GEOPHYSICAL SURVEY REPORT
NAVAL AIR STATION
MEMPHIS, TENNESSEE

SWMU's 14, 36, and 65

CTO-094

Prepared For:

Department of the Navy
Southern Division
Naval Facilities Engineering Command
North Charleston, South Carolina

Prepared by:

EnSafe/Allen & Hoshall
5720 Summer Trees Drive, Suite 8
Memphis, Tennessee 38134
(901) 383-9115

September 15, 1995

Table of Contents

List of Figures

List of Tables

This page left blank intentionally.

EXECUTIVE SUMMARY

In support of environmental investigations at Naval Air Station (NAS) Memphis, EnSafe/Allen & Hoshall conducted geophysical surveys at Solid Waste Management Units (SWMUs) 14, 36, and 65 to identify building foundations, characterize the extent of buried material, and map features of potential environmental concern.

The anomalies were classified according to the likelihood that they might be of environmental concern: Type A anomalies are well-defined features needing further investigations, Type B are weaker anomalies, Type C are anomalies not related to buried features.

One moderate Type B anomaly was identified at SWMU 14 near the former location of an outdoor washbasin. The rest of the surveyed area was anomaly-free.

Four tightly grouped Type A anomalies were identified at SWMU 36 in the previous area of Incinerator 4 and its underground storage tank (UST). UST identification, however, is uncertain due anomaly overlap caused by the tight grouping, and the absence of a northing direction on the site engineering plans.

Geophysics data for SWMU 65 show one Type A anomaly in the former location of two USTs that fueled the engine test cell S-346. Two zones of culture were identified onsite, with the rest being anomaly-free.

Follow-up investigations may be needed at Type A sites to ascertain whether the anomalies are due to innocuous, minor buried rubble, such as metal debris, or if they represent a genuine environmental concern. The geophysics data indicate very specific locations to conduct follow-up investigations.

INTRODUCTION

EnSafe/Allen & Hoshall (E/A&H) recently performed geophysical surveys at Naval Air Station (NAS) Memphis, in Millington Tennessee, to characterize subsurface conditions within three Solid Waste Management Units (SWMUs). Survey results will be used to evaluate site environmental conditions, and identify potential areas for subsequent invasive environmental investigations.

The investigations used the frequency domain electromagnetics (FDEM) technique to detect buried metals and disturbed soil. FDEM provides rapid and high-density data coverage of conductive features within approximately 6 meters of the surface.

FIELD IMPLEMENTATION

To ensure accurate and reliable data collection, and reproduction of anomaly source locations, orthogonal reference grids were used over each investigation area. The grid interval for each SWMU depended on project goals and the expected anomaly magnitudes from source bodies onsite. Baselines were marked first using a compass and back sighting from a fixed position on the grid. The fixed position for each grid was referenced as 1000N/1000E. Wood stakes were placed every 10 feet along key east-west grid lines. Data were collected along north-south lines by careful pacing, using the wood stakes to maintain the correct east-west alignment. Conductivity and in-phase data were obtained using a vertical dipole configuration at an elevation of 1 meter above ground surface (using the shoulder sling supplied with the instrument).

GEOPHYSICAL APPLICATION

Description of FDEM

FDEM is a geophysical technique useful for mapping buried drums, tanks, utility lines, old trenches, construction rubble, extent of landfills, etc. Typically the instrument is an EM-31, manufactured by Geonics, Ltd. The EM-31 consists of a 2-meter long boom with a transmitting antenna at one end and a receiving antenna at the other. The transmitting antenna is energized by a current pulse, which propagates into the ground as an electromagnetic field. As it encounters electrically responsive materials in the ground, the signal received at the surface in the receiving antenna is distorted. These distortions can then be interpreted to develop a graphical image of the subsurface.

The signal can penetrate to 6 meters below ground surface. FDEM is primarily a profiling method that does not yield detailed vertical resolution, although it can perform some limited sounding capability by varying the instrument height and dipole orientation. Resolution in plan view is often to within a meter or so. Signals are sensed by the instrument's electronics and the data are sent to a field data recorder, whose contents are downloaded to a second computer for processing and plotting.

