ANL/ESD/TM-103

Contamination Source Review for Building E6891, Edgewood Area, Aberdeen Proving Ground, Maryland

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Contamination Source Review for Building E6891, Edgewood Area, Aberdeen Proving Ground, Maryland

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Contamination Source Review for Building E6891, Edgewood Area, Aberdeen Proving Ground, Maryland

by

S. D. Zellmer, A.K. Draugelis, J. Rueda, and R.E. Zimmerman

Summary

This report was prepared by Argonne National Laboratory (ANL) to document the results of a contamination source review for Building E6891 at the Aberdeen Proving Ground (APG) in Maryland. The report may be used to assist the U.S. Army in planning for the future use or disposition of this building. The review included a historical records search, physical inspection, photographic documentation, geophysical investigation, and collection of air samples. The field investigations were performed by ANL during 1994 and 1995.

Building E6891 (APG designation) is part of the Lauderick Creek Concrete Slab Test Site, located within the Lauderick Creek Area of APG's Edgewood Area. The site was used to test incendiary munitions and for pyrotechnic and flame projects conducted by the research and development community at APG. Building E6891 was constructed in 1953 for use as a fire control center and field offices for the Lauderick Creek test facility. Building E6891 was placed on inactive status in 1976, and it has been unoccupied since that time.

The physical inspection and photographic documentation of Building E6891 were completed in November 1994. At the time of the inspection, most of Building E6891 had collapsed; only the east end of the building was still standing. The single-story, rectangular structure originally had three rooms. The 42-ft by 16-ft building was of wood frame construction with a gable roof. Exterior walls were wood, covered with asphalt sheeting. The roof, made of wood sheathing covered with asphalt shingles, was supported by wood rafters with collar ties. The building had a wood floor supported by wooden framing; no foundation was apparent at the time of ANL's inspection. The interior walls and ceiling were constructed of painted particleboard, but the interior walls and most of the ceiling had collapsed before the ANL inspection. There was no evidence of plumbing, heating, or electrical connections or floor drains inside the building.

In December 1994, ANL staff conducted geophysical surveys in the immediate vicinity of Building E6891 by using several nonintrusive methods. Geophysical survey results suggest the presence of some underground objects near Building E6891, but they do not provide conclusive evidence of the source of geophysical anomalies observed during the survey.

Air quality samples were collected upwind, downwind, and inside Building E6891 in November 1994. Analytical results showed no distinguishable difference in the levels of hydrocarbon and chlorinated solvents between the two background samples and the sample collected inside Building E6891. These results indicate that Building E6891 is not a source of volatile organic compound contamination.

No information regarding underground storage tanks associated with Building E6891 was available.

On the basis of information collected and reviewed for Building E6891, it is the authors' judgment that no significant air contamination is associated with this building. The geophysical surveys indicate some anomalies in the vicinity of Building E6891 that warrant further investigation and evaluation.

1 Introduction

The U.S. Army Aberdeen Proving Ground (APG) commissioned Argonne National Laboratory (ANL) to conduct a contamination source review to identify and define areas of toxic or hazardous contaminants and to assess the physical condition and accessibility of various APG buildings (Brubaker et al. 1994). This report provides the results of the contamination source review for Building E6891. The information obtained from this review may be used to assist the U.S. Army in planning for the future use or disposition of the buildings. The contamination source review consisted of the following tasks: historical records search, physical inspection, photographic documentation, geophysical investigation, and collection of air samples. This building is part of the Lauderick Creek Concrete Slab Test Site, located in the Lauderick Creek Area in the Edgewood Area.

Located on Chesapeake Bay in Harford and Baltimore counties, Maryland, APG occupies approximately 30,000 acres. The facility is divided into the Aberdeen and Edgewood areas (Figure 1). The primary mission at APG has been the testing and evaluation of U.S. Army warfare materials. Since its beginning in 1917, the Edgewood Area of APG has been the principal location for chemical warfare agent research, development, and testing in the United States. APG was also used for producing chemical warfare agents during both world wars, and it has been a center for the storage of chemical warfare material (Nemeth 1989).

Many of the APG facilities constructed between 1917 and the 1960s are no longer used because of obsolescence and their poor state of repair. Because many of these buildings were used for research, development, testing, and/or pilot-scale production of chemical warfare agents and other military substances (such as incendiary materials or munitions containing these materials), the potential exists for portions of the buildings to be contaminated with these substances, their degradation products, and other laboratory or industrial chemicals. These buildings and associated structures or appurtenances (e.g., underground or aboveground storage tanks, pipes, sumps) may contribute to environmental concerns at APG.

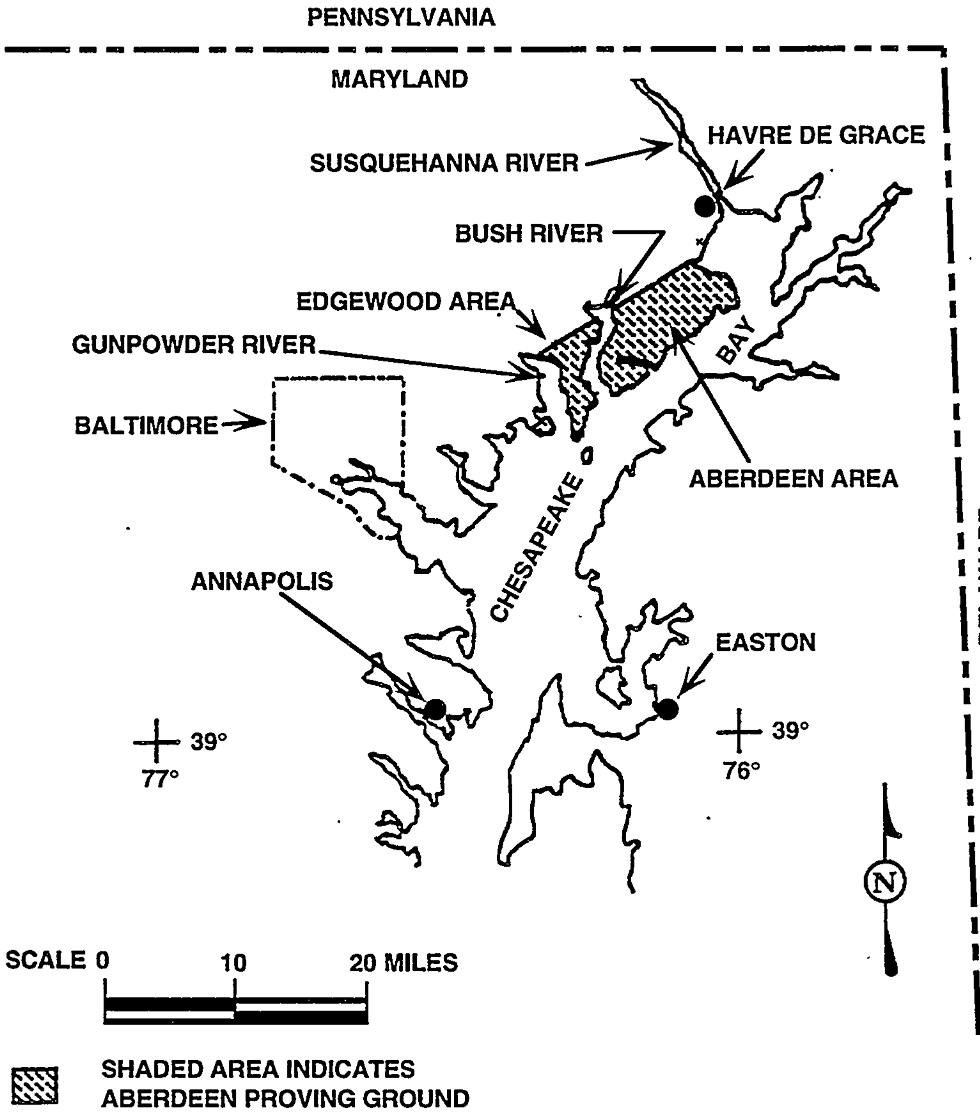


FIGURE 1 Map of Aberdeen Proving Ground Location

2 Methodology

Before the detailed building inspection, ANL personnel made a preliminary site visit to locate the building and obtain building records from APG, identify potential issues to be addressed in the health and safety plan, resolve any access restriction issues, and identify required support services.

Photographs were taken of the building's exterior and interior surfaces during the inspection in November 1994. The photographs followed a set sequence whenever possible. The exterior was photographed starting on the north side and continuing clockwise around the building; walls were photographed starting in the north or northwest corner of each room and continuing clockwise until reaching the starting point. The ceiling and floor of each room were also photographed.

The area around Building E6891 was examined during December 1994 using several nonintrusive geophysical survey methods, including total field magnetics, electrical conductivity (EM-31), time-domain electrical induction (EMF or EM-61), and ground-penetrating radar (GPR) techniques.

ANL staff collected air quality samples upwind, downwind, and inside of Building E6891 during November 1994. Organic compounds from 24-liter samples trapped in a sorbent polymer cartridge were thermally desorbed and analyzed by using a gas chromatograph equipped with a mass spectrometer. Compound identification was based on mass spectral interpretation and a computer search of the 140,000 compounds in the Wiley spectral library.

Detailed descriptions of the methodologies used for the geophysical investigation and air quality monitoring are provided in the appendices to this report.

3 Historical Record Search

Building E6891 (APG designation) is part of the Lauderick Creek Concrete Slab Test Site (Figure 2), located in the Lauderick Creek Area (also referred to as School Field No. IX) within APG's Edgewood Area. The test facility consists of a large concrete slab, vertical concrete wall, and two small support buildings: Buildings E6891 and E6892. The concrete slab measures about 300 ft by 100 ft, and the steel-reinforced concrete wall, several stories high, extends across the northeast end of the concrete slab (Nemeth 1989). The southwest wall of Building E6891 is within 5 ft of the northeast side of the concrete wall.

The Lauderick Creek Concrete Slab Test facility was used to test incendiary munitions, and for pyrotechnic and flame projects conducted by the research and development community at APG (EAI Corporation 1989). According to Nemeth (1989), the facility was constructed and first used during World War II and was possibly in use until the early 1970s.

Building E6891 is also reported to have been constructed in 1953 and placed on inactive status in 1976 (EAI Corporation 1989). The three-room building was used as the fire control center and field offices for the test facility (EAI Corporation 1989). Because of a lack of maintenance, Building E6891 has collapsed, and only a portion of the east end of the building remained standing at the time of the November 1994 field investigation.

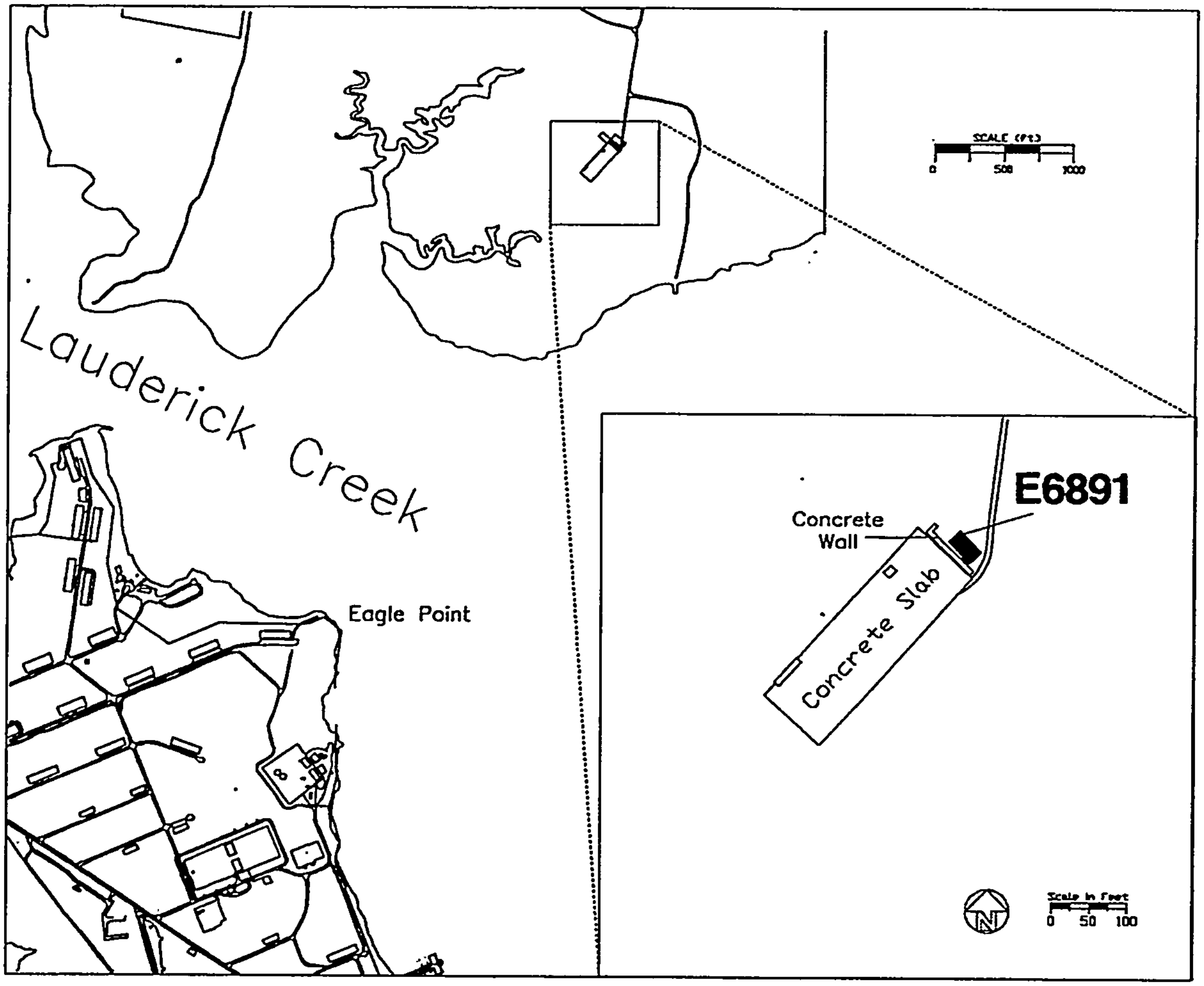


FIGURE 2 Lauderick Creek Concrete Slab Test Site, including Building E6891

4 Building Description

This section provides a detailed physical description of Building E6891 and the surrounding area as they appeared during the ANL inspection in November 1994. This physical description includes an account of the condition of the exterior walls, roof, interior walls, ceiling, and floor of the building. Most of Building E6891 had collapsed at the time of the inspection; only the east end of the building remained standing. There was no evidence of plumbing, heating, or electrical connections, or floor drains inside the building during the ANL inspection.

4.1 Site Description

4.1.1 Location

The Lauderick Creek Concrete Slab Test Site, which includes Building E6891, is approximately 0.4 miles east of Fairview Point and about 0.5 miles north-northeast of Eagle Point (Figure 2).

4.1.2 Proximity to Other Buildings

Building E6891 is located about 5 ft from the northeast side of the vertical concrete wall that forms northeast end of the concrete slab of the Lauderick Creek Concrete Slab Test Site. The only other structures in the area are the concrete wall and Building E6892, located on the southwest (opposite) side of the wall.

4.1.3 Building Structure

Building E6891 was a single-story, rectangular structure that had three rooms. The building had collapsed prior to ANL's inspection; only the east end remained standing. The building was of wood frame construction with a gable roof. Exterior walls were wood, covered with asphalt sheeting. The roof, made of wood sheathing covered with asphalt shingles, was supported by wood rafters with collar ties. The building had a wood floor supported by wooden framing; no foundation was apparent at the time of ANL's inspection. The interior walls and ceiling were constructed of white painted particleboard, but the walls and most of the ceiling had collapsed before the inspection. A reconstruction of the Building E6891 floor plan, from measurements taken during the ANL inspection and information provided in the EAI Corporation report, is presented in Figure 3. Photographs of the building exterior are presented in Figure 4.

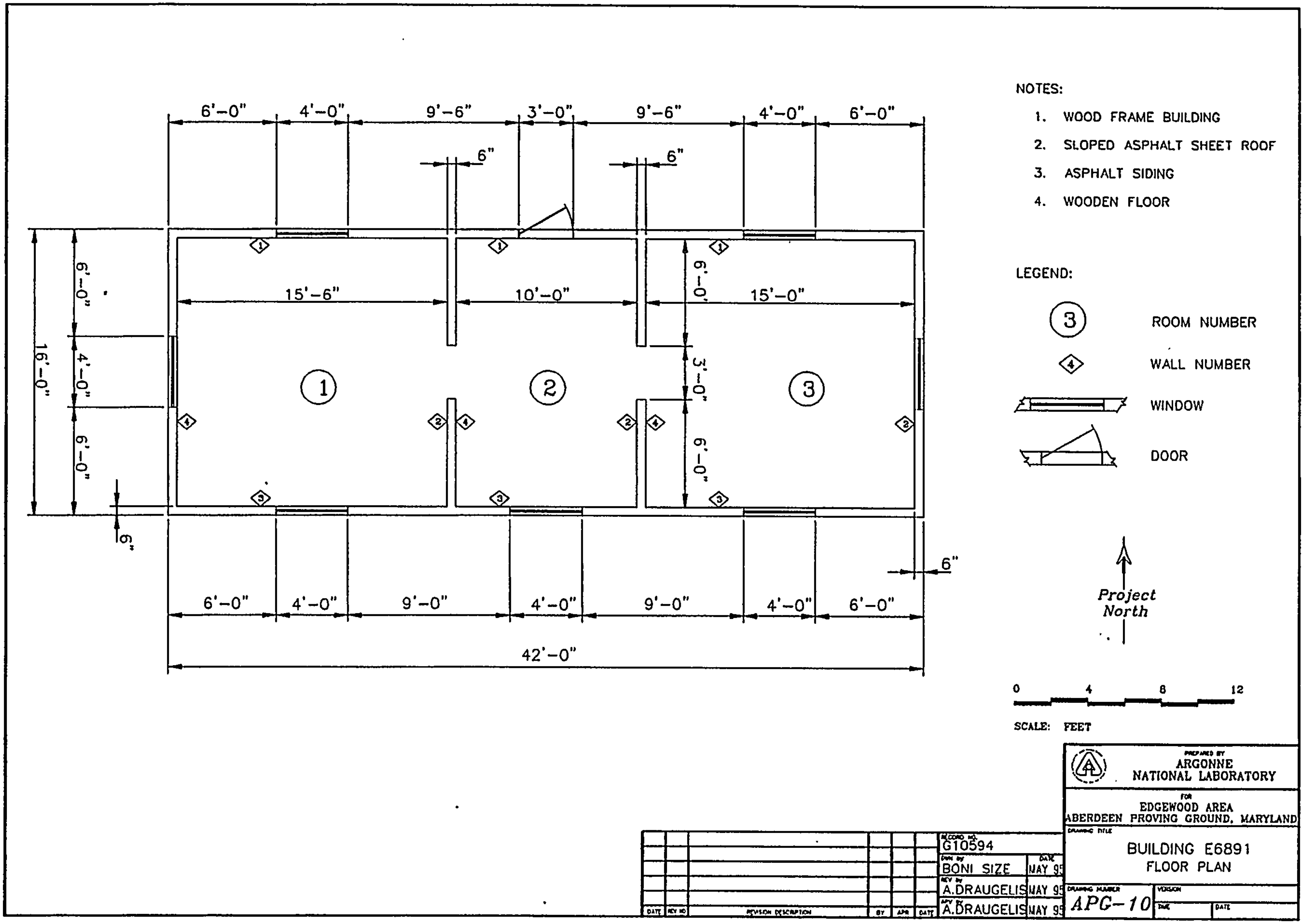


FIGURE 3 Floor Plan of Building E6891

A	East & North Elevation
C	South & East Elevation

East Elevation	B
West & North Elevation	D

FIGURE 4 Photographs of Building E6891 Exterior

4.1.4 Exterior Dimensions

The exterior dimensions of Building E6891 were 42 ft by 16 ft (Figure 3). At the east end of the building, which had not collapsed, the height of the eaves was about 8 ft. and the height at the peak of the gable was about 10 ft.

