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Interim Progress Report — Geophysics: Building E5476 Decommissioning, Aberdeen Proving Ground

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Preface

This report is one of a series on geophysical surveys around perimeters of buildings in the Canal Creek and Westwood areas of the Edgewood section of Aberdeen Proving Ground. The series was initiated in 1991 at Building E5032, where geophysical techniques were tested and a design for the surveys was established. The series continued in 1992, when surveys of Buildings E5190, E5282, E5375, E5440, E5476, E5481, E5485, E5487, E5489, E5974, and E5978 were completed. The surveys and reports were done sequentially, with lowest building numbers being completed first. For this reason, deeper insight into the magnetic, electrical, and radar imagery characteristics of the Canal Creek area was gained with progressively increasing building numbers. A survey at the Building 103 Dump, also completed during the spring of 1992, was not specifically designed to assist building decommissioning, but it is included in the series because it was conducted by our geophysics team using techniques and procedures identical to those for the building decommissioning surveys.

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Abstract

Building E5476 was one of ten potentially contaminated sites in the Canal Creek and Westwood areas of the Edgewood section of Aberdeen Proving Ground examined by a geophysical team from Argonne National Laboratory in April and May of 1992. Noninvasive geophysical surveys, including magnetics, electrical resistivity, and ground-penetrating radar, were conducted around the perimeter of the building to guide a sampling program prior to decommissioning and dismantling. The large number of magnetic sources surrounding the building are believed to be contained in construction fill. The smaller anomalies, for the most part, were not imaged with ground radar or by electrical profiling. Large magnetic anomalies near the southwest corner of the building are due to aboveground standpipes and steel-reinforced concrete. Two high-resistivity areas, one projecting northeast from the building and another south of the original structure, may indicate the presence of organic pore fluids in the subsurface. A conductive lineament protruding from the south wall that is enclosed by the southern, high-resistivity feature is not associated with an equivalent magnetic anomaly. Magnetic and electrical anomalies south of the old landfill boundary are probably not associated with the building. The boundary is marked by a band of magnetic anomalies and a conductive zone trending northwest to southeast. The cause of high resistivities in a semicircular area in the southwest corner, within the landfill area, is unexplained.

1 Introduction

Aberdeen Proving Ground (APG), in the state of Maryland, is currently managing a comprehensive Installation Restoration Program involving more than 360 solid-waste managing units contained within 13 study areas. The Edgewood section and two landfills in the Aberdeen area appear 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.

The West Branch of the Canal Creek area (Figure 1), located within the Edgewood section, is one of the areas that requires a Source Definition Study because there is an ongoing release of volatile organic compounds into the creek. A report prepared by EAI Corporation (1989) included a list of 29 potentially contaminated buildings in the Edgewood section. 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. Thirteen of the potentially contaminated buildings, including Building E5476 (Figure 2), located 200 ft south of the west end of Williams Road, are in the West Branch of the Canal Creek area and are potential sources of volatile organic compounds. Operations have ceased and the buildings have been abandoned, but processing equipment, sumps, drains, ventilation systems, and underground storage tanks remain. These appurtenances may contain liquid, solid, or vapor contaminants of unknown nature.

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 of the West Branch of the Canal Creek and other sites within the Edgewood area. Argonne National Laboratory 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 (see Figure 3 for the boundaries of the study area for Building E5476).

1.1 History of Building E5476

According to records examined by EAI Corporation (1989), Building E5476 was constructed in 1918. The main two-story building measures 40 × 41 ft and has four wings, which measure 22 × 32 ft, 15 × 27 ft, 15 × 24 ft, and 32 × 44 ft. The walls, constructed of corrugated transite, wood, and 8-in. hollow tile, rest on a concrete floor and foundation. The roof is made from corrugated transite.

Beginning in 1920 and continuing until 1977, the building was used for manufacturing a variety of agents. Experimental work began with the manufacture of diphenylamine chlorarsine. Arsenic trichloride was produced from 1921 to 1922, and mustard gas was produced from 1925 until 1940. At that time, the building was assigned to the research and development community to house a lewisite pilot plant. From 1943 until 1945, the plant was used as a distilled mustard (HD) pilot plant. In the early 1950s, the building housed an office to support a desludging and cleaning operation and an area for loading radiological simulant munitions. From the early 1960s through the mid-1970s, part of the building was converted to an experimental munitions loading facility for chloroacetophenone (CN), o-chlorobenzylidene malonitrile (CS), and 10-chloro-5,10-dihydrophenarazine (DM).

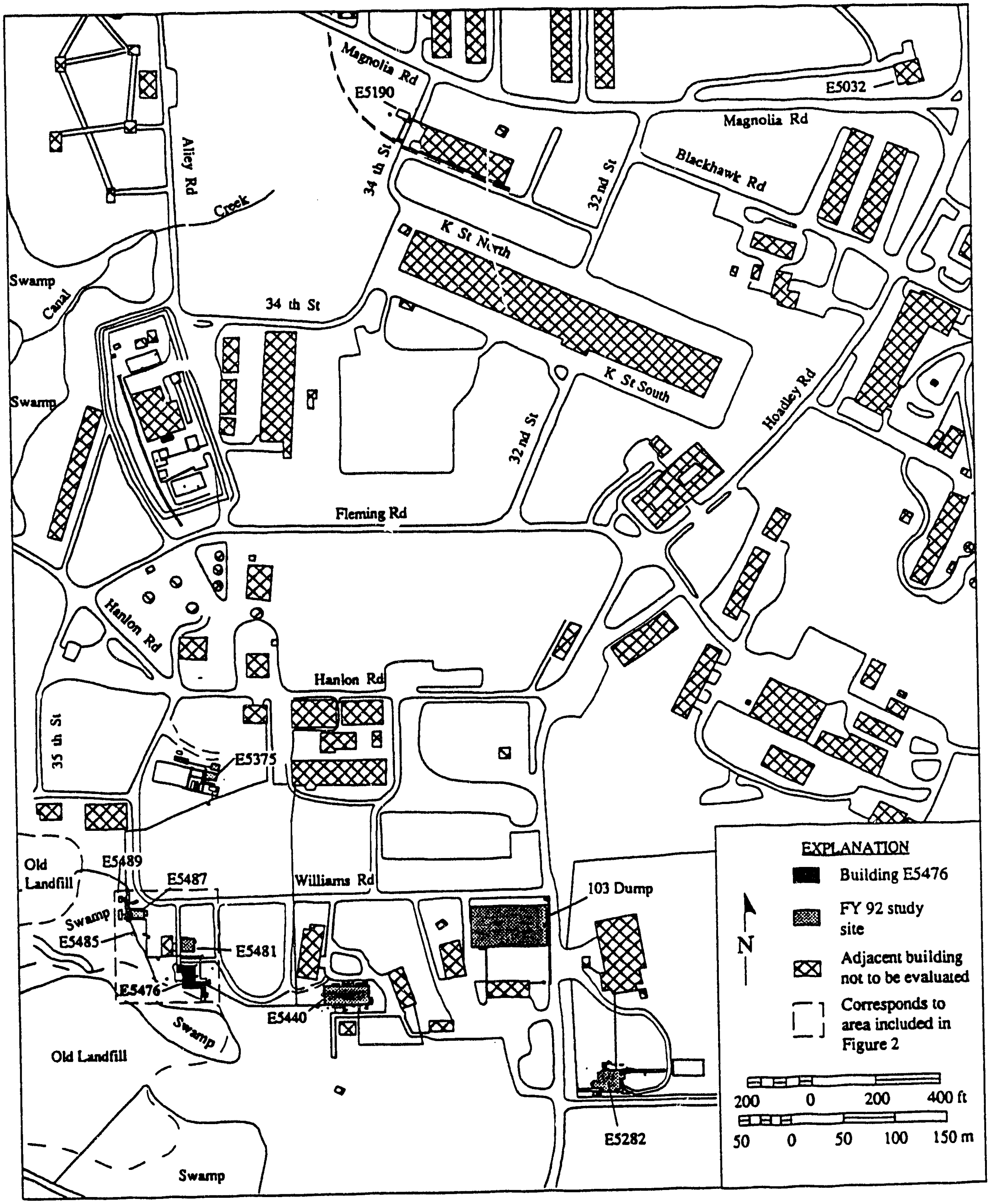

FIGURE 1 General Site Map of the Canal Creek Area, Aberdeen Proving Ground, Md.