Two parameters are measured: conductivity and in-phase. Conductivity is a measurement of how well the earth conducts electrical current. Dry materials yield low conductivities, while wet materials yield high conductivities. Saturated clays are particularly conductive. When present, buried metals may also increase the effective conductivity. Conductivity data have units of milliSiemens per meter (mS/m).

The in-phase component is a ratio of the secondary to primary field strengths (the primary field is the generated signal and the secondary is the ground's response). The in-phase component is primarily sensitive to metals, not soil moisture, and can go negative or positive over metallic objects, depending on the relative geometries of the conductor and instrument. In-phase has units of parts per thousand (ppt) of the secondary field strength.

FDEM was used on this project to detect disturbed soil and buried metals related to excavation activities, and to find potential underground storage tanks (USTs).

QUALITY ASSURANCE PROCEDURES

Equipment was calibrated according to the manufacturer's instructions every morning prior to data acquisition.

Two items of chief concern in any dataset are precision and biasing; Both can influence the interpretability of a dataset. A standard set of tests was used to investigate both types of effects. Results are outlined below.

Data Precision

A base station is normally established in a background area to determine short-term and long-term measurement precision. Periodically during data acquisition, the instrument is returned to the base station and 10 to 20 successive bursts are measured. At NAS Memphis, one base station was used for each SWMU: SWMU 14 (800N/1100E), SWMU 36 (940N/970E), and SWMU 65 (1030N/1200E).

Short-term precision shows how closely a measurement can be repeated in a short range of time, and thus is a function of inherent instrument noise. Short-term precision is estimated by a statistical analysis of the base station burst measurements. The results are as follows:

RESULTS	Conductivity (mS/m)	In-Phase (ppt)
Short-Term Precision SWMU 14	±.0672	±.0095
Short-Term Precision SWMU 36	±.0209	±.0091
Short-Term Precision SWMU 65	±.1478	±.0237
BENCHMARKS		
Desired Minimum Resolution	±1.	±0.5
Subtle Foundation Anomaly	±2.	±1.
Typical Buried Drum Anomaly	±5.	±5.

The precision is acceptable, judged by benchmarks set by the survey objectives, and hence does not influence the interpretability of the three datasets. The precision level is better than average for EM-31 surveys at the three base stations used in this investigation.

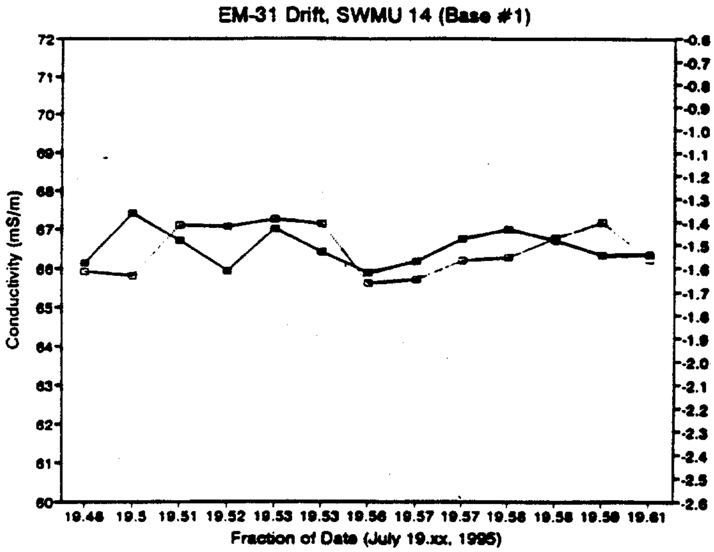
Long-term precision is primarily controlled by instrument drift, which occurs because of slight response changes in the instrument's electronics. Figure 1 shows the instrument drift recorded while occupying the three individual base stations. The minimum and maximum vertical scales are adjusted to represent ±10% of the conductivity value and ±1 ppt of in-phase, considered to be "high drift" bounds which, when exceeded, suggest that drift corrections may need to be considered. The drift is smaller than usual for EM-31 measurements and does not exceed the desired minimum resolution benchmarks defined previously. No correction is required for the magnitude of drift observed at the three individual sites.