4.1.5 Topography

The surface surrounding Building E6891 was soil covered with uncut vegetation. The area sloped gently to the northeast, away from Building E6891 and the concrete wall.

4.1.6 Vegetation in the Immediate Vicinity

The vegetation surrounding Building E6891 was uncut and consisted of a mixture of forbs, vines, and grasses, including phragmites. There were several trees growing along the south side of the building (Figure 4C).

4.1.7 External Aboveground Structures or Equipment

None.

4.1.8 Connections with Adjacent Buildings

None.

4.1.9 Underground Structures

None.

4.1.10 Surface Drainage System

None.

4.1.11 Utility Access Points

None.

4.1.12 Exterior Piping

None.

4.1.13 Nearby Roads and Sidewalks

A gravel road east of Building E6891 provided access to the Lauderick Creek Concrete Slab Test Site from other facilities in the Edgewood Area.

4.2 North Exterior Elevation

4.2.1 Dimensions

The north exterior wall of Building E6891 was 42 ft long. The height of the eaves at the east end of the north wall was about 8 ft, but most of the north wall had collapsed (Figure 4A).

4.2.2 Construction Materials

The north exterior wall was wood frame construction covered with asphalt sheeting.

4.2.3 Doors and Windows

There was one 3-ft-wide door in the center of the north exterior wall of Building E6891. Two 4-ft-square windows in the north exterior wall were located 6 ft from the corners of the building.

4.2.4 Piping

None.

4.2.5 Utility Connections

None.

4.2.6 External Equipment or Structures

None.

4.2.7 Vegetation

The vegetation north of Building E6891 was uncut and consists of forbs, vines, and grasses, including phragmites.

4.2.8 Overall Condition

Because of a lack of building maintenance, most of the north exterior wall of Building E6891 had collapsed.

4.3 East Exterior Elevation

4.3.1 Dimensions

The east exterior wall of Building E6891 measured 16 ft long. The height of the eaves was about 8 ft, and the height at the peak of the gable was about 10 ft.

4.3.2 Construction Materials

The east exterior wall was constructed of wood framing covered with asphalt sheeting.

4.3.3 Doors and Windows

There were no doors and one 4-ft-square window in the center of the east exterior wall of Building E6891 (Figure 4B).

4.3.4 Piping

None.

4.3.5 Utility Connections

None.

4.3.6 External Equipment or Structures

None.

4.3.7 Vegetation

The vegetation east of Building E6891 was uncut and consisted of forbs, vines, and grasses, including phragmites.

4.3.8 Overall Condition

Because of a lack of building maintenance, the east exterior wall showed signs of deterioration and weathering, and was the only standing wall of the structure.

4.4 South Exterior Elevation

4.4.1 Dimensions

The south exterior wall of Building E6891 was 42 ft in length. The height of the eaves at the east end of the south exterior wall was about 8 ft, but most of the south wall had collapsed.

4.4.2 Construction Materials

The south exterior wall was wood frame construction covered with asphalt sheeting.

4.4.3 Doors and Windows

There are no doors on the south exterior wall. Three 4-ft-square windows were located in the exterior wall: two were 6 ft from the corners of the building and the third was in the center of the south wall.

4.4.4 Piping

None.

4.4.5 Utility Connections

None.

4.4.6 External Equipment or Structures

None.

4.4.7 Vegetation

Vegetation on the south side of Building E6891 was limited because of the proximity of the concrete wall. There were several trees growing between the building and the concrete wall.

4.4.8 Overall Condition

Because of a lack of building maintenance, most of the south exterior wall of Building E6891 had collapsed.

4.5 West Exterior Elevation

4.5.1 Dimensions

The west exterior wall was 16 ft in length. Because the west wall of the building had completely collapsed, no height measurements are reported here.

4.5.2 Construction Materials

The west exterior wall was wood frame construction covered with asphalt sheeting.

4.5.3 Doors and Windows

One 4-ft-square window was located in the center of the west exterior wall. There were no doors in this wall of the building.

4.5.4 Piping

There were no visible pipes on or connected to the west exterior wall of Building E6891.

4.5.5 Utility Connections

None

4.5.6 External Equipment or Structures

None.

4.5.7 Vegetation

The vegetation west of Building E6891 consisted of uncut grasses, forbs, and vines.

4.5.8 Overall Condition

Because of a lack of building maintenance, the west exterior wall of Building E6891 had collapsed.

4.6 Roof

4.6.1 Type and Dimensions

Building E6891 had a gable roof measuring 42 ft by 16 ft.

4.6.2 Height

The height of the roof at the eaves was about 8 ft and, at the peak of the gables, about 10 ft.

4.6.3 Surface Materials

The roof consisted of wood sheathing covered by asphalt shingles.

4.6.4 Support System

The roof was supported by wood rafters with collar ties.

4.6.5 Condition

The roof of Building E6891 had collapsed, and most of the asphalt shingles were missing, exposing the wood sheathing (Figures 4A and 4D).

4.6.6 Equipment Located on Roof

None.

4.6.7 Chimneys, Roof Vents, or Vent Stacks

None.

4.6.8 Piping

None.

4.7 Interior Floor Plan

4.7.1 Room Numbers and Dimensions

Building E6891 originally contained three rooms, but the interior walls had collapsed. Original room dimensions were: room 1, 15 ft 6 in. by 15 ft; room 2, 10 ft by 15 ft; and room 3, 15 ft by 15 ft. Interior walls with doorways separated the center room (room 2) and the two outer rooms (rooms 1 and 3). Figure 3 shows the floor plan of the building, developed during the ANL survey and from historical documentation (EAI Corporation 1989).

Because the walls of Building E6891 had collapsed, the interior of the building was considered a single room, referred to as room 1 in this report (Figures 5 and 6).

4.7.2 Walls

The original interior walls of Building E6891 were constructed of painted particleboard. Most of the interior walls that were still standing were exposed wood sheathing and wall studs (Figure 5B).

4.7.3 Floor

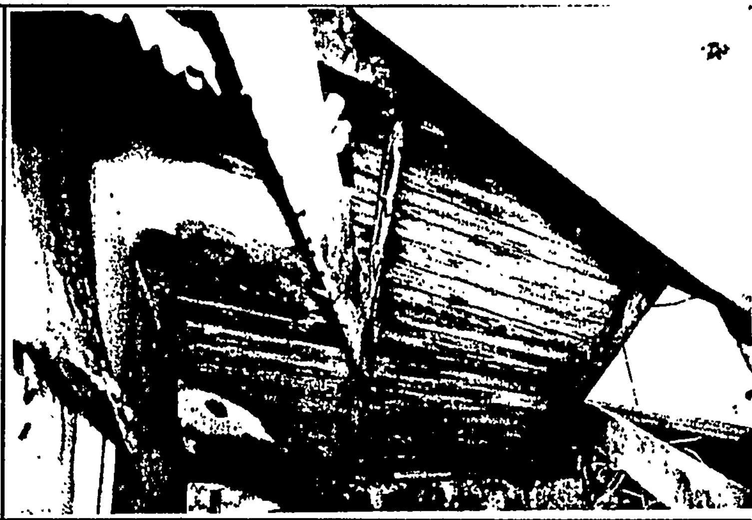
The floor, made of wood sheathing supported by wooden framing, was in poor condition because the building had no apparent foundation at the time of ANL's inspection (Figure 6A).

A	Wall 1, 2
C	Wall 4

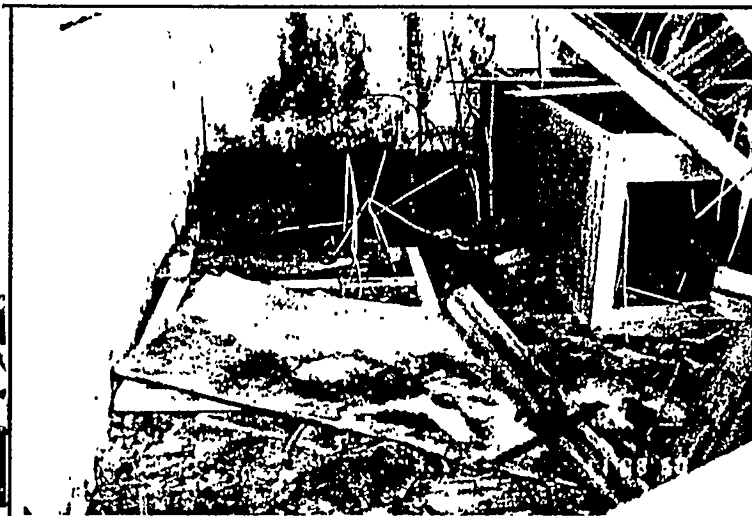
Wall 3	B
Wall 1	D

FIGURE 5 Photographs of Building E6891 Interior — Walls

A



B



C

Not Used

D

Not Used

A	Ceiling
C	Not Used

Floor	B
Not Used	D

FIGURE 6 Photographs of Building E6891 Interior — Ceiling and Floor

4.7.4 Floor Penetrations

Although Building E6891 had no identified drains, sumps, floor sinks, trough drains, or similar structures, a number of holes were observed in the floor during the ANL inspection.

4.7.5 Interior Partitions

Building E6891 originally had three rooms (Figure 3), but the interior walls had collapsed. The interior walls or partitions separating the rooms were wood studs covered with white painted particleboard.

4.7.6 Equipment or Supplies

None.

4.8 Room 1

Because the walls and ceiling of Building E6891 have collapsed, the interior of Building E6891 was considered a single room, referred to as room 1.

4.8.1 Walls

The original interior walls of Building E6891 were painted particleboard. Most of the interior walls of the building that were still standing were exposed wood sheathing and wood studs.

4.8.2 Finish Materials

The interior walls of Building E6891 were painted particleboard (Figure 4A).

4.8.3 Piping

None.

4.8.4 Equipment

None.

4.8.5 Doors and Windows

There was one 3-ft-wide door in the center and two 4-ft-square windows located 6 ft from the corners in the north exterior wall of Building E6891. A 4-ft-square window was located in the center of each of the east and west walls. There were three 4-ft-square windows in the south wall: two were 6 ft from the building corners and the third was in the center of the south wall. Doorways were located in the interior walls between the center room (room 2) and the two outer rooms (rooms 1 and 3).

4.8.6 Ceiling and Floor

The ceiling was originally painted particleboard, but most of the particleboard had fallen when the walls collapsed, exposing the wood rafters and roof sheathing (Figure 6A). The building had a wood floor supported by wooden framing. The floor was in poor condition; no foundation was apparent at the time of ANL's inspection (Figure 6B).

5 Geophysical Investigation

A geophysical survey was conducted by ANL around Building E6891 using several nonintrusive geophysical survey methods. Debris from Building E6891 covered most of an approximately 20-ft-wide area along of the northeast side of the concrete wall and extended about 5 ft beyond the northeast corner of the wall. The debris along the west 15 ft of the wall measured only about 10 ft or less in width. A copy of the geophysical survey is presented in Appendix A.

Results of the geophysical surveys permit the following conclusions:

- Large-diameter magnetic electromagnetic field (EMF), conductivity, and ground penetrating radar (GPR) anomalies are centered about 10 ft east and 45 ft north of the northwest corner of the building debris. EMF and magnetic point anomalies were also observed about 15 ft east and 25 ft north of the northwest corner of the building debris. A probable source for these anomalies is buried metals.

- Magnetic, EMF, and GPR anomalies were observed in the area northeast of the gravel road. This area is about 10 ft east and 35 north of the northeast corner of the building debris. ANL personnel noted uneven terrain in this area, suggesting that these anomalies are caused by waste metals.

- A linear conductivity low was observed starting about 15 ft north of the northwest corner of the building debris and extending about 30 ft to the east. Point magnetic and EMF anomalies are also observed within this conductivity low. These anomalies were complex and discrete point metal sources resulting in different signatures for different instruments.

- Isolated hyperbolic GPR anomalies were observed along a line starting about 13 ft north of the northwest corner of the building debris and extending east about 30 ft. The source of these anomalies may be a clay or plastic pipe.

- Addition geophysical anomalies are associated with the building debris starting about 15 ft north of the northwest corner of the building debris and extending east about 30 ft. These anomalies are more distant and have a different and unknown source.

- A northeast-trending magnetic anomaly was observed west of the concrete wall. At least nine data points within the EM-31 survey area also revealed this feature. The limits of this anomaly are unknown, although it measures at least 55 by 10 ft. Because this area was not surveyed by EM-61 or GPR, no conclusive interpretation can be made as to its source. However, buried metal associated with a pipe or trench may cause this anomaly.

The geophysical surveys suggest the presence of some underground objects near Building E6891. Probable source of these anomalies is buried metals. The complete geophysical report for the Lauderick Creek Concrete Slab Test Site is provided as Appendix A.

6 Air Quality Monitoring

ANL staff collected air quality samples upwind, downwind, and inside of Building E6891 during November 1994. Analytical results showed no distinguishable difference in the levels of hydrocarbons and chlorinated solvents between the two background samples and the sample taken inside Building E6891. These results indicate that Building E6891 is not a source of volatile organic compound contamination. The air quality monitoring letter report and data are provided in Appendix B.

7 Underground Storage Tanks

No information on underground storage tanks associated with Building E6891 is available.

8 Conclusions

On the basis of information collected and reviewed by ANL for Building E6891, it is the authors' judgment that no significant air contamination is associated with this building. Results of the geophysical surveys indicate some anomalies in the vicinity of Building E6891 that warrant further investigation and evaluation.

9 References

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Appendix A:

Final Report — Environmental Geophysics: Lauderick Creek Concrete Slab Test Area, Aberdeen Proving Ground

Final Report —
Environmental Geophysics:
Lauderick Creek Concrete Slab Test Area,
Aberdeen Proving Ground
(Building E6891 Site and Southeast Dump Site)

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Final Report — Environmental Geophysics: Lauderick Creek Concrete Slab Test Area, Aberdeen Proving Ground (Building E6891 Site and Southeast Dump Site)

Abstract

The Concrete Slab Test Site includes the immediate vicinity surrounding Building E6891 and the Southeast Dump sites which are both potentially contaminated sites in the Lauderick Creek section of Aberdeen Proving Ground. Nonintrusive, geophysical surveys, including total-field magnetic, electrical conductivity (EM-31), time-domain electrical induction (EMF or EM-61), and ground-penetrating radar (GPR) techniques were used to characterize the shallow subsurface in both areas. At Building E6891, all geophysical instruments detected a large (16 ft x 10 ft) anomaly centered at X=120, Y=135. In addition, magnetic and EMF anomalies extend along Y=125 to X=120. Point magnetic anomalies are observed along a high intensity positive anomaly lineament, located along X=95. Northeast of the gravel road, magnetic, EMF and GPR anomalies are observed over a large region. Each of these anomalies is probably caused by buried metal. A three-banded conductivity anomaly, typical of buried metal, is observed along Y=115 between X=100 and X=140. Hyperbolic GPR anomalies are observed along Y=103, between X=100 to X=130 and may be sourced by a plastic or clay pipe since they are not associated with metals. A linear magnetic positive, located approximately 40 ft west of the geophysical survey area, measures over 10 ft wide and at least 55 ft long. This lineament was also found to be a conductivity positive. Magnetic anomalies are also observed near (100, 66). In this area, only magnetometer and limited EM-31 data are available and the source of these anomalies can not be interpreted with certainty. At the Southeast Dump site, an area measuring 200 feet x 500 feet immediately southeast of the slab was studied. Two northwest-southeast trending trenches are indicated by EM-31, EM-61 and magnetic data. Ground penetrating radar contributed little to the interpretation of the trenches due to rough terrain and high clay content in near-surface soils. Point anomalies are widespread across the site, and many of those can be associated with surface debris. Geophysical data do not indicate the presence of conductive contaminant plumes in the groundwater.

1 Introduction

Aberdeen Proving Ground (APG), in the state of Maryland, is managing a comprehensive Installation Restoration Program involving more than 360 solid waste managing units contained within 13 study areas. The Edgewood Area of Aberdeen Proving Ground appears on the National Priority List under the Comprehensive Environmental Response, Compensation, and Liability Act.

Therefore, APG has entered into an Interagency Agreement with the U.S. Environmental Protection Agency to address the listed areas.

A report prepared by the EAI Corporation (1989) included a list of 29 potentially contaminated buildings in the Edgewood Area of Aberdeen Proving Ground. The buildings have been abandoned and operations have ceased, but processing equipment, incinerators, sumps, drains, ventilation systems, and underground storage tanks remain. These appurtenances may contain liquid, solid, or vapor contaminants of unknown nature. Sixteen of the buildings contain known contaminants, nine buildings contain unknown contaminants, and four of the buildings are potentially clean. The EAI report recommended that a sampling and monitoring program be established to verify contamination levels in and around each building.

