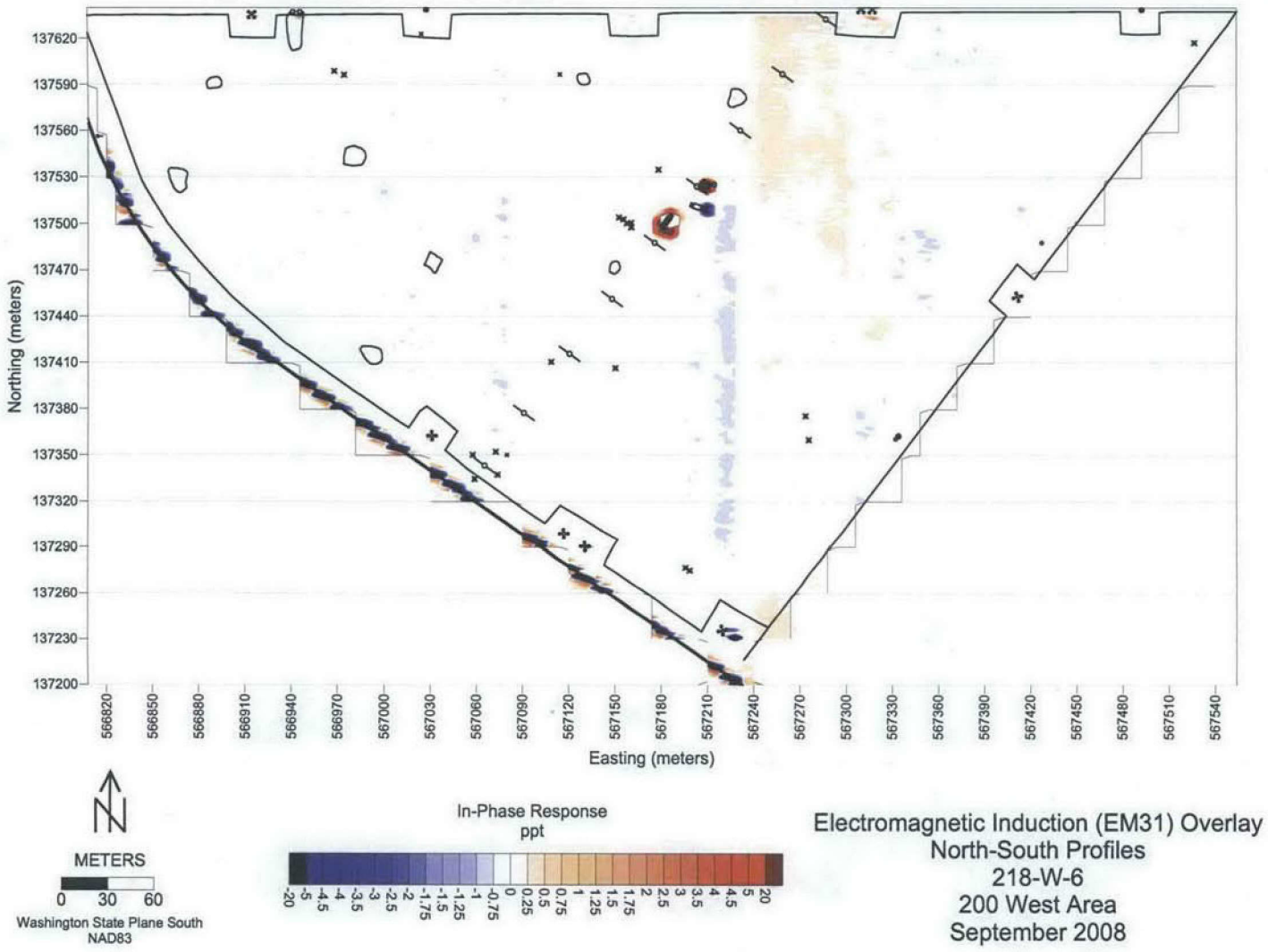


Figure D2-42. Overlay: Electromagnetic Induction In-Phase Data and Surface Features, 218-W-6, 200 West Area, September 2008