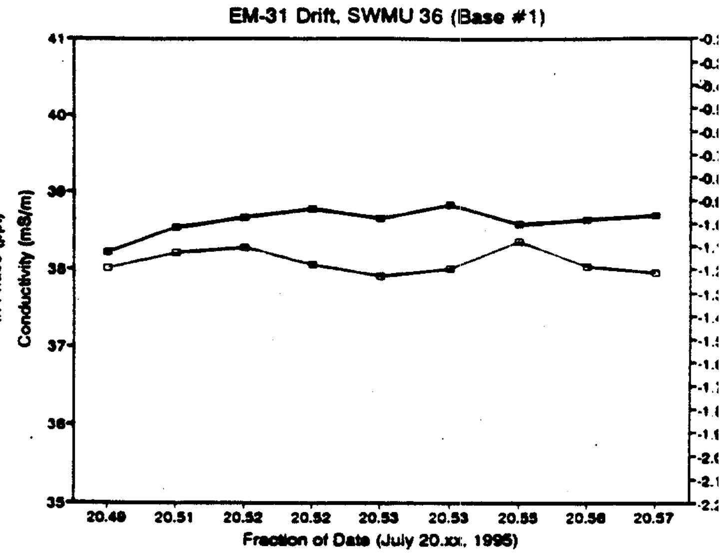
Data Biasing Effects

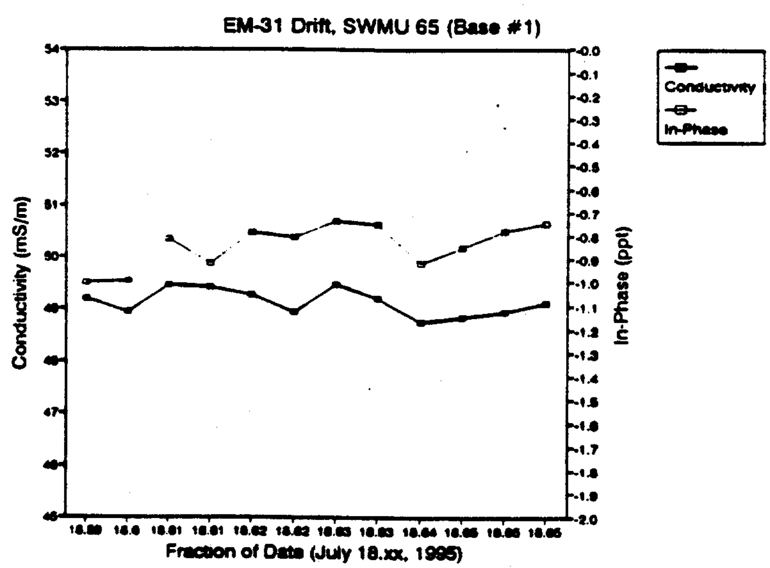
Spatial aliasing is an undersampling effect when searching for small, subtle targets, such as deeply buried single drums. The key to a successful survey is to optimize the grid spacing or data density to the smallest target being investigated. In this case, a single sump pump is the smallest object sought. Experience has shown that a 10- by 10 foot grid is a good compromise between effectiveness of detection and survey speed for objects the size of drums or pumps. Most objects of this size within the penetration range of the instrument will be detected in a 10- by 10-foot data grid.

Instrument response time/nonreciprocity effects can occur on large-scale surveys, when the instrument is advanced at a rapid rate along prescribed lines, which reverse direction on each line. This procedure produces a wavy pattern at the edges of high-amplitude anomalies due to a finite instrument response time and due to nonreciprocity when the receiver and transmitter antennas reverse positions. Effects of this nature do not compromise data quality or interpretability.

This page left blank intentionally.


EM-31 Drift, SWMU 14 (Base #1)
Conductivity (mS/m)
In-Phase (ppt)
Fraction of Date (July 19.xx, 1995)


EM-31 Drift, SWMU 36 (Base #1)
Conductivity (mS/m)
Fraction of Date (July 20.xx, 1995)


EM-31 Drift, SWMU 65 (Base #1)
Conductivity (mS/m)
In-Phase (ppt)
Fraction of Date (July 18.xx, 1995)
Conductivity
In-Phase

This page left blank intentionally.