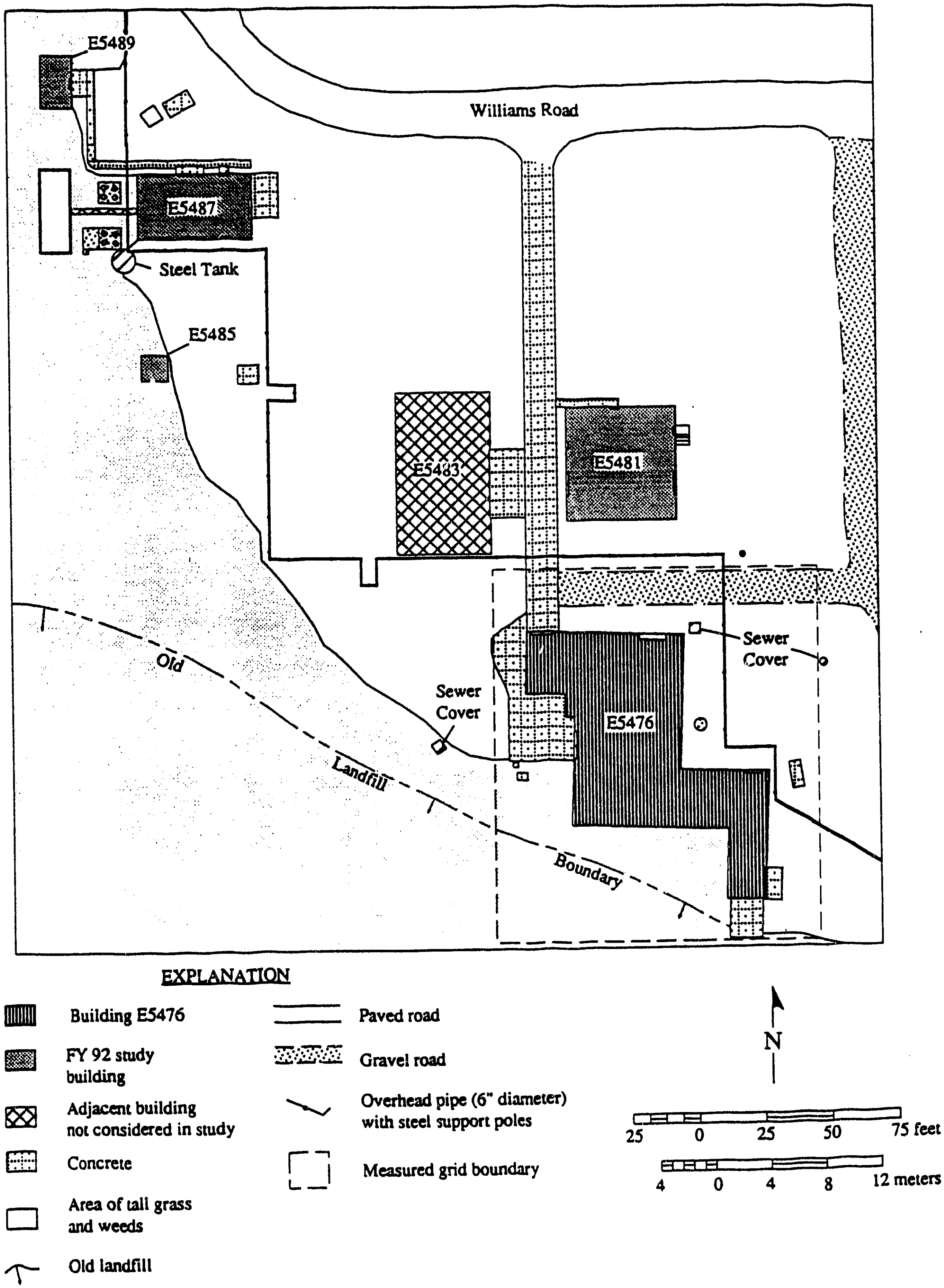

FIGURE 2 General Location Map of Building E5476

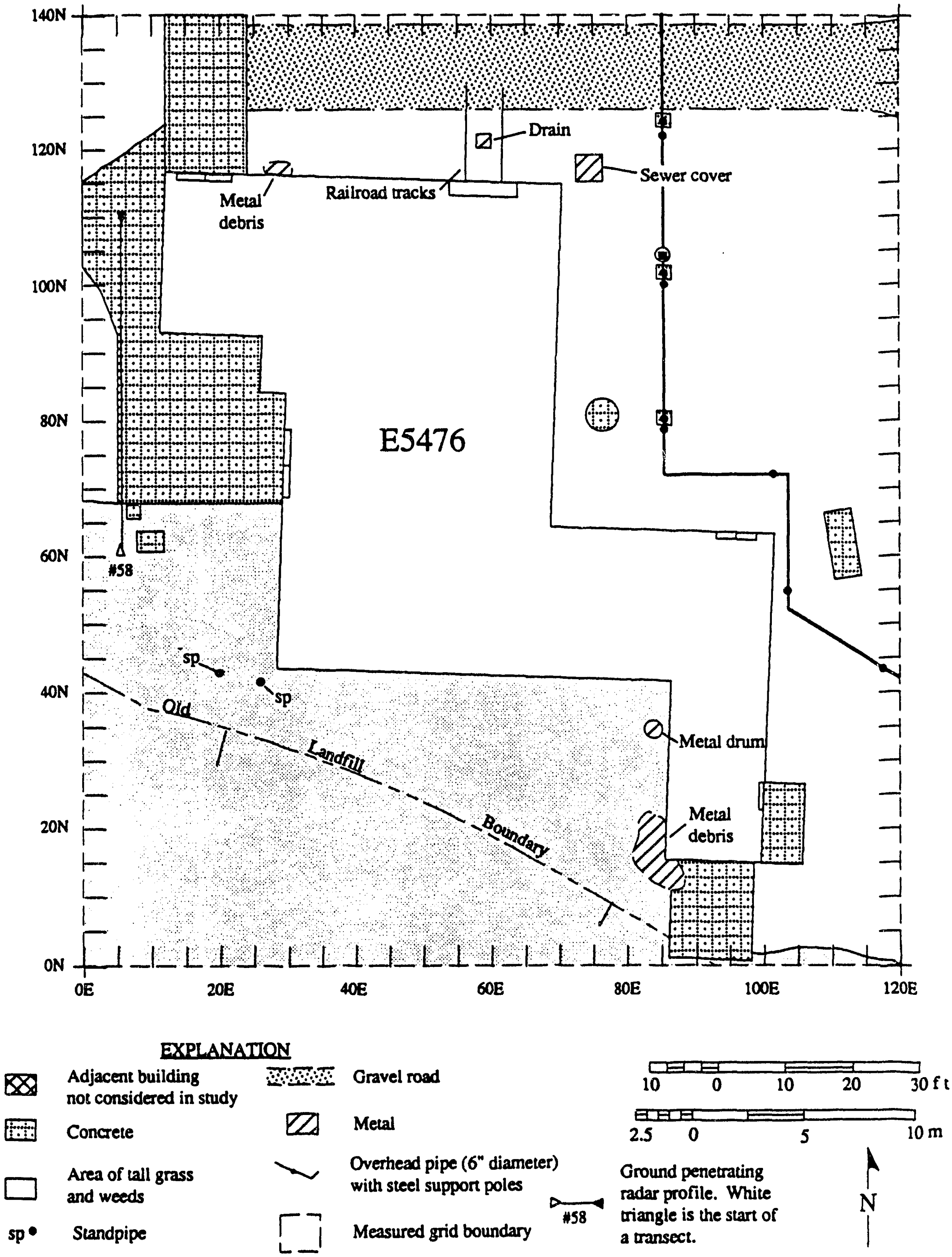

FIGURE 3 Geophysical Survey Boundaries for Building E5476

No operations have taken place in the building since 1977. According to the EAI Corporation report (1989), decontamination of the building was claimed in 1977, but agent monitoring and decontamination procedures, radiological monitoring, and cleanup procedures defining those operations were not found.

1.2 Site Reconnaissance

The geophysical survey program for Building E5476 was designed on the basis of results from a similar study completed between April 8 and April 19, 1991, for Building E5032 (McGinnis and Miller 1991), which is also located in the Canal Creek area (Figure 1). The initial evaluation was enhanced by a visit to the site in November 1991 and by inspection of aerial photos. The building is located on level terrain on the northern edge of a former wetland and landfill. The grounds to the north are well-maintained, providing good access. Tall grass is allowed to grow to the south.

In addition to surface conditions at the site, subsurface characteristics were considered in planning the geophysical surveying:

1. Surficial sediments consist of estuarine silts, sands, and clays that have intermediate resistivities and are nonmagnetic. The underlying soil properties are expected to vary both horizontally and vertically in the proximity of the site, depending on naturally occurring conditions and on the presence of building excavations and operations.

2. Buildings and other attributes of the Edgewood section of Aberdeen, such as radio and radar transmissions, will contribute to interference of magnetic and electrical fields and will cause electromagnetic surveying (an easily applied, low-cost method that is frequently used to identify buried conductive objects) to be generally inapplicable (AEHA 1989).