D2-6 Reference

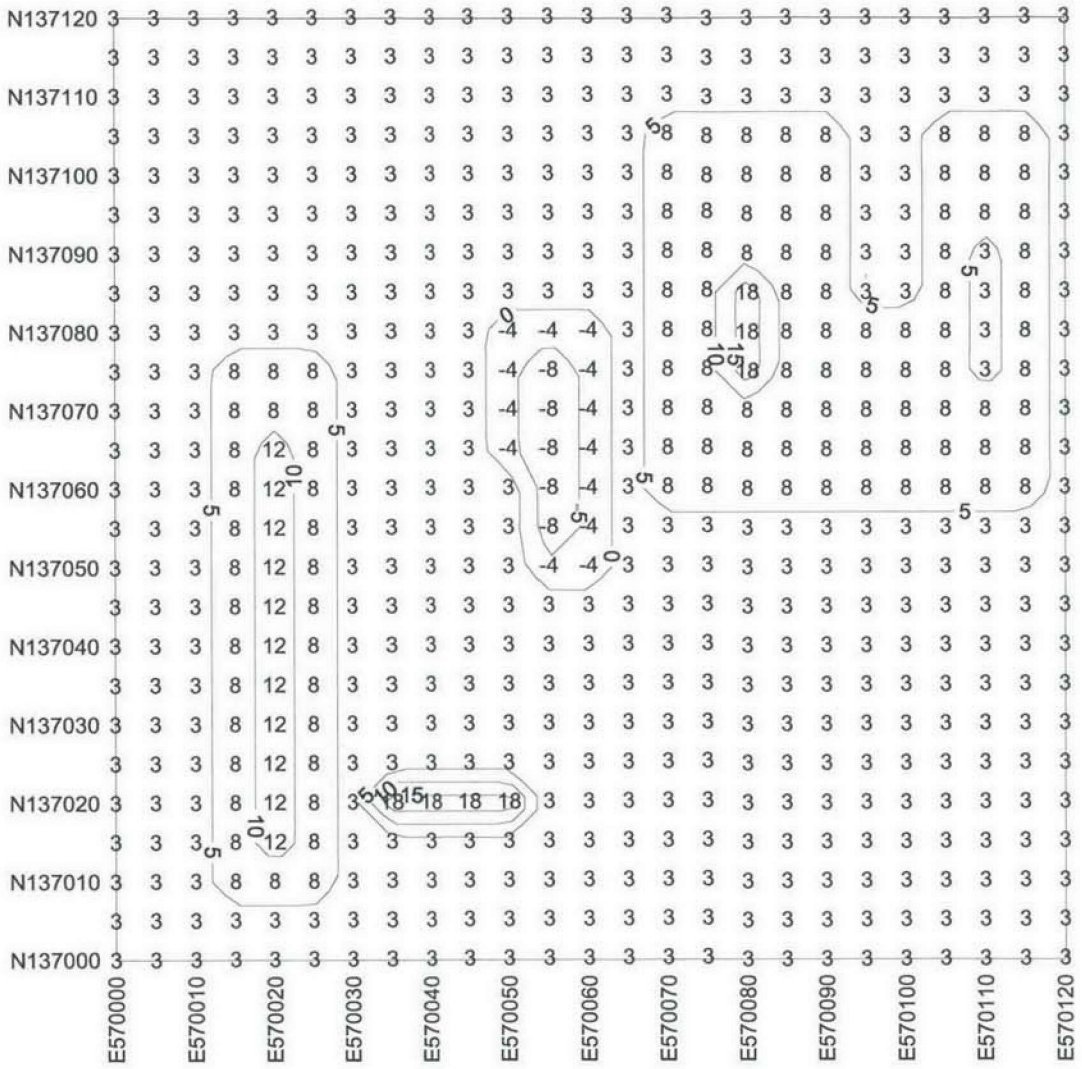
NAD83, 1991, *North American Datum of 1983*, National Geodetic Survey, Federal Geodetic Control Committee, Silver Spring, Maryland, as revised.

Attachment D3

Software Verification and Validation Data File

D3 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. Figure D3-1 shows the numbers plotted in their respective locations. These data then were gridded using the nearest neighbor method (as used in the investigation). Contours were calculated by the software and superimposed over the grid of numbers. Inspection of Figure D3-1 shows that the contours were correctly placed, based on the numbers shown in the grid.



Software Verification Plot
SURFER Version 8.08
Gridding Method: Nearest Neighbor
Cell Size: 5 x 5
Contour Interval: 5 units

Note: Golden Software Surfer, Version 8.08, October 31, 2007

Figure D3-1. Software and Verification and Validation Demonstration