GENERAL NOTES ON DATA INTERPRETATION

Each investigation created plan-view maps taken from conductivity and in-phase datasets. Site features are superimposed to aid the interpretation.

The conductivity maps reveal soil moisture changes in each SWMU. The data are depicted in color according to the color bar on the right side of each map. Both large and small conductivity values (compared to background) may be significant, although they do not necessarily indicate separate features but may be edge effects from a single feature. Extremely large and small values, sometimes with a distinct linear appearance, are often associated with fences and underground utilities. Other anomalies not related to culture are observed, ranging from broad changes over several hundred feet to very small, isolated ones.

The in-phase data maps can roughly be thought of as a metal indicator. The nominal response in a metal-free area should be nearly zero. Large positive and negative values generally indicate the presence of metal features associated with buried objects, or aboveground culture such as fences, road signs, buildings, etc. As with conductivity data, in-phase data clearly indicate buried utilities, and also show numerous small, scattered anomalies.

The anomalies identified at the three sites are classified according to their interpretated significance with respect to the individual project objectives:

- Type A — Strong, well-defined anomaly characteristic of a buried object, for which some follow-up (site walkover, soil boring, trench, etc.) is recommended.

- Type B — Weaker or more poorly defined anomaly due to a buried object, but less likely to be of environmental concern. Follow-up is deemed less critical, but depends on the investigations of Type A anomalies.

- TYPE C — Anomaly not believed to be caused by buried material of environmental concern. Examples are anomalies from ditches, culture, metal objects at the surface, etc. Follow-up is not recommended.

- TYPE D — Anomaly-free in light of the stated objectives.

A table provided for each SWMU describes the anomalies and recommendations for follow-up. If a follow-up investigation is done, the best spots for doing so are indicated for Type A anomalies in the second column on each table. Note that follow-up will first be a site walkover to determine if the anomaly is due to some nonenvironmental object, such as buried construction debris or topography. The bulk of these explanations were eliminated during the geophysics work, but a second site walkover is still recommended. Invasive work may be planned based upon the site walkover.

SWMU 14

Setting and Regional Geology

SWMU 14 is on the south side of NAS Memphis, adjacent to Seventh Avenue and the east end of D Street. This SWMU was once the site of Building S-140, which housed a paint spray booth, a paint removing area, and a paint washdown area used by Navy personnel from 1943 to 1985. Also onsite were several smaller temporary structures, primarily storage areas for equipment and chemical supplies. The site has generally flat terrain with well-defined drainage ditches to the south and west. The surface is mostly grassy and weedy, with occasional areas of bare soil or stress grass. The eastern portion of the site has a small stand of pine trees, several sidewalks, and a large open field once used as a trailer park. Scattered across the SWMU are several cement footings and light cement rubble.

Field Procedures

A 10-foot grid interval for SWMU 14 was used as a compromise for sampling potentially large footprint sources (i.e., building foundations), along with smaller sources such as sump pumps and drainage lines. Key east-west cross lines staked every 100 feet were marked with high-visibility paint. Data were obtained walking north on even-numbered lines and south on odd-numbered lines. The receiver antenna was pointed north on even lines and south on odd lines. Grid corners for the site are 1000N/1000E and 700N/1260E. Fieldwork for this site was completed in one session (July 19).