3. Multiple sources, such as iron-rich magnetized objects, nonmagnetic objects, subsurface channels containing contaminants, and plumes of contaminants of variable resistivity, may be present in the subsurface.

Multiple working technologies were utilized in the program design to mitigate interference and to either directly detect or provide inferential data on subsurface characteristics.

1.3 Geology and Physiographic Setting

The site is contained in the topographically low and flat terrain of the Coastal Plain physiographic province. The Canal Creek area is underlain by alluvial and estuarine sands, silts, and clays. A thin veneer of sediments of the Talbot Formation of Pleistocene age overlies unconsolidated sediments of the Potomac Group of Cretaceous age (Oliveros and Gernhardt 1989). The water table is less than 10 ft from the surface, and groundwater contains measurable concentrations of contaminants (USGS 1992).

Lithologies at the site were determined from the sample study of a borehole (site No. 25) drilled approximately 50 ft southeast of Building E5476. The descriptive log given in Table 1 was part of a hydrogeologic study of the Canal Creek area performed by the U.S. Geological Survey (Oliveros and Gernhardt 1989). Facies represented include soils and a clayey fill material, followed by thin beds of varying stratigraphy consisting primarily of sands to a depth of 29 ft. The single unit of greatest thickness (10 ft) was a tan sand at a depth of 19.0–29.0 ft. This sand is part of the Canal Creek Aquifer (USGS 1992).

Building E5476 is located near the south end of the area of study and is adjacent to other buildings not included in the survey. Initial construction probably involved considerable amounts of excavation and use of fill material, so that most of the shallow sediment at the site is reworked.

1.4 Surveys

The geophysical phase of the building decommissioning program at Building E5476 was carried out as planned during the period April 6 to May 8, 1992. Geophysical measurements

TABLE 1 Lithologic Log of Borehole at Site No. 25

Description	Depth (ft)	Thickness (ft)
Soil zone, brown	0.6	0.6
Fill material, brown to gray; with clay, sand and gravel	4.0	3.4
Silt, clayey, orange-brown and gray mottled	11.5	7.5
Sand, clayey, light gray and orange mottled, [mL];[a] with red-black concretions	14.0	2.5
Sand, white to gray and orange, clean, well-sorted [mL-mU]; with red-black concretions and thin clay lenses	17.3	3.3
Sand, clayey, light gray, [mU]; with small red-black concretions and some clay coatings on grains	19.0	1.7
Sand, tan, wet, clean, well-sorted [mU]; with small, white clay lenses, and sand turning gray near bottom	29.0	10.0

[a] Codes enclosed in brackets at selected horizons refer to color designations as specified in the Munsell Soil Color Charts (1975)

Source: Oliveros and Gernhardt (1989).

conformed to the work plan (McGinnis et al. 1992), which called for magnetics, horizontal direct-current electrical resistivity (DCER), and ground-penetrating radar (GPR) surveys. An addition to the plan was the use of a magnetic gradiometer/metal detector to ensure detection of anomalies between survey profiles and grid stations. Seismic imaging information was not required at the site. Each technique had its own specific objectives:

- Gradiometer/metal detector sweep — to provide a rapid, 100% sweep of the site;

- Magnetometer measurements — to determine the location of such buried, iron-rich objects as tanks, pipes, debris, etc.;

- Horizontal DCER survey — to establish the regional conductive nature of the subsurface and to identify contaminant plumes to depths of approximately 10 ft; and

- Ground-penetrating radar survey — to determine the geometry of, and to find the approximate depth to, buried objects.

The following data were acquired during field operations: (1) nonpermanent ground markings of magnetic objects, (2) 1,635 magnetic observations, (3) 491 horizontal DCER observations, and (4) 4,500 (linear) ft of GPR profile along 70 lines. Field operations required a total of four days for a four-person team. On-site personal computers (both notebook and desktop), interactive software, field equipment designed specifically for Aberdeen, and an all-terrain vehicle were used to expedite data acquisition and processing.

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 so that its sides were approximately parallel to the sides of the building. Grid spacing for all surveys was at 5-ft intervals, with the zero coordinate located at the southwest corner of the surveyed area. Positive numbers are measured north and east of the zero coordinate, whereas negative coordinates are measured south and west. The building is not perfectly aligned north-south and east-west.

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.

Maps or models are not constructed from observations made with the MAC-51B because it is not a calibrated system. The MAC-51B is an audio device used only for rapid detection of magnetic materials for further analysis with complementary instrumentation. Anomalies are identified by changes in sound amplitude and frequency and are marked on the ground surface prior to the initiation of other surveys. If anomalies detected with the MAC-51B cannot be verified with the magnetometer (see Section 2.2), the anomaly is assumed to be insignificant.

Application of the MAC-51B in its receiver mode was the first geophysical operation following establishment of survey limits. A qualitative description of the site with 100% ground coverage is achieved 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 Magnetometer/Gradiometer

Magnetics is the best technique for identifying such buried magnetized objects as tanks, drums, and small iron-rich debris. The EDA OMNI IV magnetometer/gradiometer is a total-field, proton-precession, microprocessor-based instrument that can also measure magnetic gradients. Internal software permits down-loading directly into an on-site computer.

Total-field magnetic observations were made at 5-ft and smaller intervals along profiles, yielding a grid of data that was contoured using the SURFER V. 4.0 software by Golden, Inc. (1991), to identify potential sources of contaminants and to distinguish them from background. The SURFER software was incorporated into the field acquisition procedure, so that daily map outputs were available for observation and interpretation.

The earth's magnetic field is reasonably well-known at a given time and place, although small changes in the field occur continuously, with larger changes occurring during magnetic storms. To adjust for field changes, the instrument has internal calibration to correct observations made at cross lines and base stations. Repeat readings were used to correct data for diurnal field fluctuations.

2.3 Direct-Current Electrical Resistivity Meter

Data on the electrical properties of soils at APG may permit detection of abnormally conductive or nonconductive liquid or solid contaminants. Most of the electrical properties of sedimentary materials are a product of the chemistry of interstitial fluids. Consequently, resistivity data can be diagnostic and complement magnetic and radar measurements. Direct-current electrical resistivity measurements have been incorporated into the APG study to take the place of conductivity measurements using electromagnetic methods that are typically made for investigations of this type. Electromagnetic methods could not be used because of previously reported interference problems (AEHA 1989).

Resistivity equipment used on the Aberdeen project consisted of an ABEM Terrameter and Booster, model SAS 300C, that utilized a variety of electrode configurations. A modified, eight-electrode Wenner array was the configuration selected, and it was towed behind an all-terrain vehicle. Profiles were coincident with GPR and magnetic lines, and data were recorded at 5-ft intervals along the lines. Consistency of repeat observations over a test profile and over known electrical anomalies provided assurance of relative data quality and variations. Data were contoured using SURFER software as described in the magnetics section.

Electrical depth-sounding curves using a Schlumberger electrode array were also determined in the Canal Creek area to add a three-dimensional view to horizontal mapping. Each sounding curve was interpreted using the RESIX PLUS software package written by Interpex (1988). Resistivities of undisturbed soils were comparable with those observed at Building E5032, which averaged 60 Ω-m.* (See Appendix A for further information.)

2.4 Ground-Penetrating Radar System

Ground-penetrating radar surveying was accomplished using a Geophysical Survey Systems, Inc. (GSSI), model SIR-3 radar connected to a transceiver with a cable approximately 300 ft long. Data were recorded on a digital audio tape to permit playback and computer processing. The control unit/graphic recorder was located in the transport vehicle. An IBM-compatible processing computer was located in a field office, so that the radar operator could down-load, check data-tape quality, and do preliminary processing after a day's run. Radan I computer software written by GSSI was used for processing the GPR data.

Wave-velocity characteristics of materials to be found at the Aberdeen/Edgewood area were derived from known positions of buried objects. Internal calibration was run at least twice each day to ensure that the graphic record of the range setting was consistent. Studies conducted during

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* Resistivity data acquisition and processing were done using the metric system of measurement. To convert from meters to feet, multiply values given in meters by 3.28.

the 1991 field season suggest wave velocities of 6-7 × 10^{-9} s/ft for near-surface sediment at Aberdeen; however, characteristics vary with the heterogeneity of the subsurface. Typical wave velocities for different materials are shown in Table 2.

Ground-penetrating radar is probably 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. The maximum depth of penetration with GPR at Building E5476 was approximately 8 ft below the ground surface.

TABLE 2 Approximate Two-Way Travel Times for Various Materials

Material	Two-Way Travel Time (10^{-9} s/ft)	Material	Two-Way Travel Time (10^{-9} s/ft)
Air	2	Marshy forested land	7
Fresh water	18	Rich agricultural land	8
Sea water	18	Fresh-water ice	4
Sand (dry)	4.5	Granite (dry)	4.5
Sand (saturated)	11	Limestone (dry)	5
Silt (saturated)	6	Concrete	5
Clay (saturated)	6	Asphalt	4-5
Dry, sandy, coastal land	6		

Source: Geophysical Survey Systems, Inc. (1987).