Aberdeen Proving Ground is proceeding with a program to decommission the buildings, which will eliminate the actual or potential release of contaminants into the environment. Argonne National Laboratory (ANL) has been assigned the task of developing a plan and scope of work for the proposed decommissioning. Argonne has determined that the first step in this decommissioning process, where it is technically feasible, should be a noninvasive geophysical survey around building exteriors. In this report, geophysical surveys conducted at Building E6891, part of the Lauderick Creek Concrete Slab Sudy Area, will be discussed.

Southeast of E6891, an additional geophysical survey was conducted in March 1995, above a probable dump site. The purpose of this survey was to locate and identify possible buried tanks, trenches, pipes, drainage lines and burial pits, to define the horizontal distribution of possible plumes and, if possible, to define near-surface geologic and hydrogeologic conditions. Because of the proximity to Building E6891, the results of geophysical surveys conducted at the Southeast Dump Site will also be presented.

1.1 Site History

The Lauderick Creek Concrete Slab Test facility was used for the testing of incendiary munitions, pyrotechnic, and flame projects generated by the research and development community at APG (EAI 1989). It is believed the facility was constructed and first used during World War II, and it was possibly in use until the early 1970s (Nemeth 1989).

The test facility is a concrete slab approximately 300 feet long and 100 feet wide with a concrete impact wall approximately 30 feet high at the northwest end. Waste from test activities, primarily expended test items, were dumped adjacent to the test site, primarily southeast and south of the slab. Materials that were used include black powder (potassium nitrate, charcoal, and sulfur), flaked and grain aluminum metal, sulfur, castor oil, barium nitrate, and thermit (aluminum powder and ferric oxide). Other potential contaminants include explosives and heavy metals such as barium and lead. It is not known if testing at the site involved use of other types of chemical materials (Nemeth 1989).

Building E6891 is reported to have been constructed in 1953 and was placed in an inactive status in 1976. The three room building was used as the fire-control center and field offices for the test facility (EAI 1989). Due to a lack of maintenance, Building E6891 has collapsed and debris, presumably from the building is stored to the northeast of the firing wall (Figure 2). No drainage or ventilation systems were found for the building. E6891 is free from contaminants and therefore classified as clean.

1.2 Site Reconnaissance

The geophysical survey program designs for Building E6891 and the Southeast Dump Site were based on a similar study by ANL personnel made in the Edgewood Area of APG in 1991 (McGinnis and Miller 1991).

Building E6891 (APG designation) and Southeast Dump Site are part of the Lauderick Creek Concrete Slab Test Site located in Lauderick Creek Area also referred to as School Field No. IX (Figure 1). This facility is in the Edgewood Area of the Aberdeen Proving Ground. The Lauderick Creek Concrete Slab Test facility consists of a large concrete slab, vertical concrete wall, and two small support buildings; Building E6891 and Building E6892. The concrete slab is about 300 foot by 100 foot, and a steel-reinforced concrete wall, several stories high, extends across the northeast end of the concrete slab (Nemeth 1989). The southwest wall of Building E6891 is within 5 feet of the northeast side of the concrete wall.

In planning the geophysical survey, subsurface characteristics in addition to surface conditions at the site were considered. Surficial sediments consist of estuarine sands, silts, and clays that are nonmagnetic and have electrical properties that vary both horizontally and vertically due either to natural conditions or to excavation and building effects. Such sources as iron-rich magnetized objects, nonmagnetic objects, and subsurface channels containing contaminants may be present in the subsurface.

1.3 Geology and Physiographic Setting

The Lauderick Creek area is contained in topographically low and flat terrain of the Coastal Plain physiographic province where alluvial and estuarine sands, silts, and clays underlie the region. A thin veneer of sediments of the Talbot Formation of Pleistocene age overlies unconsolidated sediments of the Potomac Group of Cretaceous age.

Lithologies at the survey site were determined from geologic logs for wells WLC-3 and WLC-9 located adjacent to the survey grid (see Figure 3 for well locations). In general, the upper 6-10 feet consists of clay and silt which is underlain by 4-5 feet of sand or clayey sand. This water-bearing sand layer is underlain by a dry, stiff clay to the bottom-of-hole depth which was

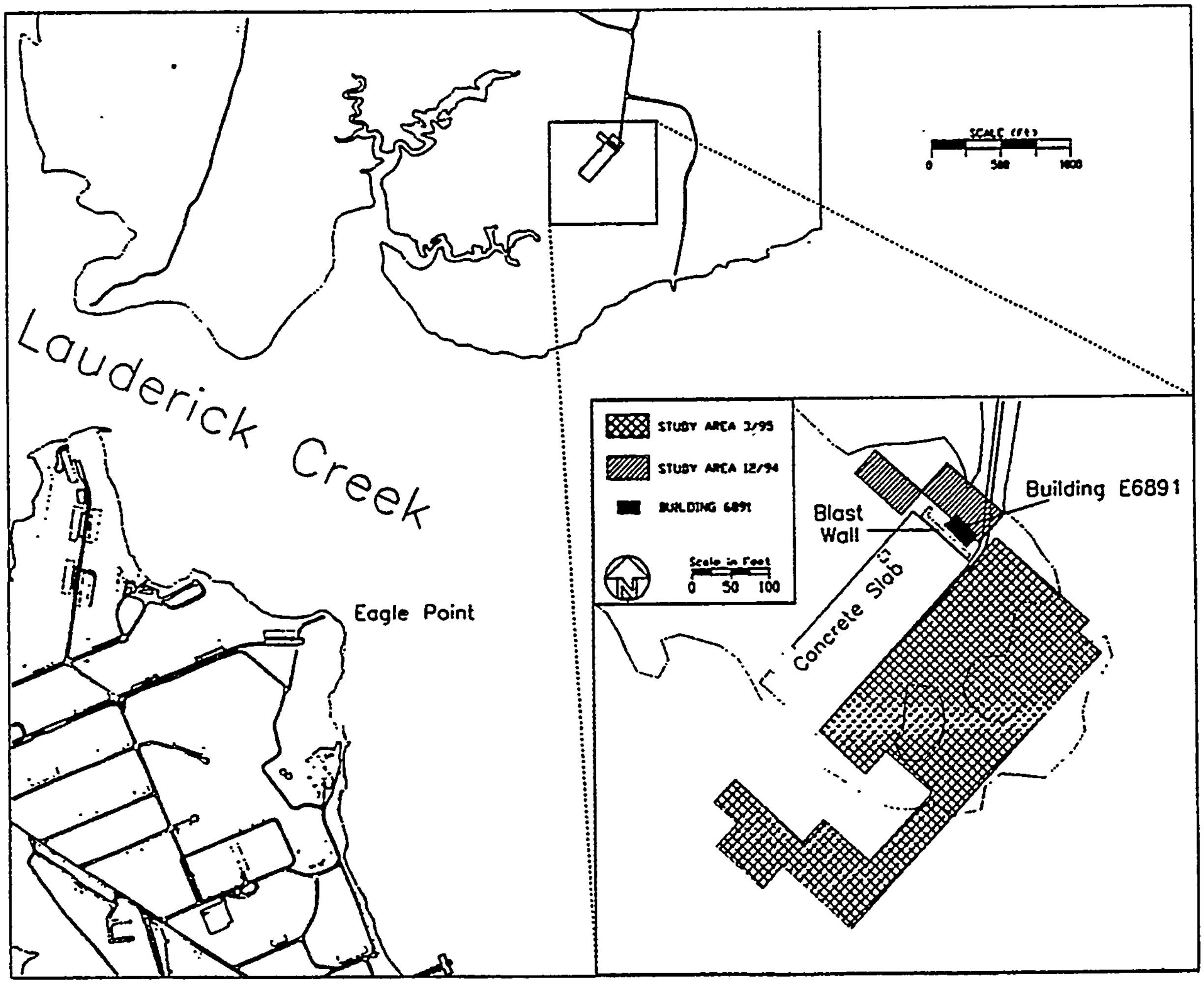


FIGURE 1 General Location Map of the Lauderick Creek Area, Aberdeen Proving Ground, Maryland

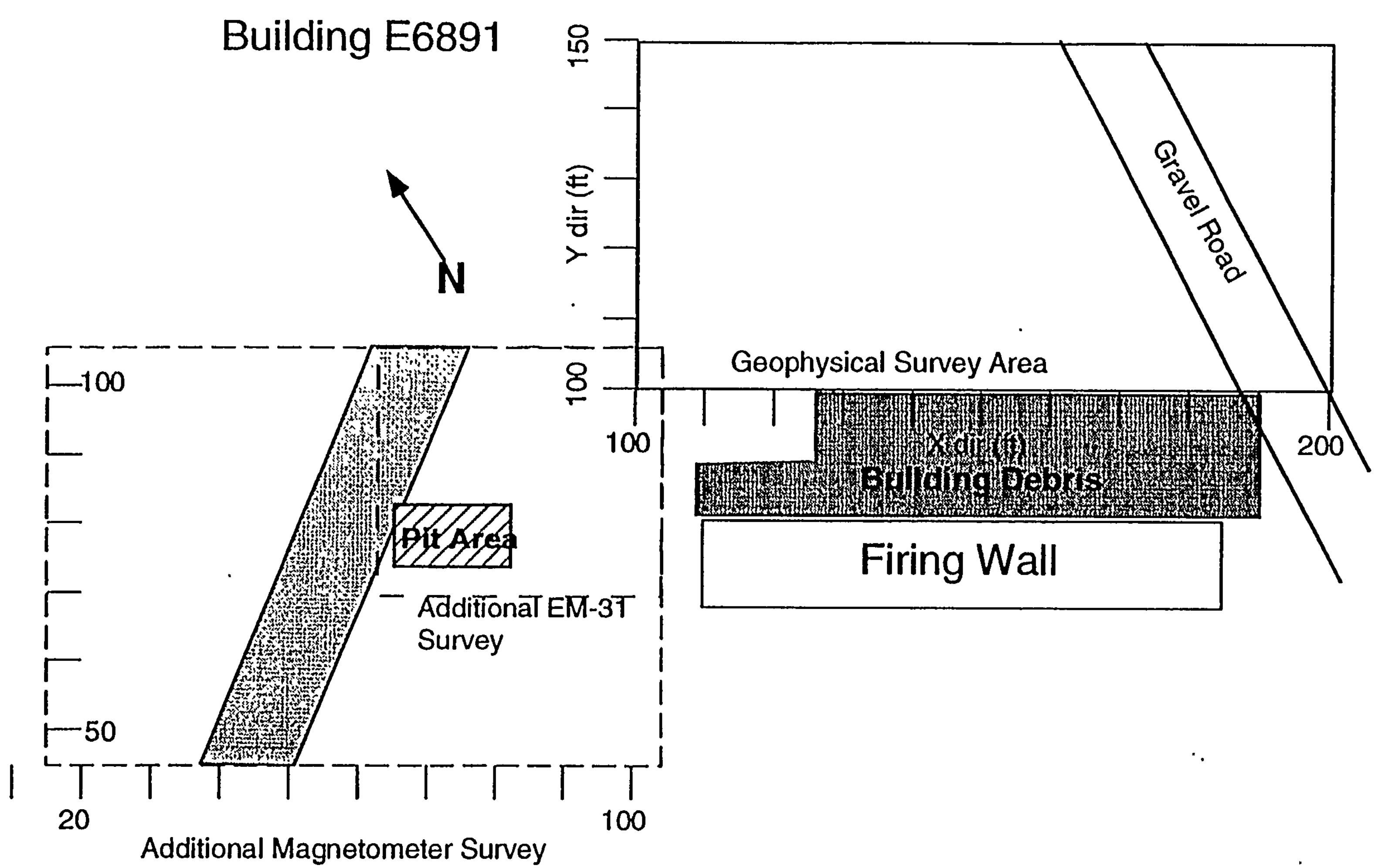


FIGURE 2 Detailed Location Map of Building E6891 Site

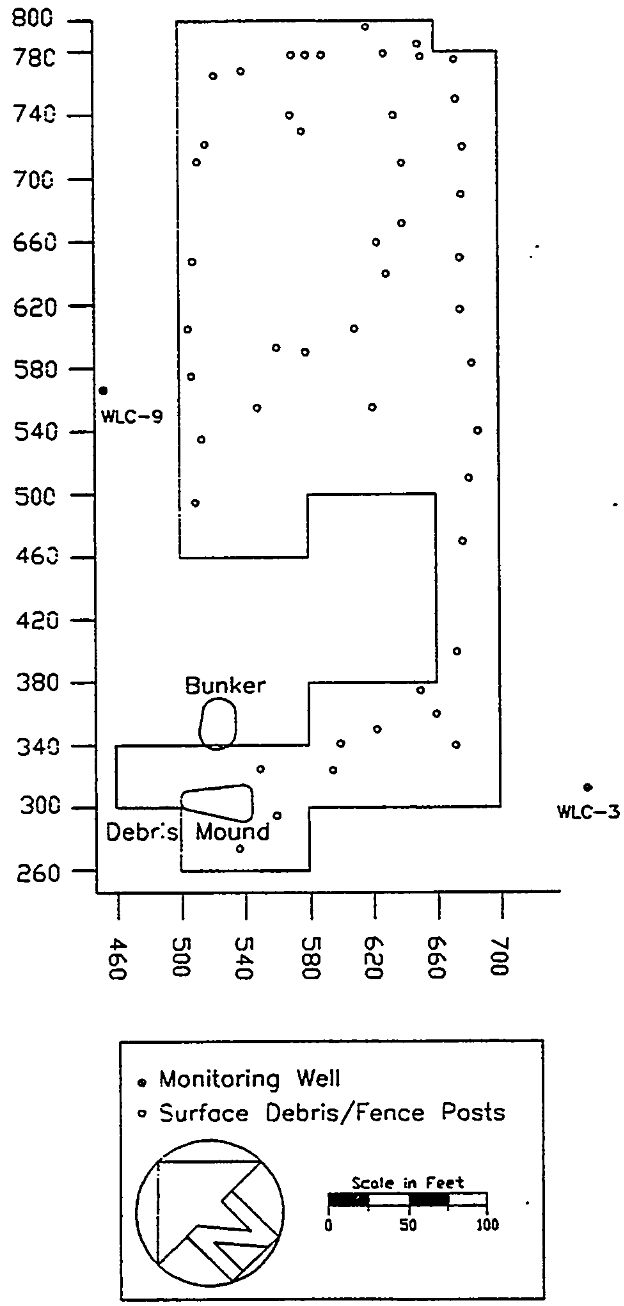


FIGURE 3 Map Showing Approximate Survey Boundaries and Locations of Metallic Surface Debris at the Southeast Dump Site

12.0 feet in WLC-3, and 20.0 feet in WLC-9. On the drilling log for WLC-3, static water levels of 1.9 and 4.3 feet are recorded. The reference point, time, and date of those measurements are not given on the log. On the drilling log for WLC-9, static water levels of 9.9 and 13.5 feet are recorded. Again, the reference point, time, and date of the water level measurements are not given on the log.

1.4 Surveys

At Building E6891, geophysical data were acquired during two days of field operations during December 1994. Geophysical data at the Southeast Dump Site were acquired during a four day period the week of March 27, 1995. On-site personal computers (both notebook and desktop), interactive software, and field equipment designed specifically for APG building studies were used to expedite data acquisition and processing. Surveys were conducted to measure total field magnetics, electrical conductivity, induced electromagnetic field (EMF), and ground-penetrating radar (GPR) profiles.

1.5 Survey Grid and Locations of Observations

Prior to geophysical surveying, wooden stakes were placed at the site corners to mark the area to be surveyed. At Building E6891, a grid was positioned so that it's southwestern grid corner was located at coordinates X=100, Y=100, and was oriented so that its axes were parallel to the edges of the firing wall (Figure 2). At the Southeast Dump Site, the southwest corner of the grid was located at coordinates X=500, and Y=260 (Figure 3). The survey grid was positioned so that the Y axis is parallel to the long edge of the concrete slab (which is aligned approximately southeast-northwest). At both sites, positive X and Y coordinates are measured approximately southwest and northeast of the starting coordinate (Figures 2 and 3). Profile X=800 at the Southeast Dump Site would coincide with X=205 at the Building E6891 site if one grid were extended. For convenience, a location of X=100, Y=150 will be represented as (100,150). Within each geophysical survey area, physical properties of the subsurface were measured with four instruments along transects parallel to the X and Y axes.

In addition, west of the Building E6891 site, transects were run over two surface depressions about 6" to 8" deep (pit area, in Figure 2) and measuring approximately 5 ft x 2 ft. Magnetometer profiles were accurately tied into the original geophysical survey area using measuring tape and survey stakes. Profiles were conducted with Y transects spaced 5 ft apart and X tie-lines spaced 20 ft apart. Locations within the magnetometer survey are probably accurate to 2-3 feet. In addition, four EM-31 profiles were also run over the depressions (Figure 2) that were not explicitly tied into the geophysical survey grid. Consequently, the locations of the EM-31 profiles relative to the firing wall are not constrained as well as the magnetometer profiles and are probably accurate to within 20 feet.

At the Southeast Dump Site, surface obstructions including dense phragmites and fallen tress made it necessary to modify the survey grid from the planned 200 ft. by 500 ft. rectangle. As a result, data were not collected in a section approximately 120 ft. by 160 ft. in the southern portion of the proposed survey area (see figure 3). The primary survey direction over the southern quarter of the area was changed to minimize the disruptions caused by fallen trees. Over the northern three-quarters of the grid, geophysical profiles were spaced five feet apart in the Y direction, with tie-lines every forty feet in the X direction. Over the southern quarter of the grid, geophysical profiles were spaced five feet apart in the X direction, with tie-lines every forty feet in the Y direction.

2 Instrumentation

2.1 Magnetic Gradiometer and Cable Locator

The Schonstedt MAC-51B magnetic gradiometer and cable locator is a dual-mode instrument designed for detecting shallow buried iron and steel objects and tracing underground cables and pipes. The system consists of a transmitter and a dual-function receiver designed to detect anomalous magnetic gradients. The MAC-51B is an audio device used only for rapid detection of magnetic materials for further analysis with complementary instrumentation.

Maps or models are not constructed from observations made with this instrument because the MAC-51B is not a calibrated system and it does not have digital data recording. Anomalies are identified by changes in sound amplitude and frequency. Any anomalies detected with the MAC-51B are marked on the ground surface prior to the initiation of other surveys. If the anomalies detected with the MAC-51B cannot be verified with the magnetometer (see Section 2.2), the anomaly is assumed to be insignificant.