Data Interpretation

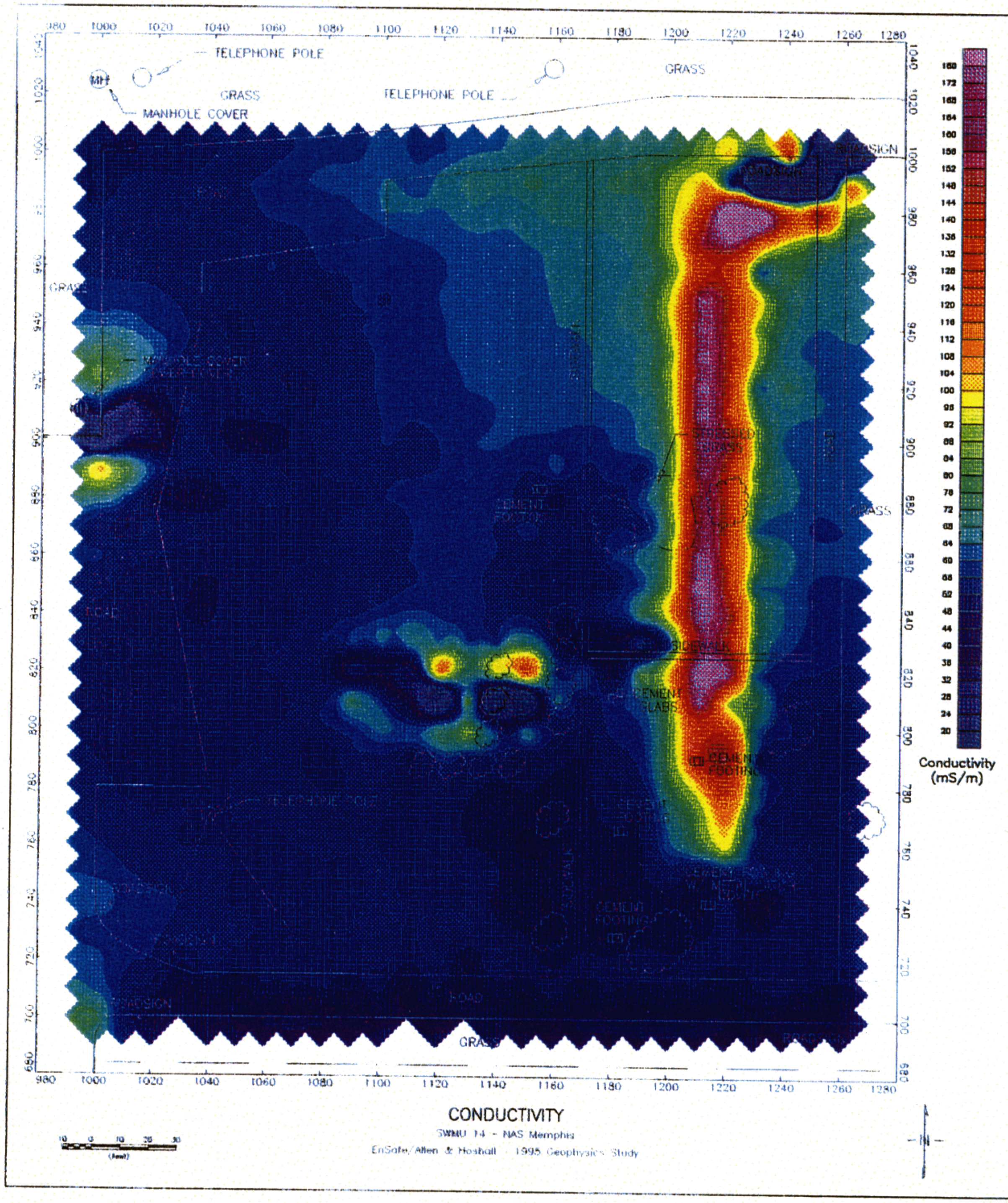
Figures 2 and 3 show the plan-view maps, consisting of conductivity and in-phase field data, respectively. Both sets of data show broad-band regional effects which characterize the inherent background conductivity levels of the subsurface. The data collection method introduced minor nonreciprocity effects along the southern boundary of the field data. The wavy pattern is the result of reversing the antenna orientation on north and south data traverses. The continuity of data, across known culture onsite, would suggest the entire dataset is valid.

Anomaly Description

Table 1 lists the anomalies identified at SWMU 14. Most anomalies at SWMU 14 are near-surface, localized features most likely unrelated to the target source bodies outlined in the site investigation plan (i.e., sumps, paint separator, and discharge line) (Figure 4). Only one area was classified anomalous, a type B, based on its spatial map position to the previous outdoor washbasin south of S-140. A possible source for this anomaly may be demolition rubble used to fill the depression left by basin excavation. Otherwise, the absence of discernible anomalies would suggest that sumps and separators may have been removed during demolition. The discharge line may be undetectable if non-ferrous materials were used in its construction. Engineering plans for this site indicate the discharge line may have been

This page left blank intentionally.