3 Geophysical Measurements and Surveys

3.1 Magnetometer Measurements

Total magnetic field observations were made at 1,635 stations for use in construction of the magnetic map shown in Figure 4. Station spacing was normally 5 ft; however, where the presurvey gradiometer scan identified anomalous zones, stations were read at intervals as small as 1 ft. Magnetic maxima and minima were truncated to permit contouring at a smaller interval. This procedure results in a "white-out" effect in the interiors of high-amplitude anomalies and a blackening of anomaly edges where gradients are highest. This enhances the visual identification of anomaly boundaries, while it eliminates essentially meaningless detail near peaks and troughs.

Building E5476 rests in a field of intense magnetic sources. No location within the area surveyed could be considered free of magnetic disturbance. Larger anomalies had field intensities almost twice the earth's natural magnetic field strength. Because of the magnetic noise, many of the 50 to 60 small-diameter anomalies lost their individual identities and became more reflective of changes in overburden type. Areas where small anomalies were particularly abundant are defined by the gravel road on the north and the old landfill boundary on the south, although the entire area surrounding Building E5476 had this characteristic. The fact that the building was sited on the margins of a wetland suggests that a large amount of fill was required to raise the floor of the structure and access roads above grade. It is likely that an iron-rich construction fill was used to raise the grade.

In addition to ferrous construction fill, the old landfill also contained debris typical of other landfills. An unusual area in the southwestern section contained many small anomalous magnetic sources; this area was also electrically resistive, which is discussed further in Section 3.2. The magnetic detail was probably due to decreased station spacing and may be representative of a normal landfill magnetic field.

One anomaly complex west of the building, between 35N and 90N, was associated with two iron standpipes and steel-reinforced concrete. A second anomaly complex, centered near 80N,90E and trending north to south, was produced by overhead steel pipes and support poles. This latter anomaly is complicated and may mask anomalies having subsurface causes.

Two large anomalies were present to the south of the building. One, along the western wall of a building addition at 20N,85E, was due to surface debris, whereas a second, at 0N,70E, was probably due to landfill. About eight other sources south of the building were probably caused by landfill debris.

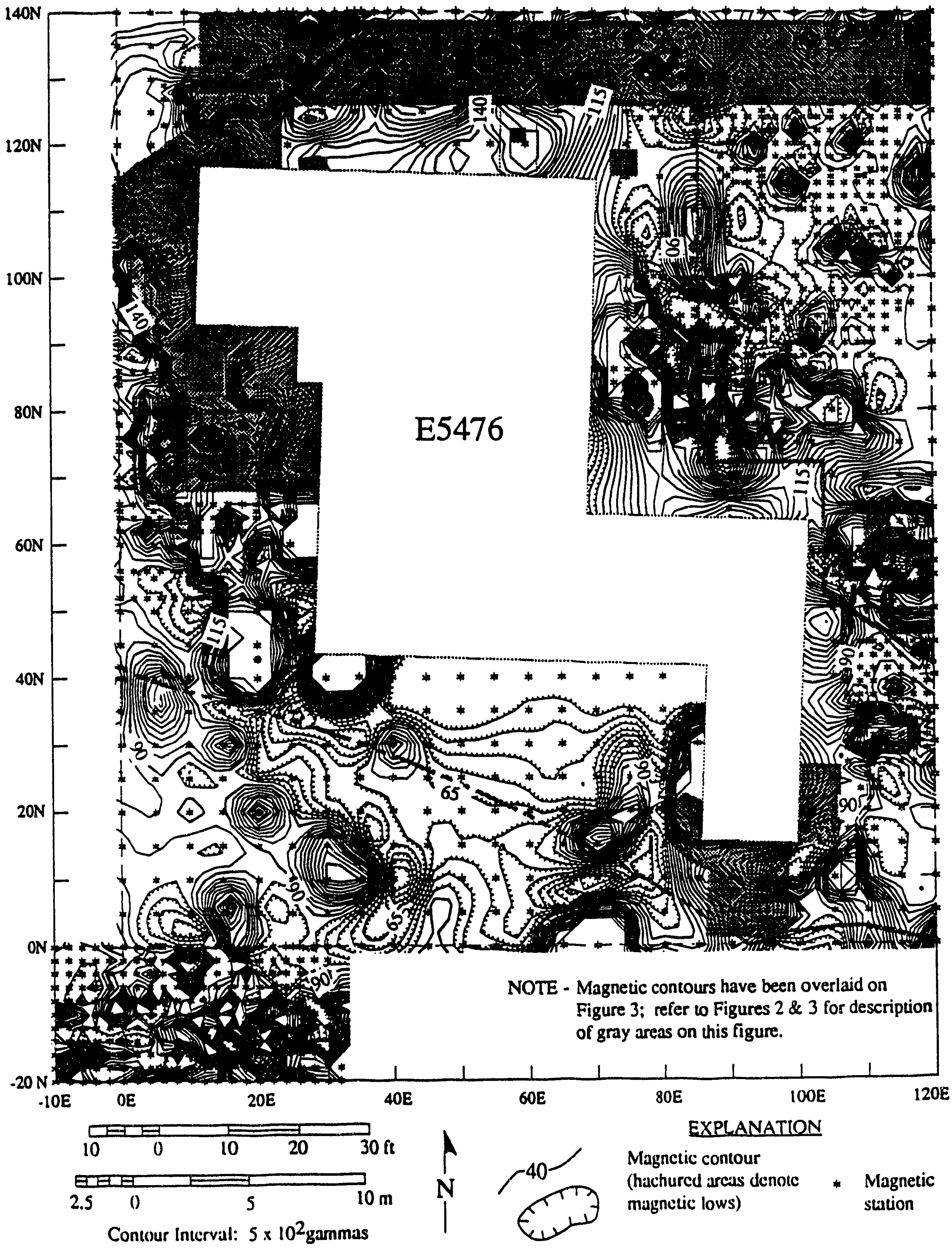

FIGURE 4 Map of Total Magnetic Field Intensity for Building E5476

3.2 Direct-Current Electrical Resistivity Measurements

The results from DCER observations made at 491 stations were used in constructing the apparent resistivity map shown in Figure 5. The electrode spacing was 2 m, a configuration that provides an average resistivity for materials lying between the surface and a depth of about 3 m. At Building E5476, these materials would include construction fill; a brown-to-gray clay, sand, and gravel; and most of the thickness of the Upper Confining Unit (Oliveros and Gernhardt 1989), which is a silty clay.

From previous work (McGinnis and Miller 1991), background resistivities for these fine-grained, organic-rich, clayey materials were found to range from 50 to 150 Ω-m. As a basis for comparison with minima observed in other areas, a value of 6 Ω-m was observed over the "bare spot," a suspected buried tank at Building E5032, and high resistivities of up to 180 Ω-m were observed in the vicinity of a suspected old railroad bed. Electrical depth-sounding curves collected for background in the Edgewood area indicate that resistivity values normally decrease with depth, probably due to increasing saturation and salinity. Where anomalous materials are present, this generalization is not valid.

An electrical depth-sounding curve measured at a station centered 400 ft north of Building E5476 is shown in Appendix A (see Figure A.3). The sounding station was located in an open, grass-covered field north of Williams Road. Inversion of this curve results in an interpreted model where the upper 4.1 m of earth has a surficial resistivity of 366 Ω-m. From 4.1 m to the maximum depth of exploration, the average resistivity value of undisturbed material is 105 Ω-m. This resistivity corresponds to a section consisting primarily of sand, as identified on the driller's log, and is representative of undisturbed, natural, saturated materials.

Resistivities determined from horizontal surveying are less affected by small-diameter, metallic debris associated with construction fill than the magnetics measurements. For this reason, conductive anomalies can be useful in identifying tanks, pipes, and metallic drains, particularly where the conductive anomalies are associated with larger magnetic anomalies. In addition, anomalies indicating the presence of highly resistive sources and having plume-shaped patterns suggest the possibility of a leachate, particularly where such anomalies extend outward from a building.

Conductive areas associated with Building E5476 include (1) a sinuous feature associated with the gravel road north of the building, (2) small anomalies in the northeast quadrant, (3) a north-south lineament in the southeast corner of the survey area, (4) a wraparound anomaly encompassing the entire southwest quadrant, and (5) a three-point conductive lineament centered at 30N,50E, immediately south of the building.

Anomalously resistive areas include (1) a zone extending outward from the northeast corner of the building, (2) a zone along the south border of the original building, and (3) an area in the southwest corner in the landfill.