Surveying with the MAC-51B in its receiver mode is the first geophysical operation following establishment of survey limits. A qualitative description of the site, with 100% ground coverage, is achieved by using the gradiometer, whereas the results obtained with other techniques, although more quantitative, are spatially limited to single-point, survey-grid observations or to continuous readings along spaced profiles.

2.2 Total Field Magnetics Meter G-822L

Magnetometer surveys are used for identifying such ferromagnetic objects as tanks, drums, drain pipes, water lines, and small ferrous objects. An EG&G Geometrics G-822L cesium vapor magnetometer was used to measure the total magnetic field around Building E6891. The G-822L was operated in a continuous-recording mode and acquired a magnetic measurement at intervals of approximately one-third of a foot.

Because of their dipolar field, magnetic anomalies due to a source having a simple shape exhibit a characteristic signature consisting of a positive magnetic peak and at least one negative magnetic trough. If iron-rich waste is buried in the northern hemisphere and becomes magnetized in the earth's field, a large positive anomaly with a weak negative offset to the north will occur over any iron-rich symmetrically-shaped body. The horizontal distance between the paired peak and trough is proportional to the depth of burial, size, and shape of the source, whereas, the amplitude of the anomaly is inversely proportional to the square of the depth of burial. Metallic debris at, or just below, the ground surface produces strong, closely spaced magnetic peaks and troughs separated by high gradient areas.

When using the G-822L magnetometer, the sign of magnetic anomalies must be viewed with extreme caution, because in a region of high gradients, the magnetometer becomes untuned and provides zero readings. Contouring software for the G-822L has been designed to bridge the zero gap with mean values taken from the last readable data along the profile. Thus, because of the bipolarity of magnetic anomalies and the variability of gradients, it is possible for an isolated anomaly or a lineament to change from a positive to a negative feature along the trend. For the purposes of this study, the polarity of the anomaly is unimportant, whereas, the absolute strength of the magnetic anomaly and whether it appears as a "point" source or as a linear feature are more important to the geophysical interpretation.

2.3 Conductivity Meter EM-31

Mean conductivities were obtained with the Geonics EM-31, an electrical induction instrument that measures mean terrain conductivity to depths of approximately 20 ft. In electromagnetic (EM) profiling, electrical current flow is induced into the ground by a transmitter (induction coil); a receiver measures the secondary magnetic field caused by the low-intensity "eddy" currents induced in the subsurface. The field strength of the secondary magnetic currents is almost linearly proportional to the electrical conductivity of the surrounding sediment.

Data were collected at 0.5-s intervals with the EM-31 and were stored on the OMNI 720 data logger, which can log quad-phase electrical conductivity data, and in-phase inductive data for metals simultaneously, as well as store survey geometry. For this survey, data were recorded in quad-phase only. Internal software permits downloading data directly into an on-site computer. Conductivity contouring in milliSemens/m (CmS/m) is incorporated into the field acquisition procedure, so that daily map outputs are available for observation and interpretation. EM methods have been used extensively in the Edgewood Area at Beach Point, J-Field, and various buildings surveyed by ANL staff.

2.4 Time Domain Millivolt Meter EM-61

EMF data were obtained in millivolts with a Geonics EM-61, a portable, time-domain, electrical induction instrument that transmits an electrical pulse into the ground and measures secondary EMFs caused by metallic objects beneath the instrument. As a consequence of its coil arrangement, the EM-61 is relatively insensitive to surface interference and is more sensitive to deeply buried metallic targets. Data are recorded on three channels: responses from an upper coil, a lower coil, and a coil difference.

Data were collected at a rate of three readings per second and were stored on the OMNI 720 data logger. Internal software permitted downloading data directly into an on-site computer. Contouring of data in millivolts (mV) was incorporated into the field acquisition procedure, so that daily map outputs were available for observation and interpretation. Inspection of the data sets acquired at Building E6891 and at other APG sites surveyed by Argonne personnel indicates that the measurements obtained from the lower coil are sufficient to identify buried metallic sources within the gridded area.

2.5 Ground-Penetrating Radar System

Ground-penetrating radar surveying and data processing were accomplished using Geophysical Survey Systems, Inc., Radan III software (Galinovsky and Levin, 1990) and a model SIR-2 radar connected to a transceiver with a cable approximately 300 ft long. Data from the SIR-2 system were downloaded directly to the personal computer. The control unit/thermal printer was located in the transport vehicle. A computer was located in a field office, so that the radar operator could download, check data quality, and do preliminary processing after a day's run.

Wave-velocity characteristics of near-surface materials were derived from tables of travel-time conversion to depth for various earth materials (Geophysical Survey Systems, 1987). For example, the two-way conversion to depth for average soil is 7-9 ns/ft. As the degree of soil saturation increases, the two-way conversion to depth also increases which, in effect, decreases the maximum penetration depth. Clay also tends to decrease the maximum penetration depth. For example, at Building E6891, a range setting of 70 ns was used for the entire survey. Due to unknown saturation conditions and subsurface heterogeneities, the depth of penetration with GPR at E6891 can range between 8 and 12 feet below the ground surface. For the purposes of this report, a maximum penentration depth of 10 feet was assumed.

Ground-penetrating radar is the best method available to determine depth and geometry of objects buried near the surface. The weakness of the method is its limited depth of exploration due to wave-propagating constraints imposed by the electrical properties of soils.

3 Geophysical Measurements and Surveys: Building E6891 Site

Gridding of the total magnetic field (G-822L) and time-domain EMF (EM-61) data sets was achieved using SURFER For Windows software by Golden Software, Inc., Golden, Colorado (1994) with the minimum curvature method. Documentation supplied for the MINC gridding program suggests that grid intervals from one-half to one-fifth of the profile spacing will yield adequate gridding results for data acquired along profiles (Cordell 1992). Thus, a grid interval of 1.25 ft was used for each set of grid data, which represents a grid interval of one-fourth of the profile spacing (5 ft). Following processing and gridding with the SURFER software, anomalies were enhanced by using color-contouring software developed at ANL by Thompson (1994). These color-contour maps are presented in this report. The data set comprises 11170 magnetic measurements; 1264 EM-31 measurements, and 1834 EM-61 measurements. Profile plots of selected GPR traverses are also presented and are part of a data set comprising 1308 linear feet.

3.1 Total Field Magnetics Measurements

The magnetic field measured around Building E6891 is shown in Figure 4 using a 100 nT contour interval. Also shown are the location of sample points, which, due to the density of data collection, appear as solid black lines in the figure. A prominent magnetic high, centered on (120, 135), dominates the observed magnetic field. This anomaly measures about 16' along profile Y=135 and just less than 10' along profiles parallel to the Y axis. However, along profile X=125, the magnetic positive continues as a series of high/low magnetic pairs to about Y=120. This anomaly is sourced by buried metal of significant size. Scattered small diameter high/low magnetic pairs surround the large anomaly on all sides. Small diameter iron-rich debris is probably buried in these areas.

Magnetic anomalies with diameters of less than 5 ft. are distributed to the southwest of the gravel road and northeast of the building debris. Along line Y=100, these anomalies can be attributed to the building debris. However, northeast of about Y=105, these anomalies are remote from the building debris and must have a different source.

A complex distribution of high and low magnetic anomalies is observed over a large region, northeast of the gravel road. At this location, the ground surface is uneven relative to the southwest side of the gravel road. Iron-rich debris may be buried beneath the area.

The magnetic field map over the surface depressions ("pits") utilizes a 250 nT contour interval (Figure 5). No significant magnetic anomalies are observed over the surface depressions (pit area). However, a major northeasterly trending linear magnetic positive anomaly measuring 10 ft wide and 55 ft long is located west and north of the pit area. The northeastern or

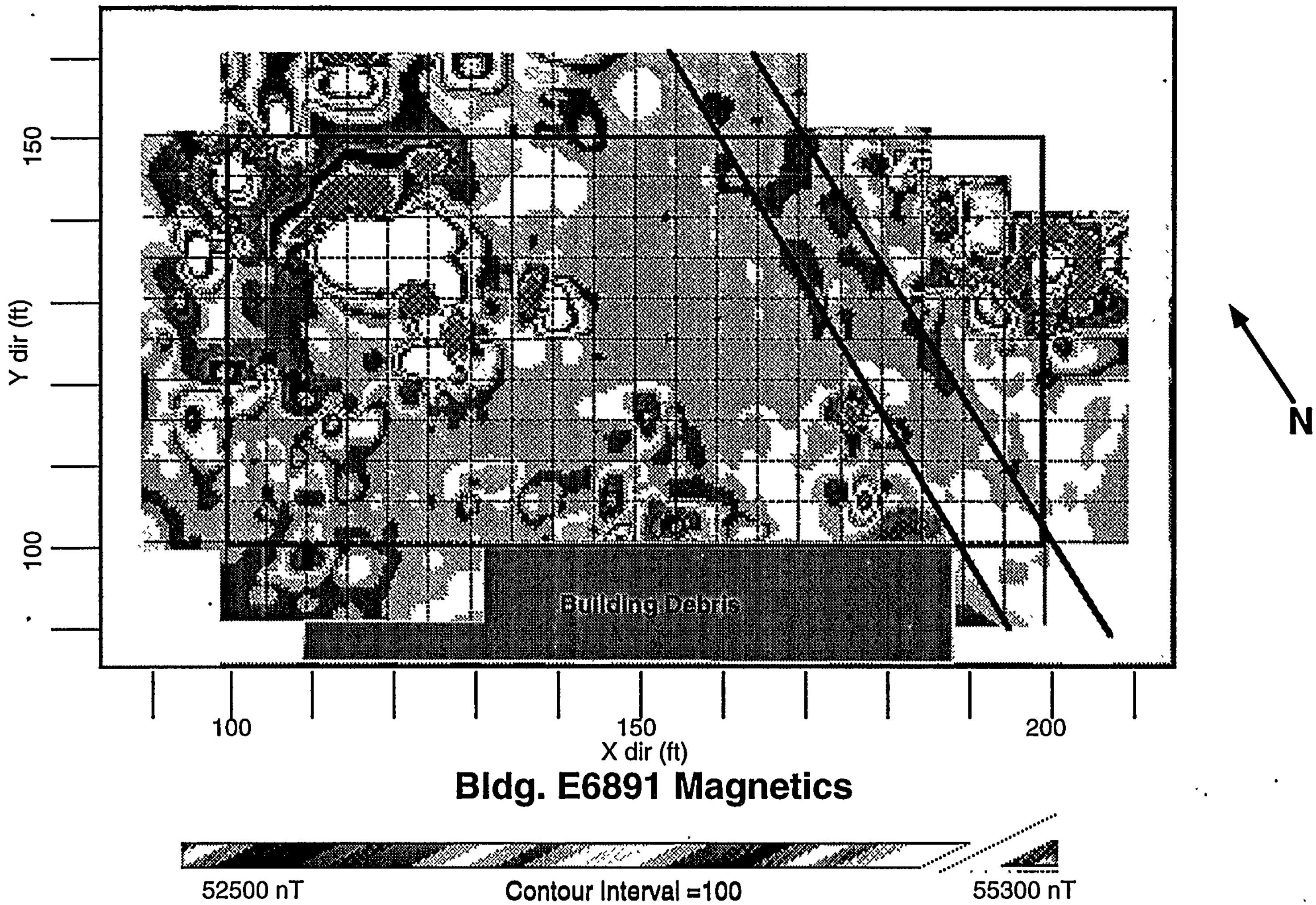


FIGURE 4 Map of Total Magnetic Field Anomalies at Building E6891 Site (measured by using a Geometrics G-822L cesium vapor magnetometer)

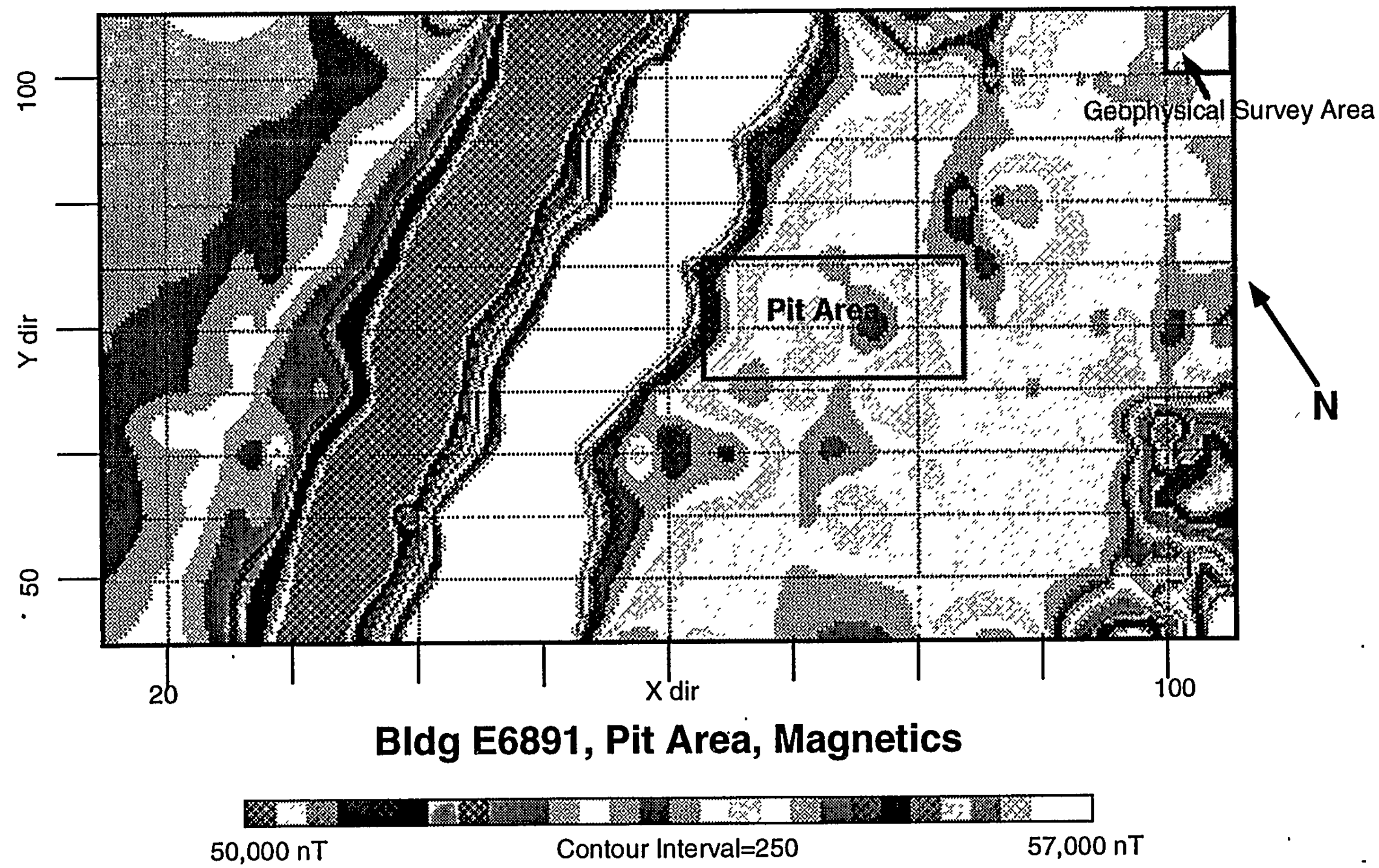


FIGURE 5 Map of Total Magnetic Field Anomalies of the Area Surrounding the "Pits" (measured by using a Geometrics G-822L cesium vapor magnetometer)

southwestern limits of this feature are unknown. To the northwest, a magnetic low parallels this anomaly. This signature is typical of buried iron-rich material in the northern hemisphere that becomes magnetized in the earth's field. Because of the dipolar nature of the magnetic field, a positive anomaly is produced over the source with a negative companion anomaly offset to the north.

Magnetic minima are observed between (100, 65) and (100, 72). Other magnetic anomalies are observed at (90, 90) and (90,100). The sources of these anomalies are unknown. A complete list of the significant magnetic anomalies and their cooresponding grid locations is given in Table 1.

3.2 Terrain Conductivity Measurements

Two illustrations (Figures 6 and 7) using orthogonal data sets are used to define conductivity anomalies because of the azimuthal bias inherent in the EM-31. The gravel road is plotted with thick black lines. Although metals are good conductors, their shape and orientation in relation to the azimuth of the EM-31 transmitter and receiver can result in an electromagnetic field in which the apparent conductivity, as read by the EM-31, is negative. Negative conductivities are an artifact of crossing high-conductivity gradients with the EM-31 boom. When crossed at right angles by the EM-31, an elongated piece of metal (such as a buried pipe of wire) will produce three banded anomaly lineaments. The lineaments will consist of a central minimum bounded by two maxima (Geonics Limited, 1992). A lineament, consisting of a central minimum, bounded by two maxima are observed, centered on Y=115, between X=100 and X=140 (Figure 6).

Isolated conductivity anomalies (Figure 6) near the southern boundary of the survey area between X=150 and X=180 are probably sourced by building debris.

The conductivity low, centered on X= 120 (Figure 7) is detected along two profiles, Y=135 and Y=140. The source of the conductivity highs centered on (130, 120), (140, 110) and (195, 110) are unknown (Figure 6).

No conductivity anomalies are detected over the pit area, located west of the original survey grid (Figure 8). However, conductivity positive anomalies along the northwestern edge of the pit area are defined by at least nine data points. A complete list of the significant conductivity anomalies and their cooresponding grid locations is given in Table 1.