Figure 2
Conductivity Map of SWMU 14.



00599CB1Y

Figure 3
In-Phase Map of SWMU 14.

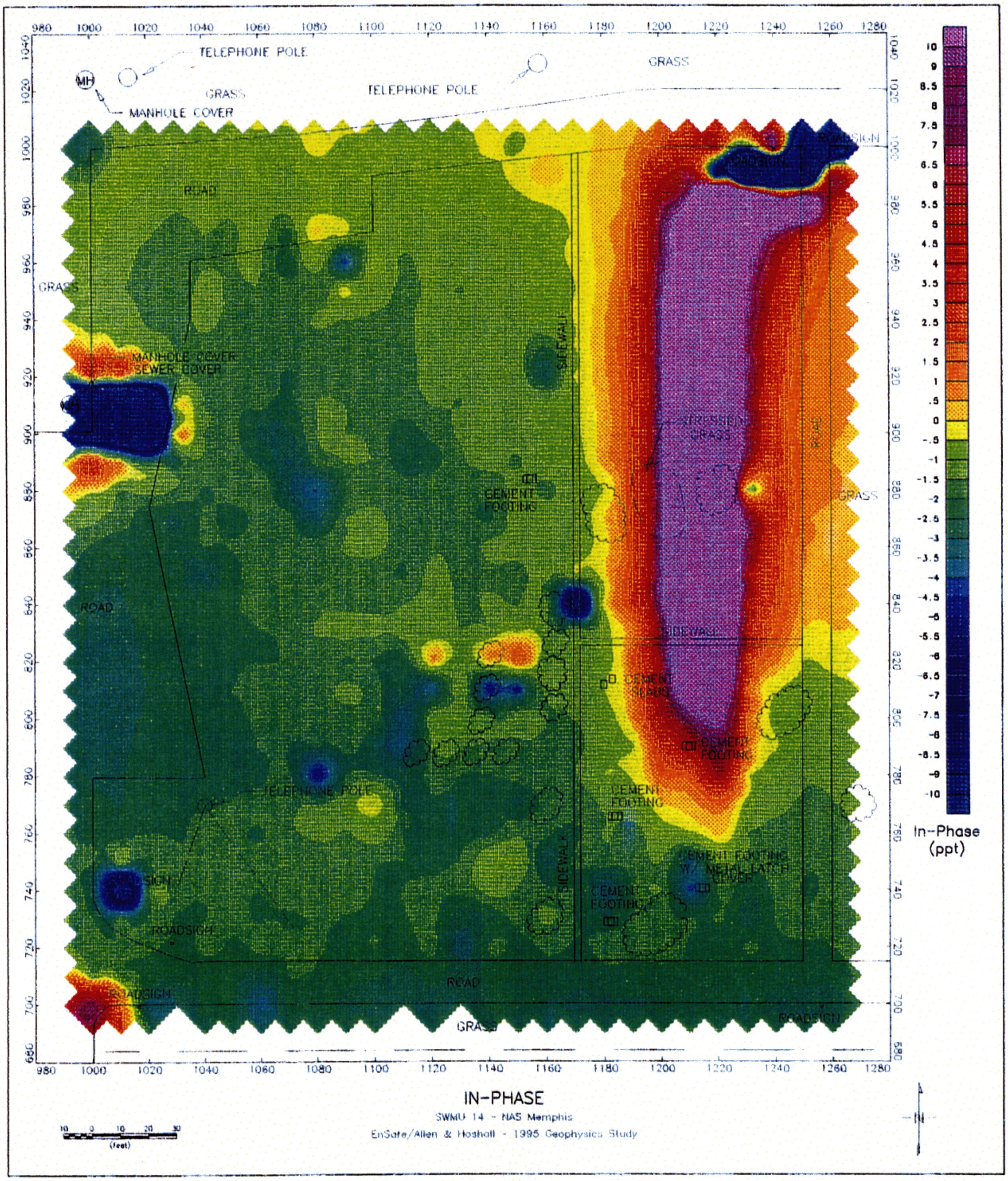
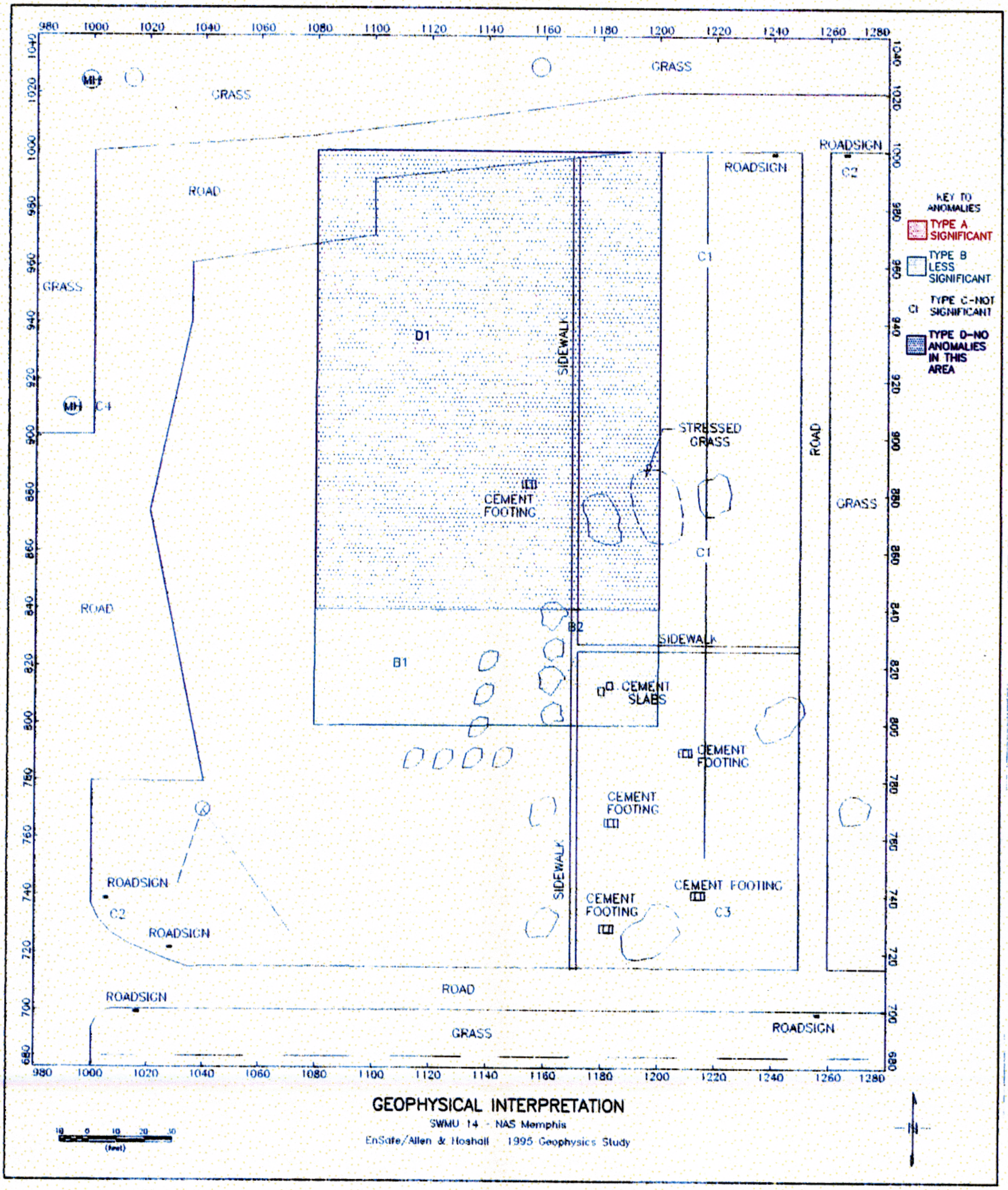