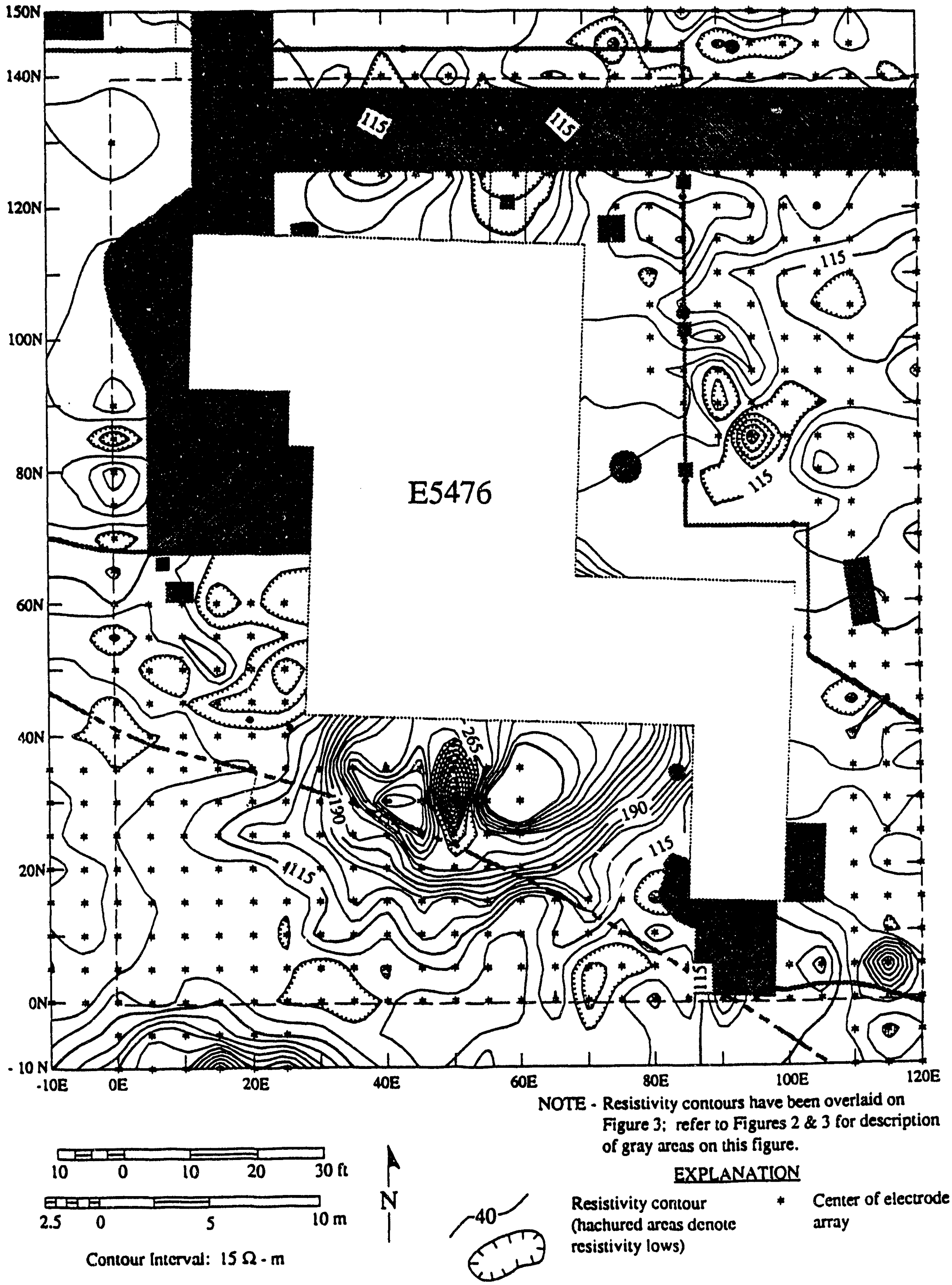

FIGURE 5 Apparent Resistivity Map of Building E5476

3.3 Ground-Penetrating Radar Measurements

Ground-penetrating radar measurements were made over 4,500 ft of traverse along 70 individual profiles. The lines are numbered in sequence and are listed in Appendix B, 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 80-, 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 90 ns was used for 56 profiles over the entire site. An additional 14 profiles were collected at a range setting of 50 ns to resurvey selected areas at a higher resolution with shallower depth of penetration. All profiles were collected at a rate of 16 scans per second. Good penetration was observed over most of the site, with resolution down to about 8 ft below the ground surface.

Without verification by another technique or by passing the antenna over a known buried object, 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.

GPR surveying is heavily dependent on the state of the ground surface. Because of the diverse surface conditions around the perimeter of Building E5476, the character of the radar signal changed rapidly and often. Although numerous point-source reflectors were observed along some of the profiles, particularly the east-west profiles on the north side of the building, the most common feature of the profiles was signal change due to change in surface conditions. Grassy terrain is generally accompanied by a chaotic radar image, whereas concrete and asphalt surfaces support a more coherent subsurface image. Passing the antenna over a steel cover results in a strongly ringing image.

The GPR data for the west side of the building show the strong reflectivity of the concrete slab. A portion of this slab appears to contain steel reinforcement, which is seen in Figure 6 as undulations in the strong reflector. The vertical scale is shown on the right side of the profile, whereas the horizontal scale is defined by broken, vertical marker lines at 10-ft intervals. This profile was collected at 50 ns to enhance this near-surface reflector, and as a result, the depth of penetration is less.

The GPR data over the area to the south of the building are very difficult to interpret due to the rough and undulating ground surface and the dense, tall grasses that covered the area. Consequently, the GPR data cannot assist in determining the northern boundary of the landfill. However, scattered debris does appear near the surface within a few feet of the south side of the building.

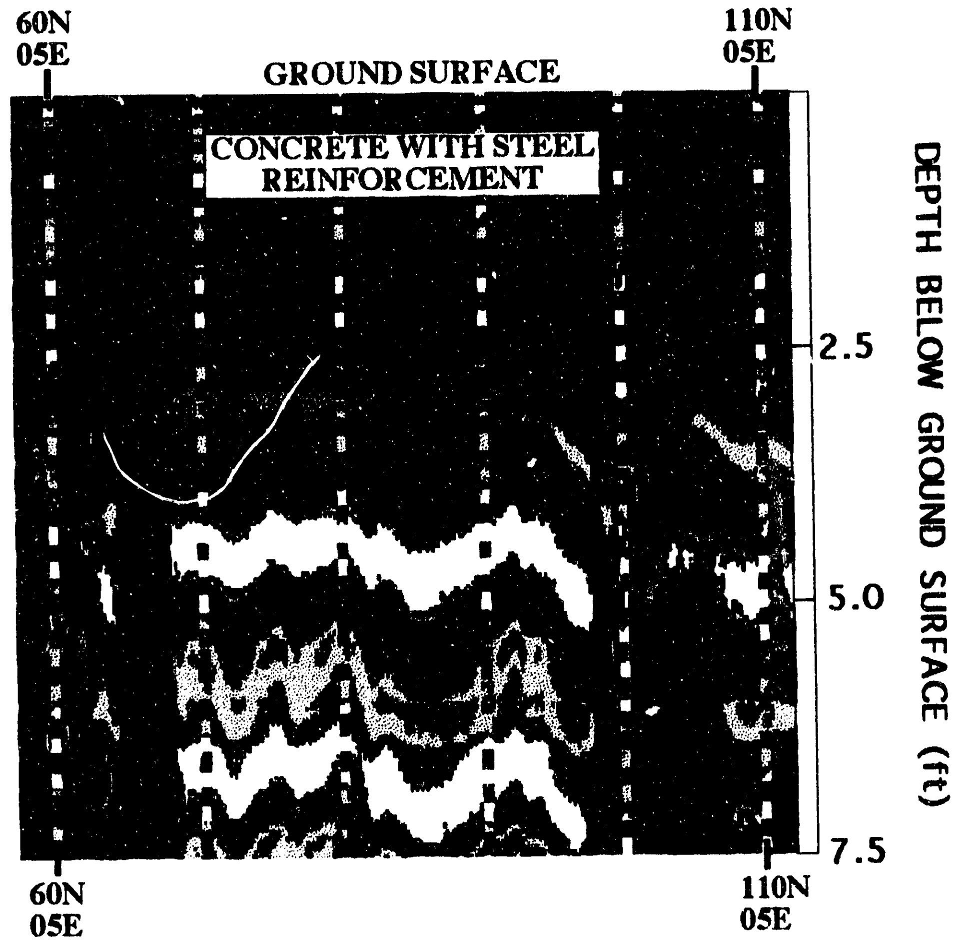

FIGURE 6 South-North Ground-Penetrating Radar Profile for the Area West of Building E5476 (The location of this profile is shown in Figure 3 as line No. 58.)