TABLE 1 Location and Description of Geophysical Anomalies Detected near Building E6891 Site

Coordinates		Geophysical Instrument*				Possible Origin
X	Y	MAG	EM-31	EM-61	GPR	
38-70	55-105	✓	✓			Source unknown
90	90	✓				Source unknown
100	65	✓				Source unknown
100	72	✓				Source unknown
105	60	✓				Source unknown
95	115-150	✓		✓		Source unknown
110-128	132-138	✓	✓	✓	✓	Buried metal. Possible UST
125	120-132	✓		✓		Buried metal., source unknown
105-130	103				✓	Non-metallic, small diameter pipe
105	150	✓				Source unknown
115	155	✓				Source unknown
130	157	✓				Source unknown
100-140	115		✓			Possible trench.
112	115	✓		✓		Buried metal., source unknown
140	130	✓		✓	✓	Buried metal., source unknown
140-180	100	✓	✓	✓	✓	Building Debris
150	115	✓		✓		Buried metal., source unknown
150	115	✓		✓		Buried metal., source unknown
155	105	✓		✓		Buried metal., source unknown
155	105	✓		✓		Buried metal., source unknown
185-210	120-150	✓		✓		Buried metal., source unknown
190-200	130				✓	Buried metal., source unknown
195	110		✓		✓	Buried metal., source unknown

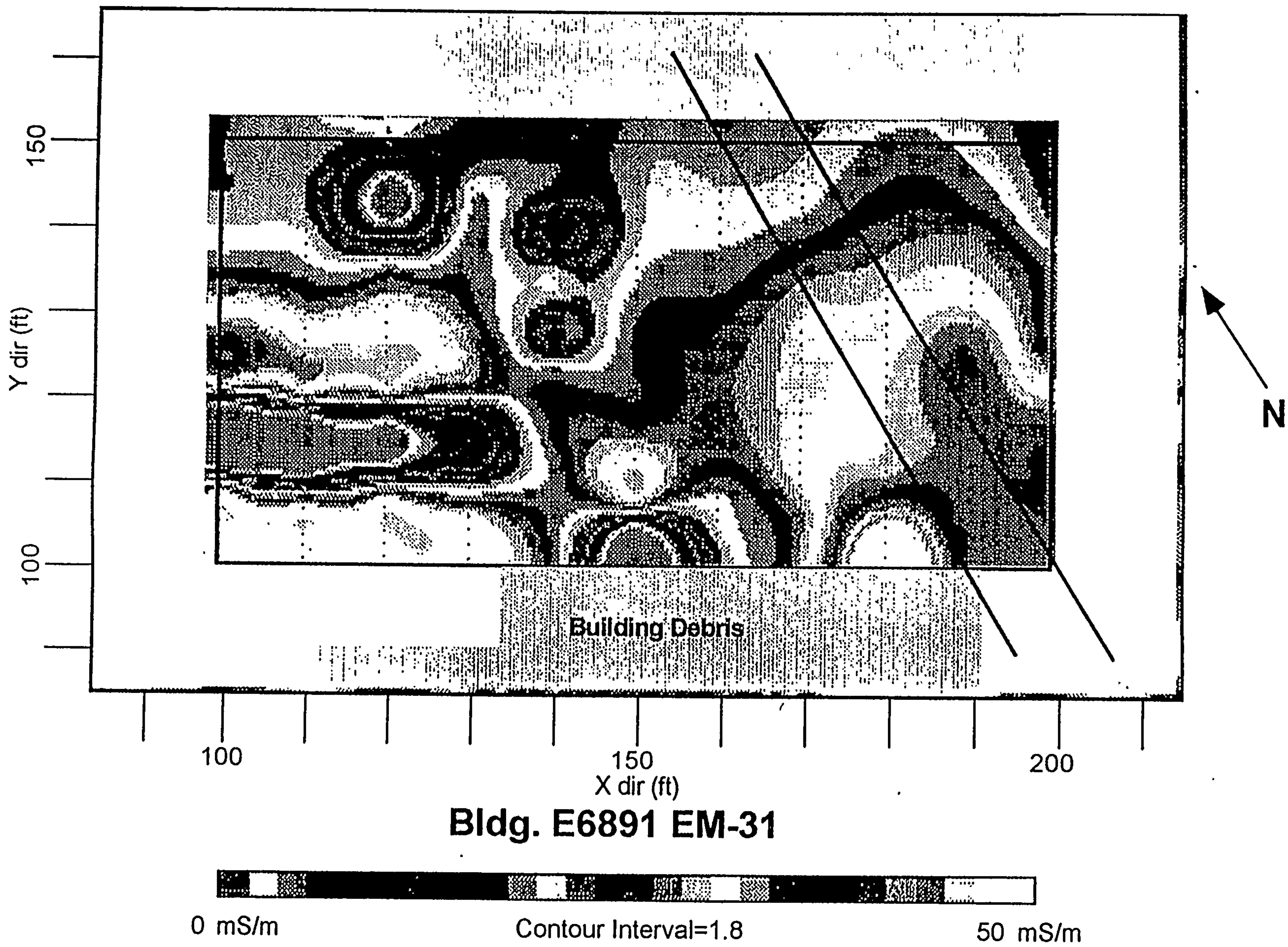


FIGURE 6 Map of the N-S Conductivity Anomalies at Building E6891 Site (measured by using a Geonics EM-31 instrument)

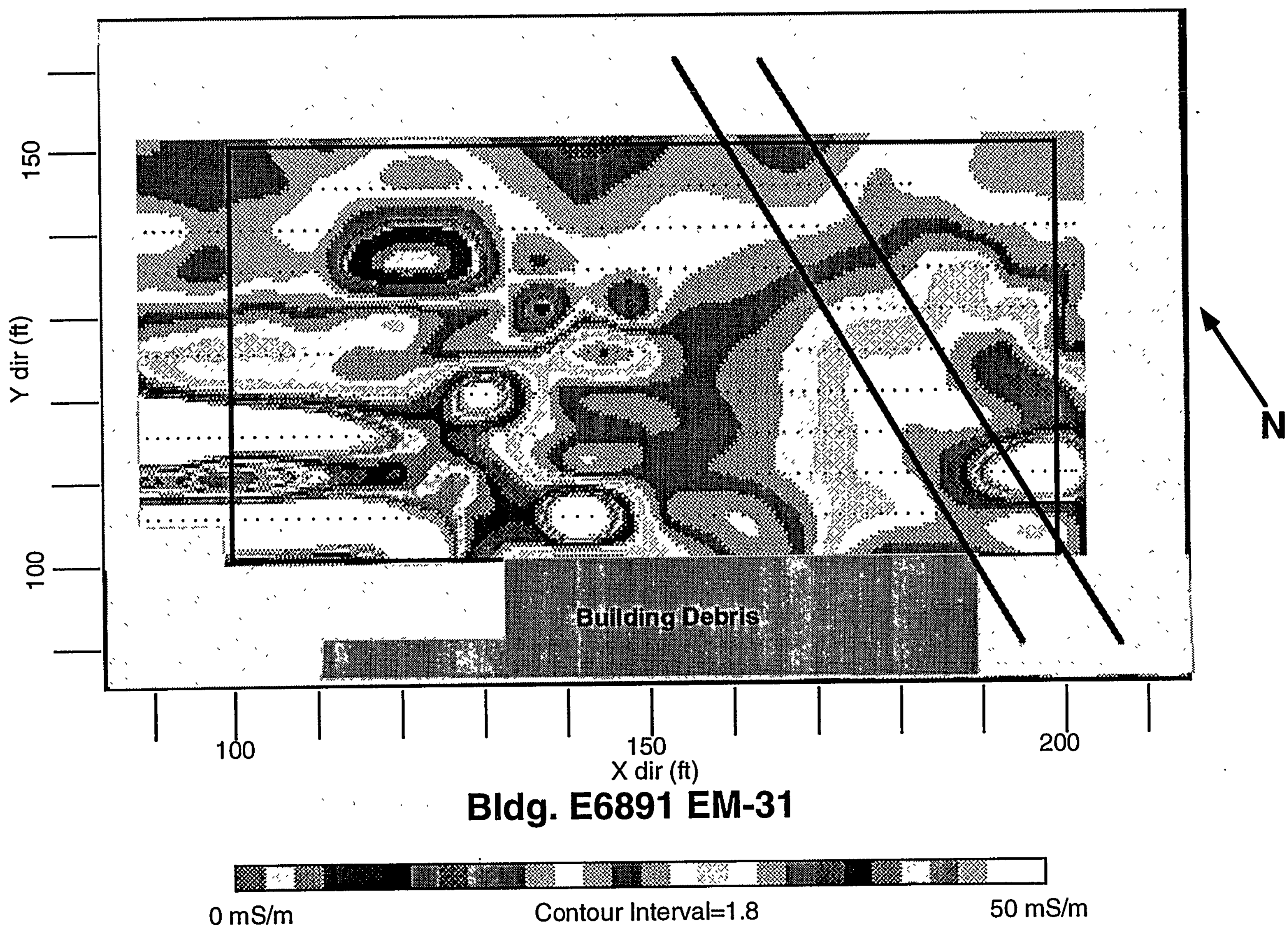


FIGURE 7 Map of the E-W Conductivity Anomalies at Building E6891 Site (measured by using a Geonics EM-31 instrument)

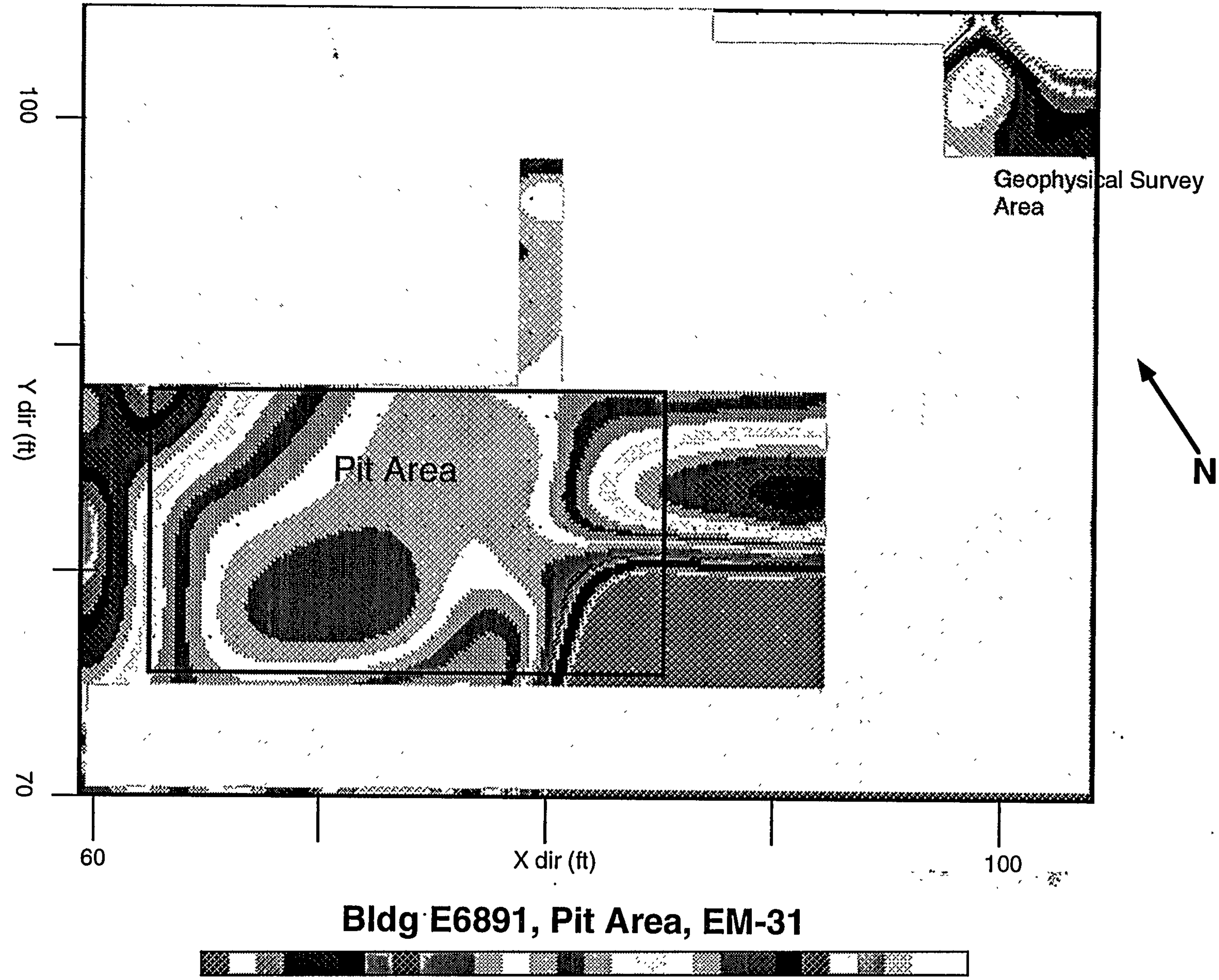


FIGURE 8 Map of the Conductivity Anomalies in the Area Surrounding the "Pits" (measured by using a Geonics EM-31 instrument)

3.3 Induced EMF Measurements

A color-contour map constructed from EM-61 lower coil data is shown in Figure 9. The gravel road is plotted with thick black lines. A prominent irregularly shaped EMF positive anomaly is centered on (120, 140). This anomaly is sourced by buried metals.

The linear band of EMF positives detected along X=95 between Y=115 and Y=150 is approximately 5 feet wide and extends to the northeast, out of the mapped area. This anomaly becomes slightly wider between Y=145 to 150. EMF positives are also centered on (113, 115), (140, 130) and (140, 150). The sources of these anomalies are unknown.

Northeast of the gravel road, strong EMF positive anomalies are observed along profiles parallel to the Y axis. At this location, the ground surface is uneven relative to the southwest side of the gravel road. Metal debris is buried beneath the area.

Between X=150 and 180, EMF positives along Y=100 are probably caused by building debris. However, isolated EMF positives are also observed in this area along lines Y=105 and Y=115. These anomalies are well separated from the pile of metal and must have a different source. A complete list of the significant EMF anomalies and their cooresponding grid locations is given in Table 1.

3.4 Ground-Penetrating Radar Measurements

The locations of GPR lines are shown in Figure 10 and are also listed in Attachment A. The lines are numbered in sequence, along with the beginning and ending positions relative to the grid survey. Prior to running the production lines for the survey, replicate runs were made over the same line to determine which of the three transceivers, the 100-, 300-, or 500-MHz antenna, was best suited to study the terrain surrounding the site. The transceiver providing the best penetration and resolution of buried objects was the 300-MHz unit. Different range settings were also tested over the same transect to determine the optimum resolution and depth of penetration. A range setting of 70 ns was used for the entire survey, at a scan rate of 32 scans per second.

Without verification by another technique or by passing the antenna over an object of known depth, characteristics of radar anomalies may only be inferred. However, where anomalies are also seen with magnetic or resistivity profiling, a diagnostic interpretation of the radar anomaly is possible. Good penetration was observed over most of the site, with resolution down to only about 10 ft below the ground surface.

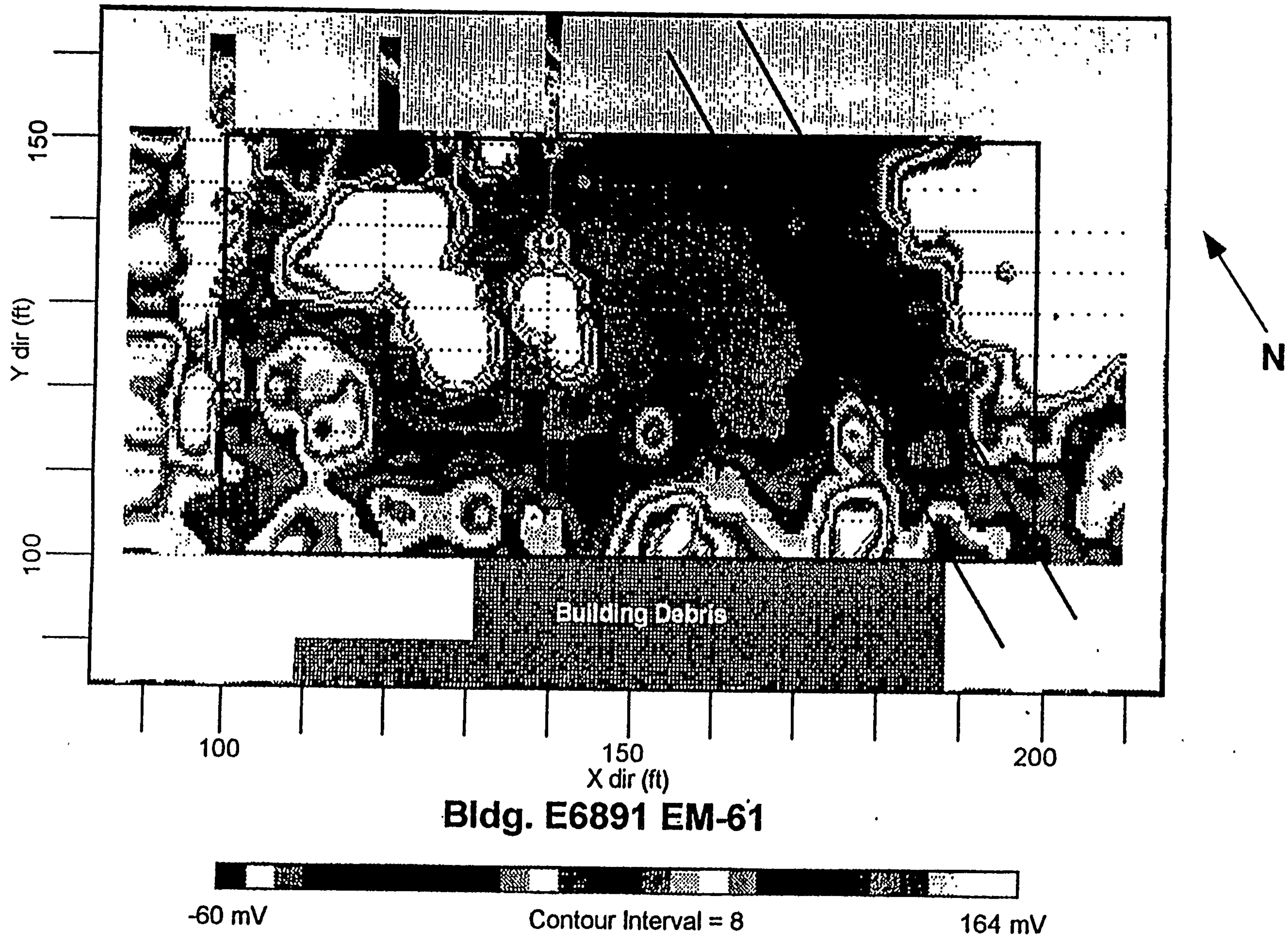


FIGURE 9 Map of the EMF Anomalies at Building E6891 Site (measured by using a Geonics EM-61 instrument)