4 Discussion

A combined magnetics/resistivity map is shown in Figure 7. The north and east segments of the composite map are filled with complex and apparently random distributions of positive and negative magnetic anomalies. In many cases, conductive and magnetic zones are coincident; however, in the northeast quadrant, a broad area of low conductivity contains many magnetic sources. The low-conductivity zone trends northeast from the northeast corner of the building and is not associated with any known surface feature.

In the southeast corner, the situation is reversed; a north-south conductive lineament has no precisely equivalent magnetic signature, although a magnetic anomaly, approximately centered at 25N,110E, probably has the same source as a more intense resistivity anomaly located in the lineament. The lack of complete equivalency is partly due to the difference in sensing area during data acquisition. Magnetic field intensity varies as the inverse square of distance from the source to the magnetometer sensing head, whereas resistivity or conductivity is measured along a 6-m line between the ends of the exterior current electrodes.

In the south and west, two locations within a curved belt of high conductivity are both strongly conductive and magnetic. One is centered at 0N,70E, and the second is near the southwestern corner of the original building. Because the former is within the confines of the postulated landfill margin, it is believed to be caused by debris unassociated with the building. However, the latter, located west of the building, is most likely associated with two iron standpipes and steel-reinforced concrete. The steel reinforcement can be seen in several GPR profiles.

One resistivity anomaly complex with no magnetic counterpart is centered at 30N,50E. It consists of a conductive lineament aligned north-south and flanked on the east and west by highly resistive terrain. This unusual signature is significant because this complex borders the exterior wall of the original structure, and the anomaly may represent a conductive pipe surrounded by soils saturated with more resistive fluids. The electrical complex is of interest because it occurs in a magnetically quiet zone. Magnetic stations were read directly over the conductive anomaly, so if a conductive metal pipe is present, it does not contain ferrous material.

The high-resistivity zone in the southwest corner of the site is of interest because of its implications for characterization of the old landfill, rather than for its significance relative to Building E5476. The zone is filled with small magnetic sources, suggesting that the sources are separated by nonconductive soils, liquids, and debris.

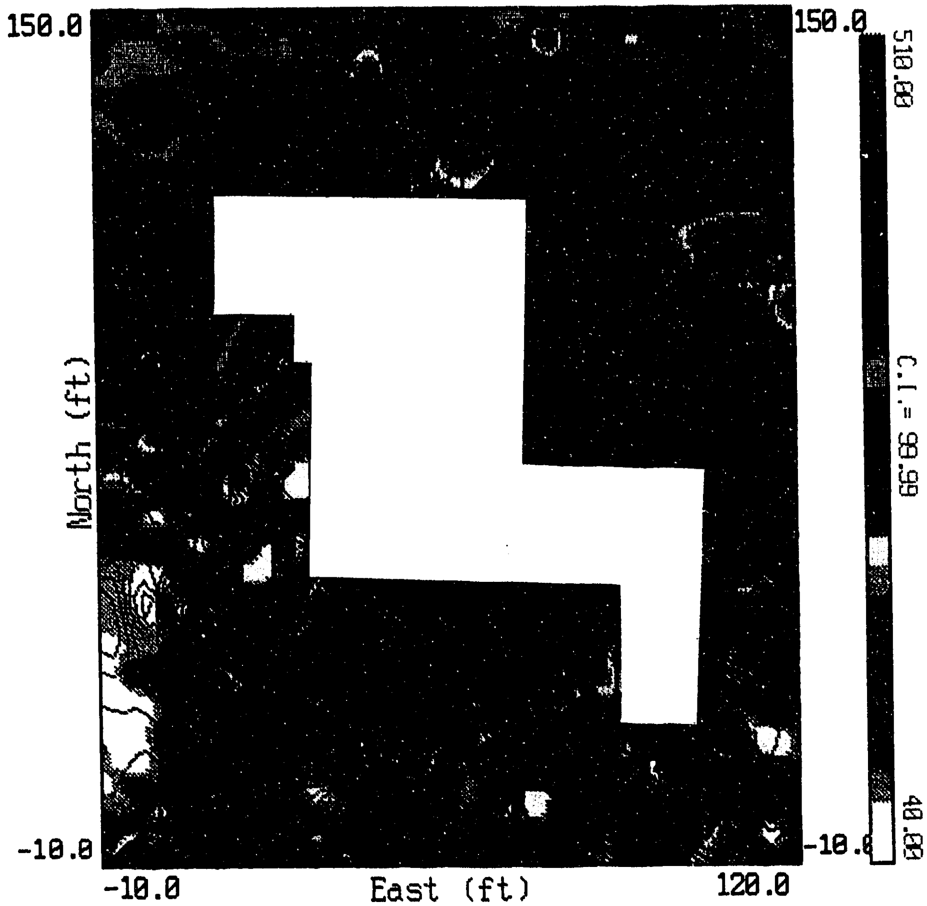

FIGURE 7 Magnetics/Resistivity Overlay Map of Building E5476

5 Conclusions

Specific conclusions drawn from the geophysical surveys at Building E5476 are the following:

- Magnetic anomalies surrounding the building are believed to be associated with construction fill.

- Any plumes of nonconductive liquids that might be present would be located in the high-resistivity areas near the northeast corner of the building or along the southcentral wall of the original structure, as shown in Figure 7.

- Magnetic anomalies located west of the building are most likely associated with reinforced concrete, which is seen in several GPR profiles.

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AEHA: see U.S. Army Environmental Hygiene Agency.

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USGS: see U.S. Geological Survey.

Appendix A:

Electrical Depth-Sounding Curves

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Electrical Depth-Sounding Curves

Four Schlumberger electrical depth soundings near buildings in the Edgewood area provide a depth dimension to resistivities of soils, sediment, and anomalous unidentified materials. Soundings were made near Buildings E5282, E5440, E5481, and E5974. Locations of centers of stations and orientations of electrode arrays are listed in Table A.1, and the curves are shown at the end of Appendix A as Figures A.1-A.4.

Inversion of these curves using the Interpex code, RESIX PLUS (Interpex Limited 1988), indicates that resistivity of dry soils is from 200 to 300 Ω-m;* saturated sediments, about 100 Ω-m; saturated, organic-rich sediments, about 200 Ω-m; and anomalous materials range from less than 10 to 10,000 Ω-m. Maximum current electrode spacings (AB/2) ranged from 40 to 100 m, providing information to depths of about 50 m.

Normal undisturbed curves were observed at Buildings E5282 and E5481. These stations were located in topographically low areas where the water table lies within 3 m of the surface.

A reasonable interpretation of the curve at Building E5440, which was centered in an open area northeast of the building, is not feasible without more historical information about the site. Former roads, landfills, and other subsurface artifacts could explain the orders of magnitude change in resistivity values from 15 Ω-m to 10,000 Ω-m at a depth of 11 m.

TABLE A.1 Location of Centers of Stations and Orientations of Electrode Arrays for Schlumberger Electrical Depth Soundings at APG

Station Center	Array Orientation	Maximum Electrode Spacing (m)
Northeast of Building E5282	E-W	50
Northeast of Building E5440	NW-SE	40
North of Building 5481	E-W	80
Northwest of Building E5974	NW-SE	100

* Electrical depth soundings were measured in the unit of Ω-meter. Thus, discussion of electrical depth soundings in this report gives depths measured in meters. To convert from meters to feet, multiply depths in meters by 3.28.

The sounding curve at Building E5974 displays the most unusual surface resistivities. A 2.7-m-thick layer of extraordinarily high resistivity (3,055 Ω-m) near the surface is underlain by a layer having a higher than normal value (440 Ω-m) extending to a depth of 50 m. This is underlain by a layer having normal resistivities of near 123 Ω-m.

Earth resistivity models calculated from inversion of the sounding curves are shown in Table A.2.

TABLE A.2 Resistivity Models Calculated from Electrical Depth Soundings

Station	Resistivity (Ω-m)	Thickness (m)	Depth (m)
E5282	108	0.4	0.4
	244	4.5	4.9
	95	unknown	unknown
E5440	269	1.2	1.2
	14	10.1	11.3
	11,525	unknown	unknown
E5481	366	4.1	4.1
	105	unknown	unknown
E5974	783	0.9	0.9
	3,055	2.7	3.6
	440	46.4	50.0
	123	unknown	unknown

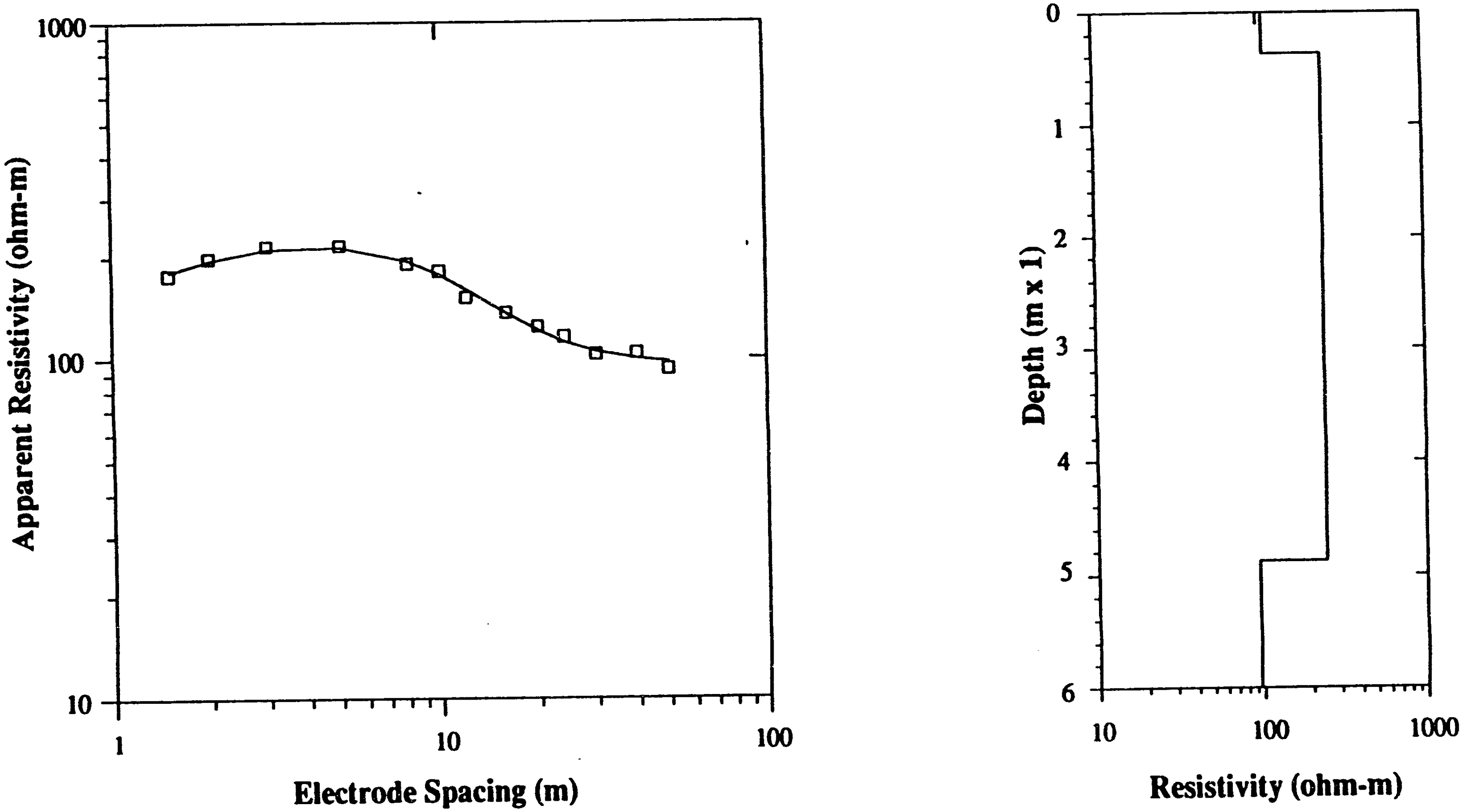

FIGURE A.1 Electrical Depth-Sounding Curve near Building E5282

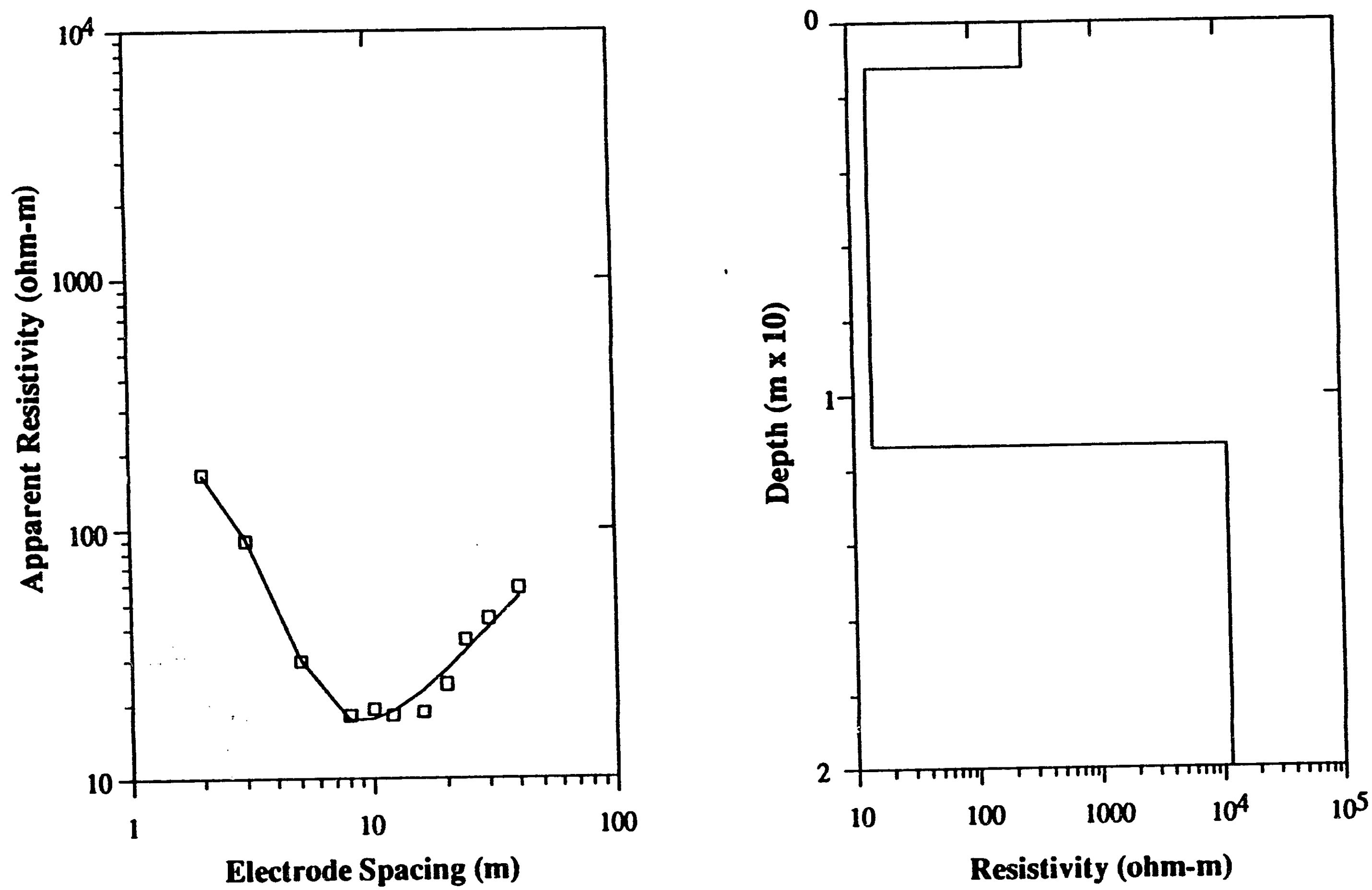

FIGURE A.2 Electrical Depth-Sounding Curve near Building E5440

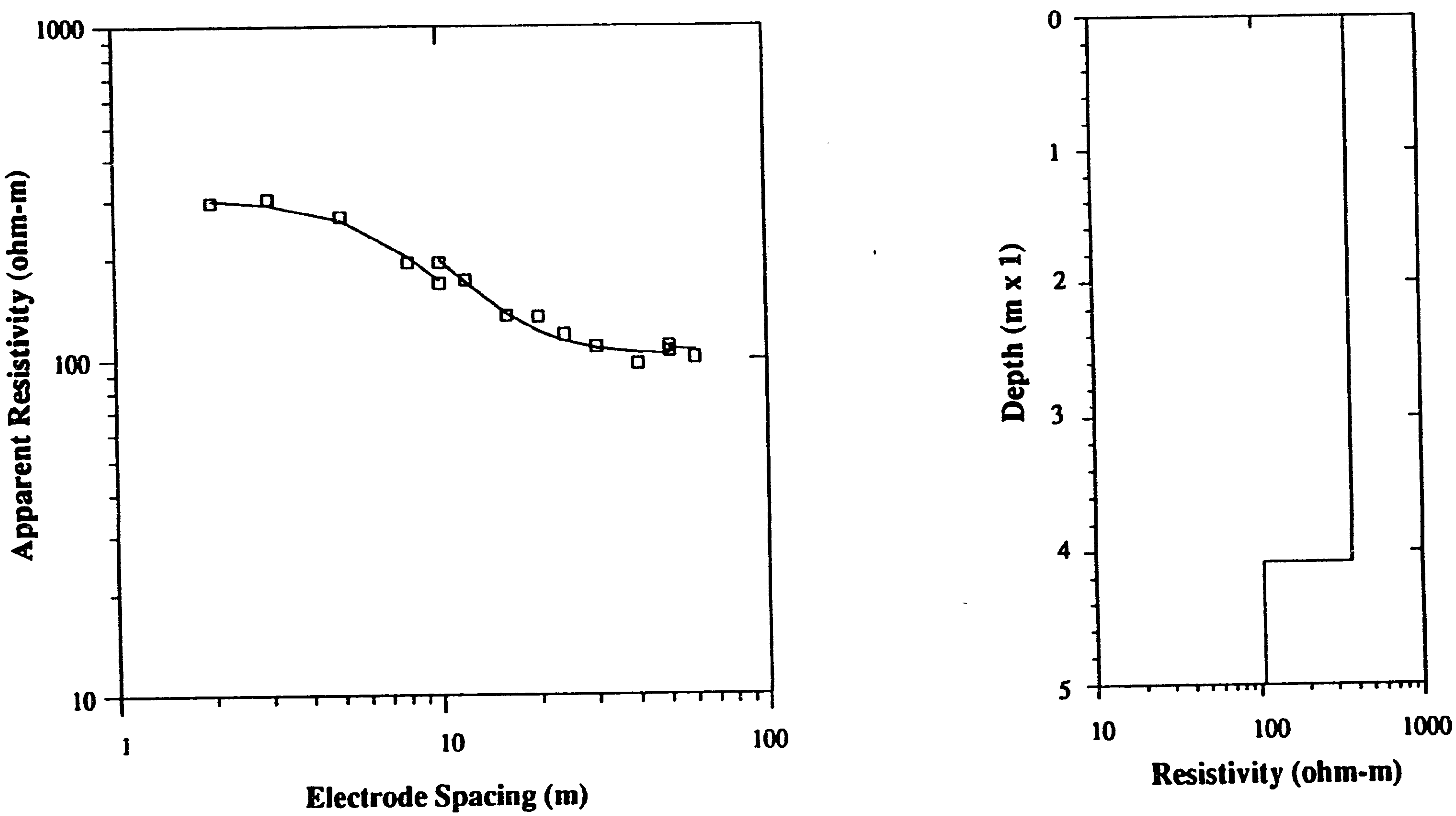

FIGURE A.3 Electrical Depth-Sounding Curve near Building E5481

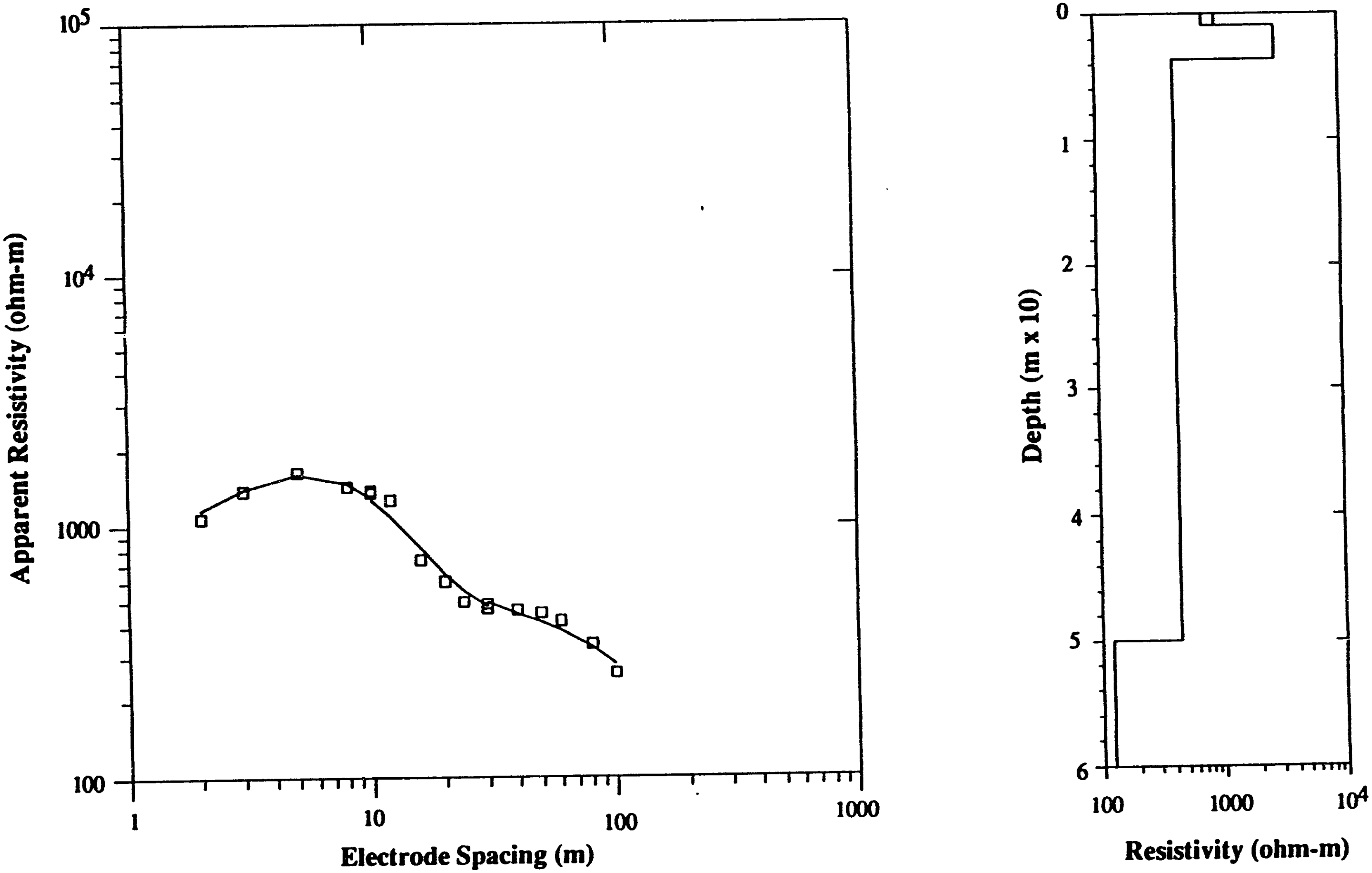

FIGURE A.4 Electrical Depth-Sounding Curve near Building E5974

Appendix B:

Ground-Penetrating Radar Line Coordinates

Appendix B:

Ground-Penetrating Radar Line Coordinates

Line No.	Start Coordinates North	Start Coordinates East	End Coordinates North	End Coordinates East
1	140	00	140	120
2	135	00	135	120
3	130	00	130	120
4	125	00	125	120
5	120	54	120	120
6	115	69	115	120
7	110	69	110	120
8	105	70	105	120
9	100	70	100	120
10	95	75	95	120
11	90	71	90	120