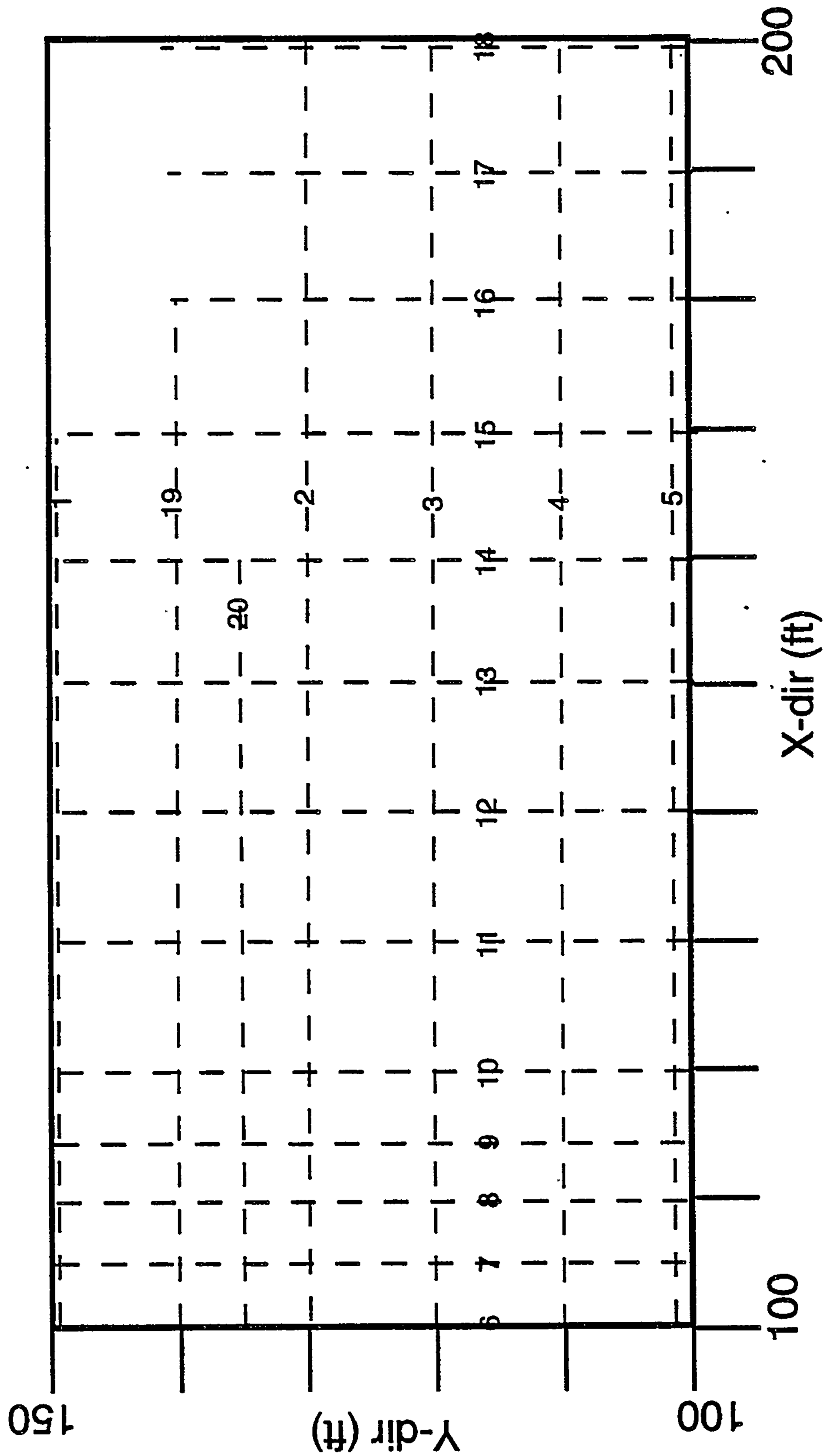
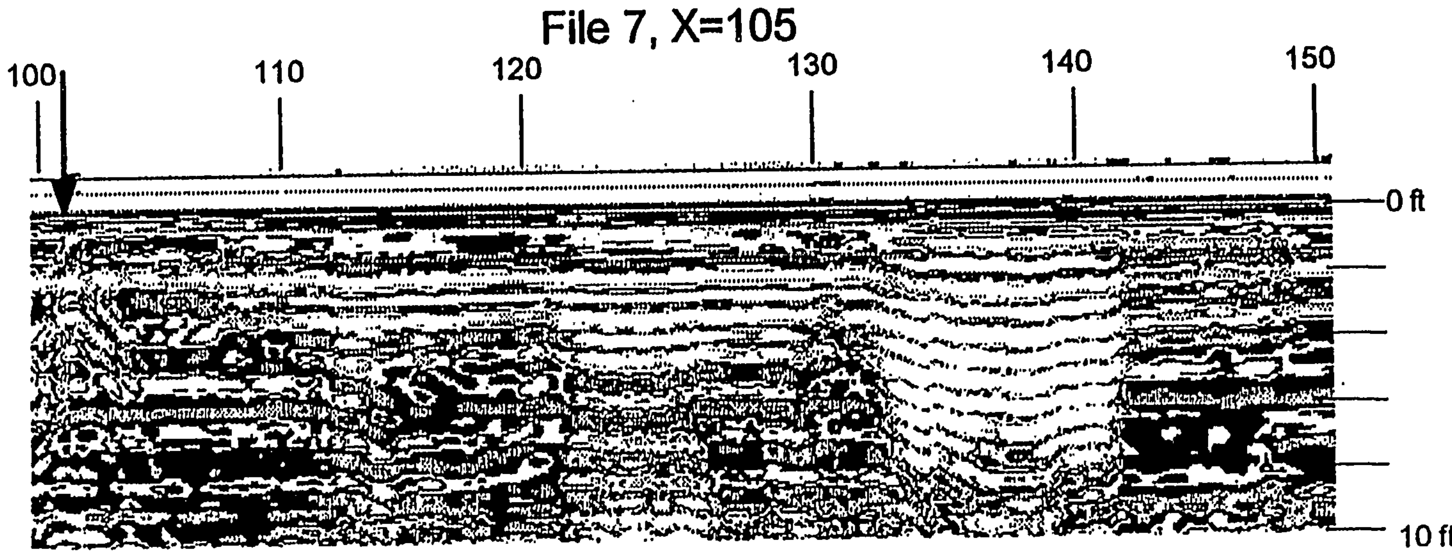


FIGURE 10 Map of Ground-Penetrating Radar Profile Locations

GPR transects were run over the survey area surrounding Building E6891 along X and Y transects spaced 10 ft apart where possible. Geologic logs from nearby wells show interlayered clay and clay-rich silt to depths of 15-20 ft. As in other GPR surveys conducted at APG where similar sub-surface conditions exist (McGinnis and others 1994), strong horizontal reflectors are observed. For example, between X=100 and X=130, strong horizontal GPR reflections probably represent ringing from shallow clay layers (Figure 11). They are strongest between X=100 to 110 and Y=130 to 140 and seem to pinch out away from this region, arguing for a geologic source. On the other hand, GPR profiles between X=110 to 130 and Y=130 to 150 show distinct anomalies that are discordant with the surrounding horizontal reflections. These anomalies probably have an anthropogenic source.

Hyperbolic GPR anomalies along profiles between X=105 and X=130 at about Y=103 (Figure 11) are not detected by magnetic or electromagnetic surveys, indicating a non-metallic source. Therefore, this apparent lineation could be caused by a thin buried plastic or clay pipe.

At least four distinct GPR anomalies are observed along Y=130 between X=190 and X=200, starting at a depth of about 2.5 ft (not shown). Strong GPR reflections are also observed along Y=110 between X=195 to 200. The sources of these anomalies are unknown. GPR anomalies are also observed near the building debris along the southern edge of the survey area and at (140, 130).



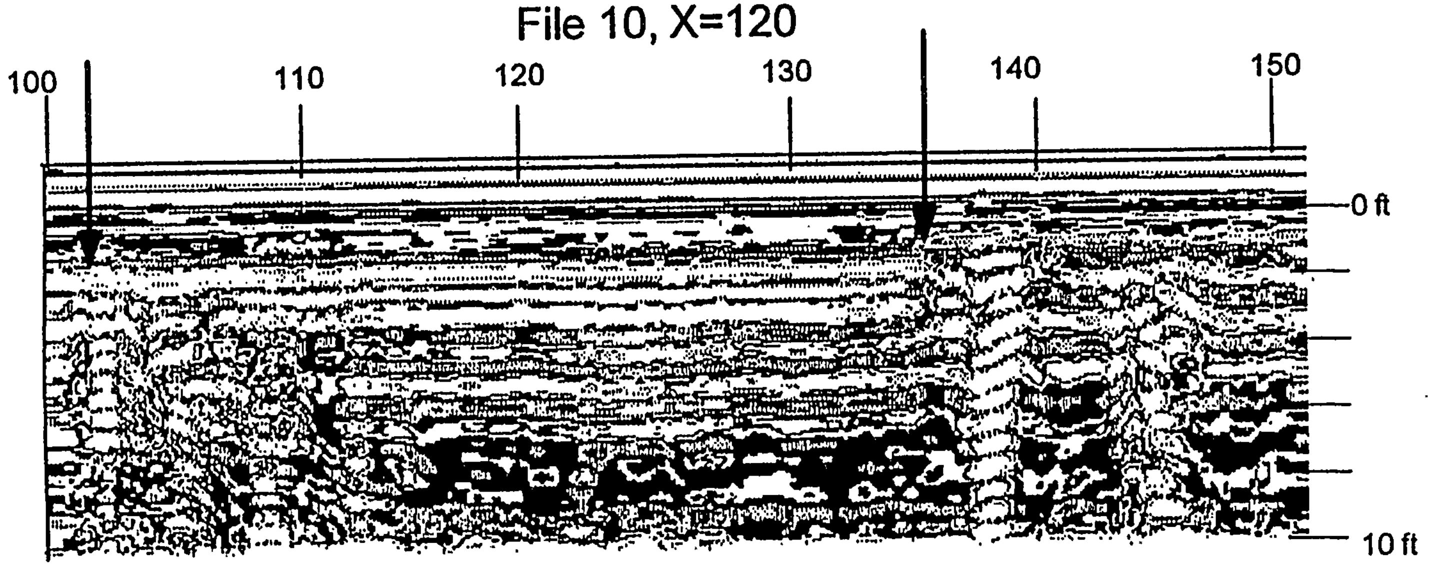


FIGURE 11 Ground Radar Images along Transects Parallel to the Y-Axis near Building E6891 (The maximum penetration depth is estimated at 10 feet.)

3.5 Discussion

A complete list of the significant anomalies and their cooresponding grid locations is given in Table 1. All geophysical instruments detected a large metallic body centered on (120, 135). EMF and magnetic anomalies define the bounds of this anomaly which measures about 16 ft by 10 ft. In addition magnetic and EMF positive anomalies continue along X=125 between Y=132 to 120. This anomaly is also sourced by buried metal.

A linear EMF positive is observed immediately west/southwest of the survey grid, along X=95. Within this apparent lineation, a series of high/low magnetic pairs are also observed. Conductivity measurements see nothing to the north along X=95; however, significant positive anomalies are present in the southwest corner. The sources of these anomalies are unknown. GPR data are unavailable at this location. Magnetic, EMF and GPR anomalies are detected at (140, 130). Conductivity data here are not definitive. The sources of these anomalies are unknown.

Magnetic, EMF and GPR anomalies are observed northeast of the gravel road. In this area, ANL personnel noted that the ground surface more rugged than southwest of the road. This area is underlain by a significant amount of metal.

The three-banded conductivity anomaly lineament observed along Y=115 strongly suggests that metal is buried beneath the site. Equivalent magnetic and EMF anomalies were not detected in this area, however, point anomalies are observed along the lineation. It is suggested that the EM-31 sees a bulk conductivity of the upper 18 feet; however, the magnetic and EM-61 see discrete points.

All geophysical surveys utilized at the site detected anomalies immediately northeast of the pile of building debris along Y=100, which are probably sourced by metals associated with the pile. Isolated point magnetic and EMF anomalies are observed northeast of the building debris and south of the gravel road. These anomalies must be sourced by a different and unknown source.

Within the conductivity high observed along Y=110 between X=190-200, a GPR anomaly is also detected. The source of this anomaly is unknown.

The observed surface depressions located west of the primary survey area did not produce magnetic or conductivity anomalies. However, a strong linear magnetic positive anomaly is located just west of the pit area and trends approximately northeasterly (Figure 2). This anomaly was also detected by approximately nine data points along the edge of the EM-31 survey. The lateral extent of this anomaly is unknown, but is at least 55 ft long and over 10 ft wide. Since only magnetic and EM-31 data are available at the site, a conclusive interpretation is difficult. Nevertheless, a buried metallic cylinder or metal-filled trench is consistent with the available data. More geophysical data, including GPR, EM-61 and EM-31, are required before a conclusive interpretation can be made.

4 Geophysical Measurements and Surveys: Southeast Dump Site

Gridding of the total magnetic field (G-822L), terrain conductivity (EM-31) and time-domain emf (EM-61) data sets was achieved using SURFER Version 4.0 software by Golden Software, Inc., Golden, Colorado (1991) with the minimum curvature method. Documentation supplied for the MINC gridding program suggests that grid intervals from 1/2 to 1/5 the profile spacing should yield adequate gridding results for data acquired along profiles. A grid interval of 1.25 feet was used for each set of grid data which represents a grid interval of 1/4 the profile spacing (5 feet). Following processing and gridding with the SURFER software, anomalies were enhanced by using color-coded software developed at ANL by Thompson (1994). The data set is comprised of 76,000 magnetic measurements, 12,000 EM-31 measurements, and 20,000 EM-61 measurements over a linear traverse of about 21,000 feet. Profile plots of selected GPR traverses are also presented and are part of a data set comprising approximately 8,700 linear-feet.

Magnetic field readings were taken at least once every two hours at a designated, relatively quiet base station to facilitate diurnal corrections if necessary. Observed variations during the field operations did not exceed 35 nanoteslas, which is small in comparison to most anomalies within the study area. For example, the contour interval for the magnetic map presented in the following section is 200 nanoteslas between color values. Therefore, no diurnal corrections to the data were deemed necessary. Major anomalies detected are listed in Table 2.

TABLE 2 Location and Description of Major Geophysical Anomalies Detected near Southeast Dump Site

Coordinates		Geophysical Instrument*				Possible Origin
X	Y	Mag	EM-31	EM-61	GPR	
550-590	650-780	X	X	X	X	Buried Metal
670	350	X	X	X		Surface Debris (Mound)
530	310	X	X	X		Surface Debris
520-560	450-530	X	X	X		Buried Metal
640	555	X	X	X		Source unknown
620	540	X	X	X		Source unknown
555	560	X	X	X		Steel Sign/Post

4.1 Total Field Magnetics Measurements

The total-intensity magnetic field measured over the survey area is shown in Figure 12. The course contour interval between color values (200 nanoteslas) is indicative of the large amount of scattered metallic debris. Many magnetic anomalies are observed throughout the site, some quite strong, that can be directly correlated with observed debris at the surface. Notice the common occurrence of small magnetic anomalies in Figure 12 at locations where surface debris are indicated in Figure 3. A few relatively large anomalies are discussed below. Of these, at least two prominent linear trends are not associated with any surface debris, and are attributed to buried metallic objects.

A strong magnetic anomaly is observed in the southwest corner of the study area centered at grid coordinates (535, 310). The anomaly coincides with a mound of debris with metallic objects scattered throughout the mound. A large cluster of magnetic anomalies is observed centered at grid coordinates (650, 360), and somewhat smaller clusters are observed centered at grid coordinates (630, 660), (620, 560), and in the southwest corner of the study area both west and north of the mound of debris described above. At each location stated above, a relatively large amount of surface metallic debris, including corroded remnants of steel drums and other large items, were observed in the field. The north-to-south trend of small anomalies along X=670 are cased by fence posts.

Two well-defined, linear magnetic anomalies are present within the survey area that are not associated with surface debris, and are labeled A and B in Figure 3. Anomaly A is a linear feature approximately 15-25 feet in width from approximately X=585, Y=780, extending southwest to X=555, Y=640. Anomaly B is a linear feature approximately 15-25 feet in width from approximately X=540, Y=560, extending southwest into the area where data could not be collected due to dense phragmites. Both anomalies run roughly parallel to the long axis of the concrete slab. These anomalies are probably caused by buried metallic objects. EM-31 and EM-61 anomalies correspond very well with the magnetic data. Other magnetic anomalies observed are related to metallic surface debris and steel fence posts.

4.2 Terrain Conductivity Measurements

The electrical conductivity measurements using the EM-31 conductivity meter are shown for profiles conducted parallel to the Y axis in Figure 13 and to the X axis in Figure 14. Two illustrations are used to show conductivity anomalies because of the azimuthal bias inherent in the EM-31 instrument.

Strong conductivity anomalies observed in both Figures 13 and 14 correlate with prominent magnetic anomalies discussed in the previous section and shown in Figure 12. The strong linear trend along Y=500 is caused by steel within the cement slab. The anomaly centered at (530, 310) coincides with the mound of metallic debris described earlier. Likewise, smaller

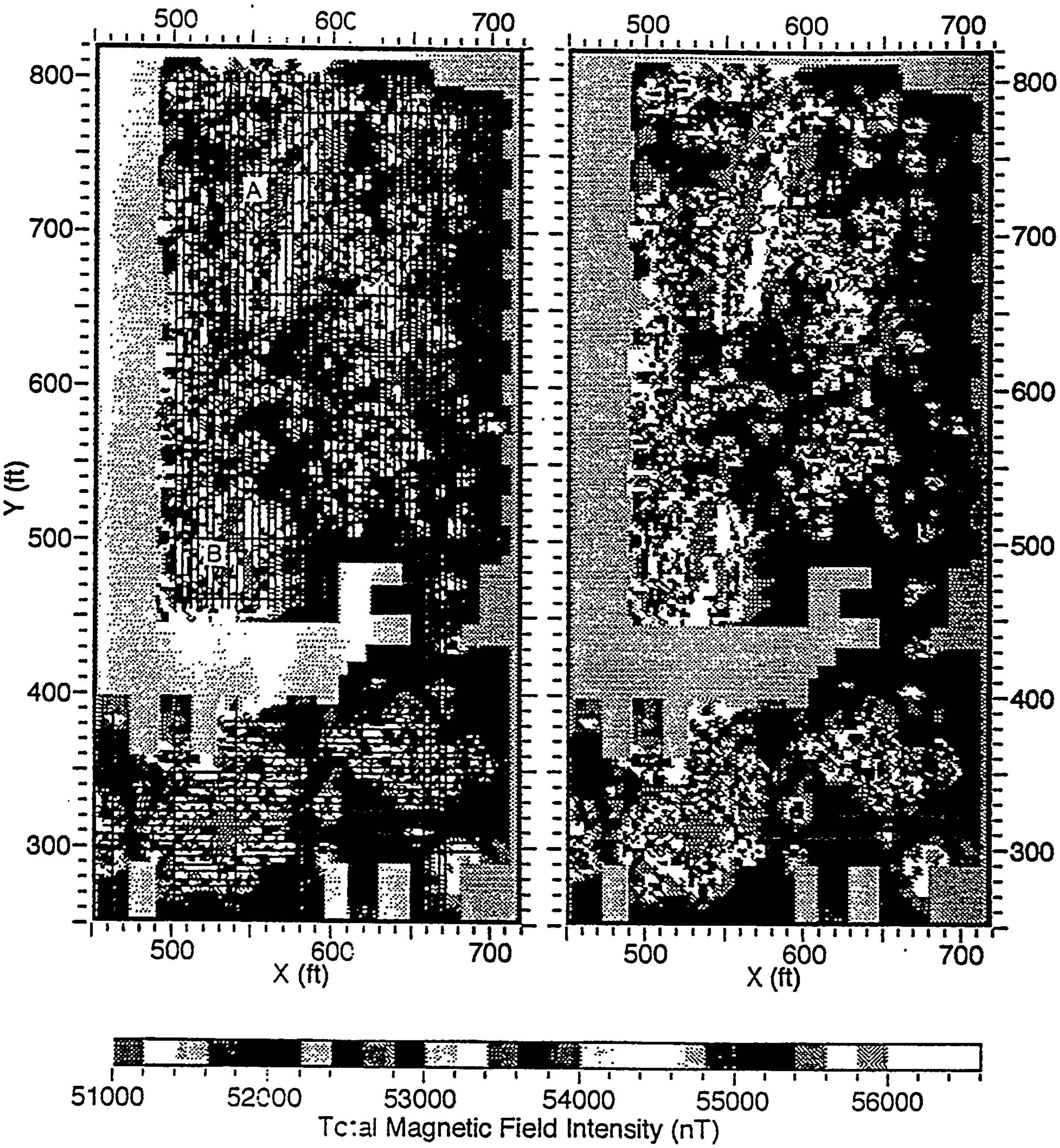


FIGURE 12 Total Magnetic Field Anomaly Map inside the Southeast Dump Site Survey Boundary

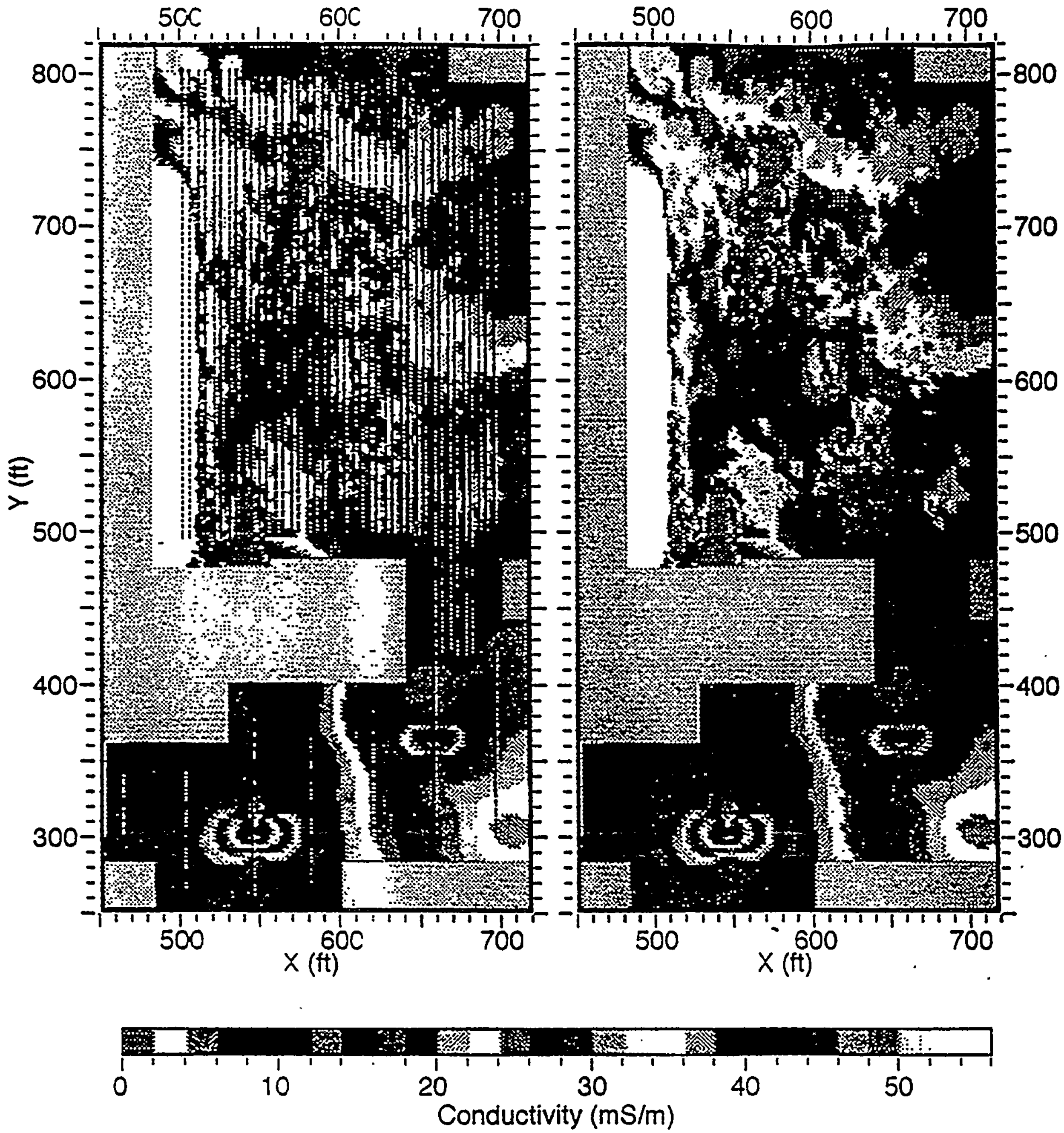


FIGURE 13 EM-31 Transects Parallel to the Y-Axis inside the Southeast Dump Site Survey Boundary

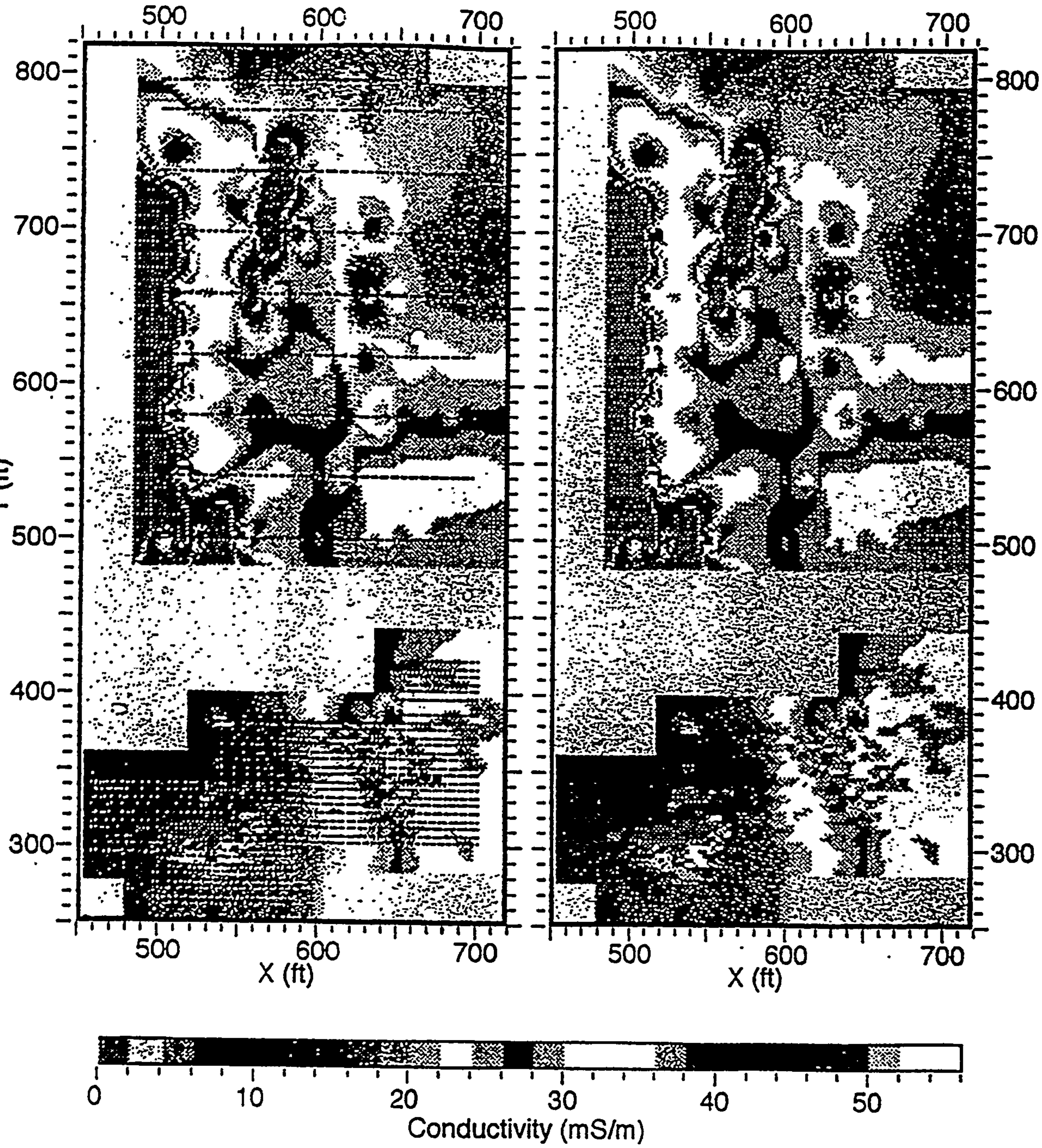


FIGURE 14 EM-31 Transects Parallel to the X-Axis inside the Southeast Dump Site Survey Boundary

anomalies, such as those centered at (650, 365) and (630, 660) coincide with observed surface metallic debris and with magnetic anomalies.

The two well-defined, linear conductivity anomalies labeled A and B on both Figures 13 and 14 are coincident to the magnetic anomalies with the same labels in Figure 12. As noted in the previous section for the magnetic anomalies, the conductivity anomalies are not associated with any significant accumulations of surface debris, but are attributed to buried metallic objects.

4.3 Induced EMF Measurements

The time-domain electrical-induction measurements using the lower-coil data from the EM-61 conductivity meter are shown in Figure 15. Difference measurements between lower and upper coils are shown in Figure 16. Strong EMF anomalies in Figure 15 and EMF difference anomalies in Figure 16 correlate both with prominent magnetic and conductivity anomalies discussed in the previous two sections (Figures 12-15). The background data in Figure 16 are relatively less sensitive to scattered surface debris, thereby allowing the relatively large anomalies to be observed more readily. Otherwise, the anomalies observed in both figures are similar and in the same locations. Once again, the strong linear trend along Y=500 (in both Figures 15 and 16) is caused by steel within the cement slab. The EMF anomaly centered at (530, 310) coincides with the previously described mound of metallic debris. The anomaly centered at (650, 365) coincides with observed surface metallic debris and with both magnetic and conductivity anomalies. The north-to-south trend of small anomalies along X=670 are caused by fence posts.

The two well-defined, linear EMF anomalies labeled A and B on both Figures 15 and 16 are coincident to the magnetic and conductivity anomalies with the same labels in Figure 12-15. As noted in the sections for magnetic and conductivity anomalies, the EMF anomalies are not associated with any significant accumulations of surface debris, but are attributed to buried metallic objects.

A color-contour map constructed from EM-61 lower coil data, which responds to all signal from the surface to approximately nine feet, is shown in Figure 15. EM-61 highs correspond with EM-31 and magnetic highs descried previously. Figure 16 shows the EM-61 vertical gradient (which essentially filters out the response from surface debris). Again, the EM-61 vertical gradient map corresponds very closely with the EM-31 and magnetic maps with respect to the suspected trenches.

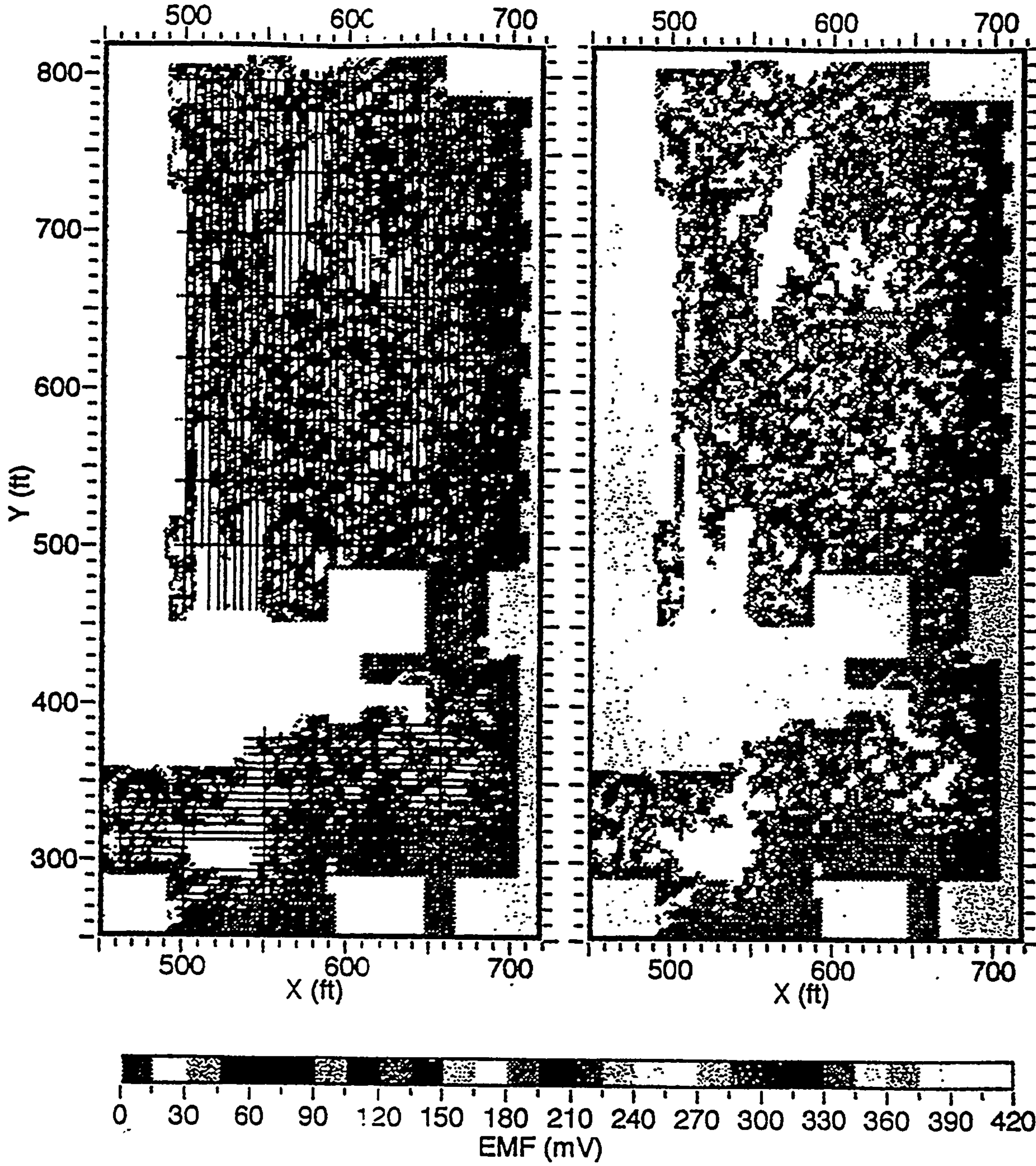


FIGURE 15 EM-61 Millivolt Anomaly Map inside the Southeast Dump Site Survey Boundary

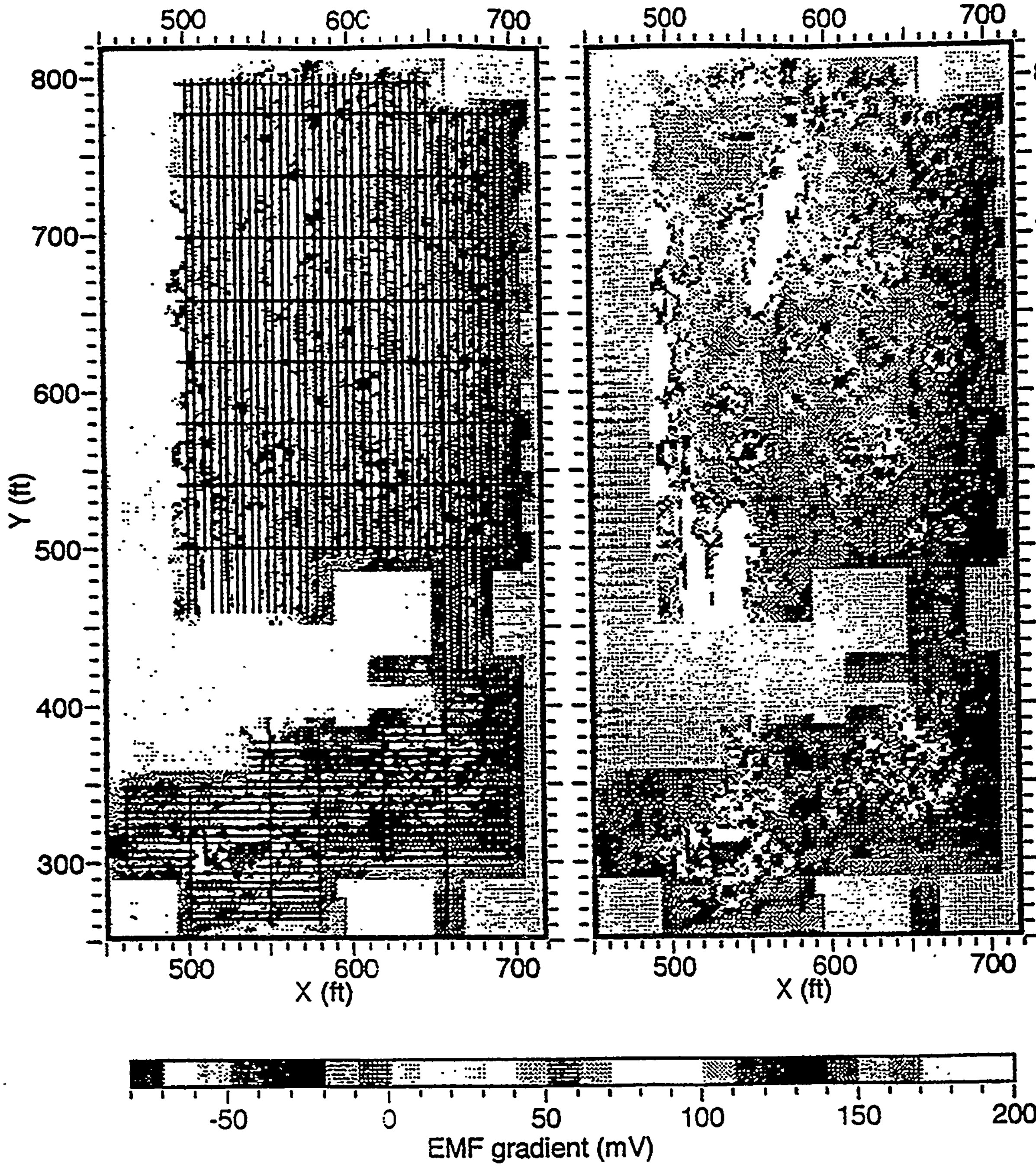


FIGURE 16 EM-61 Vertical Gradient Map inside the Southeast Dump Site Survey Boundary

4.4 Ground-Penetrating Radar Measurements

Coordinates of GPR lines are shown in Attachment B. The lines are numbered in sequence along with the beginning and ending positions relative to the survey grid. Based on earlier experience in the area, the 300-MHz antenna was selected for use at the site. Range settings of 100-150 ns were used for the entire survey at a scan rate of 32 scans per second. Rough terrain caused considerable bouncing of the antenna resulting in many noisy, low-quality GPR profiles. High clay content in near-surface materials and wet conditions limited radar penetration to a maximum depth of approximately 4 feet, with penetration limited to 2 feet over much of the area. Penetration to depths of 10 feet were attained at the Building E-6891 site in December 1994 when soils were much drier.