12	85	71	85	120
13	75	71	75	120
14	00	120	140	120
15	00	115	140	115
16	00	110	140	110
17	00	105	140	105
18	72	100	140	100
19	72	95	140	95
20	72	90	140	90
21	72	80	140	80
22	72	80	140	75
23	120	65	140	65
24	122	30	140	30
25	00	00	140	00
26	00	05	140	05
27	00	10	140	10
28	00	15	90	15
29	00	20	90	20
30	00	25	80	25
31	00	30	35	30
32	00	35	40	35
33	00	40	45	40
34	00	45	45	45
35	00	50	36	50
36	00	55	36	55
37	00	60	40	60
38	00	70	44	70
39	00	75	45	75
40	00	80	44	80

Line No.	Start Coordinates North	Start Coordinates East	End Coordinates North	End Coordinates East
41	00	120	00	00
42	05	120	05	00
43	10	120	10	00
44	15	85	15	00
45	20	85	20	00
46	25	85	25	00
47	30	85	30	00
48	45	29	45	00
49	50	29	50	00
50	55	29	55	00
51	60	29	60	00
52	65	26	65	00
53	70	25	70	00
54	75	29	75	00
55	80	29	80	00
56	85	24	85	00
57*	60	00	110	00
58	60	05	110	05
59	60	09	110	09
60	60	28	60	-20
61	65	28	65	-20
62	70	28	70	-20
63	75	28	75	-20
64	80	28	80	-15
65	85	28	85	-15
66	90	23	90	-15
67	95	8	95	-20
68	100	8	100	-20
69	105	8	105	-20
70	110	8	110	-20

* Lines No. 57-70 were collected at a range setting of 50 ns.

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