GPR data did not correspond well with magnetic or resistivity data at the two principal anomalies discussed above. GPR transects perpendicular to the anomalies showed very subtle or no changes in electrical properties, however, transects parallel to the long axes of the anomalies displayed chaotic reflection zones characteristic of disturbed soils (Figures 17 and 18). Hyperbolas were not evident in the radar data suggesting that the buried objects responsible for the EM and magnetic anomalies are probably an accumulation of small metallic objects such as shell casings. The reason for the inconsistencies between radar transects at different orientations across the EM/magnetic anomalies is unknown.

4.5 Discussion

A strong correlation exists between terrain conductivity, EMF and magnetic observations. EM-31, EM-61 and magnetic highs suggest the presence of buried metallic materials in two trenches that are roughly parallel to the concrete slab. Trench A is approximately 20-30 feet wide and 110 feet long and is located approximately 60-80 feet from the concrete slab. Trench B is 20-30 feet wide and extends into an area where data could not be collected due to dense phragmites. Small point anomalies observed are probably associated with metallic surface and near-surface debris which is widespread across the site (see Figure 3). The large, roughly circular anomaly near the southwest corner of the grid is associated with a large mound of metallic debris approximately 10-12 feet high. The irregular cluster of anomalies near the southeast corner of the grid is associated with some large steel beams and other surface debris in that area. Geophysical data does not indicate the presence of conductive contaminant plumes in the groundwater beneath the site. GPR did not work well at the site due to rough terrain and high clay content in near-surface materials.

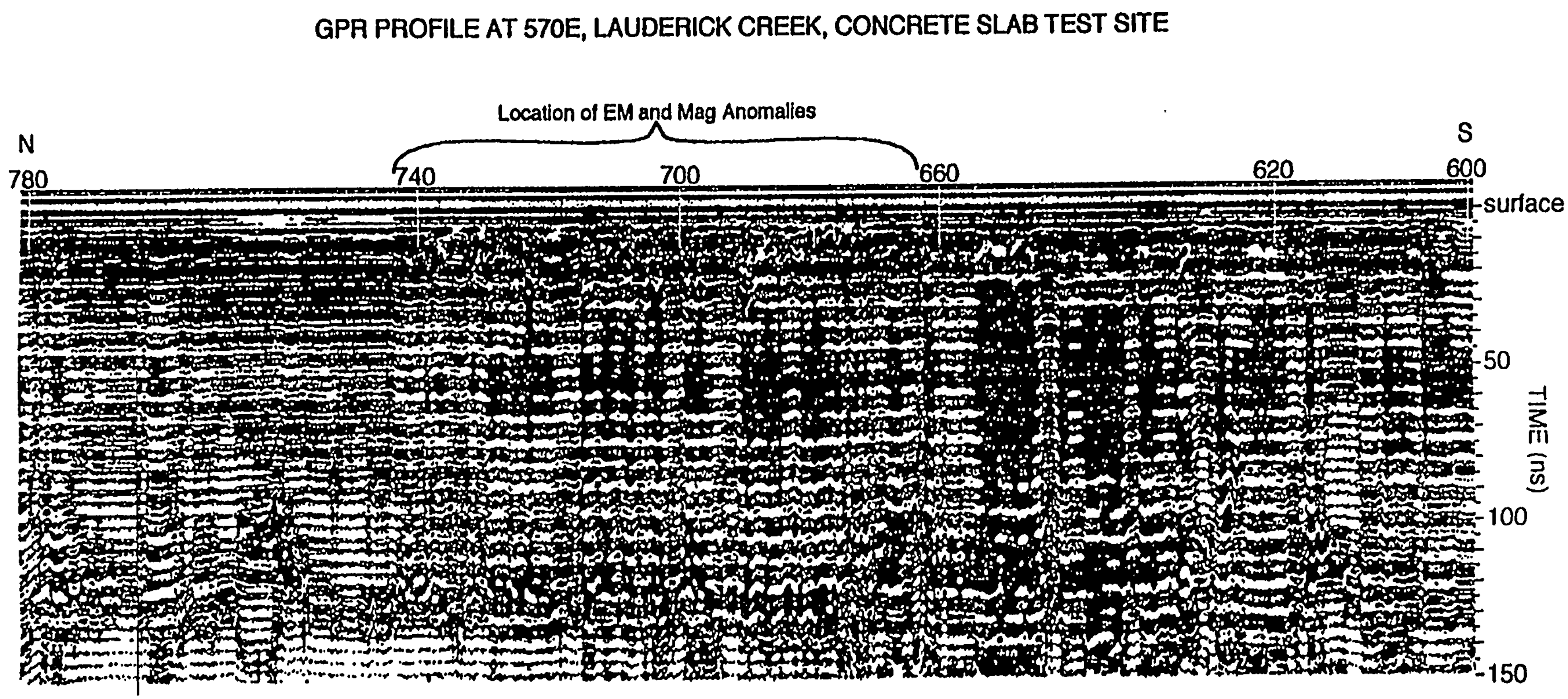


FIGURE 17 Ground Radar Image Along the Long Axis of the Anomaly Located in the Northern Section of the Southeast Dump Site Survey Grid (The maximum penetration depth is estimated at 3 feet.)

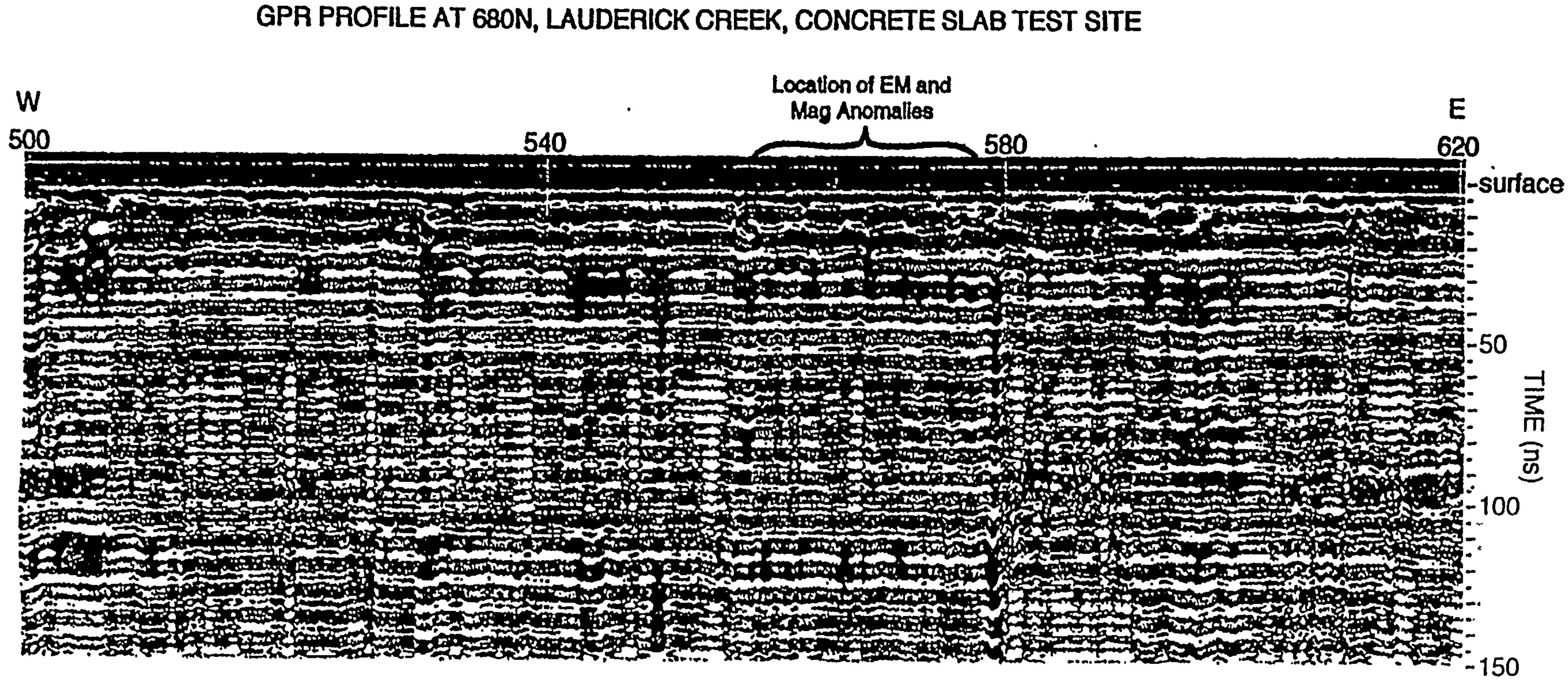


FIGURE 18 Ground Radar Image Perpendicular to the Anomaly Located in the Northern Section of the Southeast Dump Site Survey Grid (The maximum penetration depth is estimated at 2 feet.)

5 Conclusions

5.1 Building E6891 Site

Site geophysical surveys consisting of total field magnetics, EM-31 conductivity, EM-61 millivolt, and ground-penetrating radar around building E6891 permit the following conclusions:

1. Large diameter magnetic, EMF, conductivity and GPR anomalies are centered on (120, 135). In addition, EMF and magnetic point anomalies extend along X=125 to Y=120. Buried metals are a probable source for these anomalies.

2. Magnetic, EMF and GPR anomalies are observed in the area surrounding (200,135), northeast of the gravel road. Uneven terrain was noted by ANL personnel, suggesting that anomalies are caused by waste metals.

3. A linear conductivity low is observed along Y=115, between X=100 to X=130. Point magnetic and EMF anomalies are also observed within the conductivity low. Anomalies here are complex and discrete point metal sources result in different signatures for different instruments.

4. Isolated hyperbolic GPR anomalies are observed along Y=103 between X=100 and X=130 which may be sourced by a clay or plastic pipe.

5. Geophysical anomalies are associated with building debris. Geophysical anomalies between X=150-180 and Y> 105 are more distant and have a different, but unknown, source.

6. An northeasterly trending magnetic anomaly is observed west of the firing wall, within the additional geophysical survey. At least nine data points within the EM-31 survey also detected this feature. The limits of this anomaly is unknown, although it is at least 55 ft x 10 ft. Since the area was not surveyed by EM-61 or GPR, a conclusive interpretation can not be made as to its source. However, buried metal associated with a pipe or a trench, is a likely cause for this anomaly.

5.2 Southeast Dump Site

Site geophysical surveys consisting of total field magnetics, EM-31 conductivity, EM-61 millivolt, and ground-penetrating radar around the Southeast Dump Site permit the following conclusions:

1. EM and magnetic data clearly identified two buried trenches running parallel to the concrete slab. GPR was not useful for further characterization of these anomalies.

2. The EM-61 vertical gradient data indicates that with the exception the two large linear anomalies, most of the anomalies observed are associated with surface debris or materials buried just below the surface.

3. The more southerly of the two trenches probably extends to the south into an area where data could not be collected. This anomalie is not apparent south of the "no data" area. The anomaly south of the no data area is associated with a mound of surface debris, and does not appear to be connected with the trench anomaly. To fully characterize the extent of the trench anomaly would require clearing of the area followed by additional geophysical surveys.

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Attachment A:

Ground-Penetrating Radar Line Coordinates: Building E6891 Site

Attachment A: Ground-Penetrating Radar Line Coordinates: Building E6891 Site

Line #	Start Coordinates		End Coordinates	
	North	East	North	East
1	105	80	105	40
2	100	90	100	40
3	90	110	90	50
4	85	110	52	85
5	100	100	40	100
6	90	110	55	110
7	15	90	15	10
8	10	70	10	10
9	0	30	88	30
10	0	20	85	20
11	0	10	85	10
12	92	12	146	112
13	102	5	163	111
14	128	0	190	110

Attachment B:

Ground-Penetrating Radar Line Coordinates: Southeast Dump Site

Attachment B: Ground-Penetrating Radar Line Coordinates: Southeast Dump Site

	Start Coordinates		End Coordinates	
Line No.	North	East	North	East
1	300	700	300	550
2	300	550	300	700
3	310	700	310	560
4	320	565	320	700
5	330	700	330	630
6	330	625	330	460
7	320	460	320	560
8	290	580	290	500
9	280	500	280	580
10	270	580	270	500
11	260	500	260	580
12	260	580	380	580
13	380	620	300	620
14	300	660	350	660
15	370	660	460	660
16	410	700	300	700
17	500	500	800	500
18	800	510	540	510
19	540	510	500	510
20	500	520	800	520
21	800	530	500	530
22	800	540	500	540
23	500	550	560	550
24	540	550	800	550
25	500	560	800	560
26	800	570	600	570
27	580	570	500	570
28	500	580	600	580
29	610	580	800	580
30	800	590	500	590
31	500	600	660	600
32	680	600	800	600
33	800	610	680	610
34	660	610	540	610
35	530	610	500	610
36	500	620	660	620
37	675	620	780	620
38	800	630	710	630
39	660	630	500	630
40	500	640	590	640

	Start Coordinates		End Coordinates	
Line No.	North	East	North	East
41	620	640	800	640
42	800	650	685	650
43	780	660	700	660
44	660	660	500	660
45	500	670	520	670
46	525	670	565	670
47	580	670	660	670
48	700	670	780	670
49	780	680	690	680
50	680	680	620	680
51	620	690	780	690
52	780	700	630	700
53	780	700	780	500
54	800	500	800	650
55	740	500	740	700
56	700	700	700	500
57	680	500	680	620
58	660	500	660	620
59	640	620	640	500
60	620	500	620	690
61	580	620	580	500
62	540	500	540	700
63	500	700	500	620
64	500	620	500	500
65	480	520	480	580
66	440	580	440	520
67	460	640	460	660
68	420	700	420	660
69	410	700	410	670
70	400	700	400	660
71	380	620	380	700
72	360	700	360	625
73	350	630	350	700
74	340	700	340	460
75	340	460	300	460
76	260	500	340	500
78	320	565	320	460
79	300	460	300	500
80	360	540	360	580
81	380	580	380	540

Appendix B:

Air Quality Monitoring Report

The air sample analyses indicate that Building E6891 is not a source of volatile organic compound contamination.

End Date
4-12-96

Air Quality Monitoring Report

Air samples were collected and analyzed on-site at APG by ANL during the week of November 14, 1994. Samples were collected by drawing ambient air through a Tenax TA sorbent polymer sampling cartridge (4 mm I.D. × 11.5 cm) traps at the rate of 200 mL for 120 minutes, yielding a 24-L sample volume. The cartridges were analyzed by thermally desorbing the trapped organic compounds with a Dynatherm model 900 ACEM thermal desorption unit on to a Hewlett-Packard 5890 series II gas chromatograph (GC) equipped with a Hewlett-Packard 5972 mass spectrometer (MS).

The MS was used for detecting and identifying organic compounds desorbed from the Tenax traps. Spectra were obtained by scanning from 45 to 400 atomic mass units at a rate of two scans every second. Identifications were based on mass spectral interpretation and a computer search of the 140,000 compound Wiley spectral library. A standard mixture of volatile organics containing toluene at 200 ng L^{-1} and other aromatic hydrocarbons was run daily to assure that the instrument was operating properly. All quantitations are estimates, using the assumption that analyte response factors should be similar to toluene in the standard mixture of volatile organics.

The majority of the volatile organic compounds found during the ANL air monitoring are commonly found in any building (hydrocarbons and chlorinated solvents). Table 1 lists the major components found in the air samples taken in and around Building E6891.

TABLE 1 Major Components Found in Air Samples

Compound	Building E6891 (ng L^{-1})	Upwind (ng L^{-1})	Downwind (ng L^{-1})
Benzene	0.12	0.10	0.12
Toluene	0.16	0.11	0.14
Hexanal	ND†	ND	ND
Tetrachloroethene	0.01	ND	ND
Ethyl Benzene	0.03	0.02	0.03
Xylenes	0.09	0.06	0.10
Alpha Pinene	0.04	0.03	0.03
Benzaldehyde	0.21	0.25	0.26
Phenol	0.04	0.06	0.06
Beta Pinene	ND	ND	ND
Methyl Phenyl Ketone	0.11	0.17	0.20

† Not Determined