Figure 4
Geophysical Interpretation for SWMU 14.



made of plastic, which would make it undetectable using FDEM. Type C anomalies, attributed to surface and subsurface culture, are quite prevalent here; the most noticeable example is the linear feature along the eastern survey boundary. The source for this anomaly may be an abandoned water line that supplied potable water to the adjacent property when it was a trailer park. The large magnitude response of the water line is due to a coupling effect along the north-south traverses. Culture has the potential of masking meaningful anomalies; however, at this site, the culture is distant enough not to interfere with site interpretation. Approximately three-quarters of the surveyed area is anomaly-free (Type D). The remainder was left undesignated due to cultural interference or because the data show subtle changes which could indicate some limited soil disturbance.

Table 1
SWMU 14 Anomaly Interpretations

No.	Best Position to Investigate	Notes
B1	1140E/810N	Moderate anomaly; metal indicated. Anomaly may be associated with washdown basin at S-140 site.
B2	—	Strong anomaly; metal indicated. Single station anomaly.
C1	—	Buried utilities; possibly water main.
C2	—	Surface culture; road sign.
C3	—	Surface culture; cement footing with metal cover.
C4	—	Buried utility; sewer main.
D1	—	Zone cleared of anomalies.

SWMU 36

Setting and Regional Geology

SWMU 36, the former location of Incinerator 4, is on the north side of NAS Memphis off from Dakar Street Extended near the base's northwestern perimeter. Since the incinerator's demolition in 1984, the lack of site activity has allowed the area to be overgrown with dense vegetation.

During its operation, 1943 through 1984, the incinerator burned classified material, including nonhazardous paper and plastic identification cards. The incinerator was housed in a split-level structure constructed of wood and cement bricks. The incinerator was in the lower level which extended 7 feet below grade. Adjacent to the building was a 1,100 gallon fuel UST, that supplied the incinerator equipment. The tank was installed 2 feet below grade to facilitate gravity feed to the incinerator.

SWMU 36 has generally flat terrain excluding the artificial mound left by the incinerator's demolition. The front half of the site is generally clear of heavy brush and mainly consists of scrub weeds and grasses. The back half is covered by new growth saplings, which extend back approximately 20 to 30 feet to old growth. Terrain in the new growth is generally uneven with numerous shallow depressions. In the northwestern section of the new growth is a mound, approximately 3 feet high and 4 to 5 feet long. Scattered along the margin of the new growth are several cement and asphalt piles. Rebar, presumably part of the foundation, is also exposed at the surface at several locations. During the survey, rebar and asphalt piles were observed in close proximity and most frequently within and along the new growth forest line. The cement piles tended to occur along the periphery of the SWMU site, encircling the asphalt and rebar piles.

Field Procedures

Data collection on SWMU 36 used a grid interval of 5 feet with every grid node marked with either a wood stake or high-visibility paint. All data were collected walking north with the receiver antenna pointed north. Data were acquired over two days, mostly the first day (July 20). On the second day (July 21), acquisition efforts pushed deeper into the woods to characterize anomalous features identified the previous day. Grid corners for the site are 1040N/945E and 920N/1000E.

Data Interpretation

Figures 5 and 6 show plan-view maps of conductivity and in-phase field data, respectively. Most of the recorded response at this site could be characterized as nominal. Large anomalous responses occur in a localized area near surface piles of rebar and asphalt. Engineering plans place the incinerator and its fuel cell in the general area of the large anomalous responses. The proximity of these large anomalous features, both positive and negative, complicate delineating responses to a specific source body.

Anomaly Description

Table 2 lists the anomalies identified at SWMU 36. Anomalies cover a small percentage of the survey area, but a large percentage are classified Type A (Figure 7). Of the five anomalies identified, four are classified Type A and attributed to buried conductive material. The fifth anomaly is classified Type B, which usually requires no follow-up work. However, in some cases of clustered, strong anomalies, one anomaly relegated to Type B does not eliminate it from further invasive examination; it merely implies that Type A anomalies should be evaluated first. A Type C anomaly, attributed to a sewer line, is identified trending east-west across the northern portion of site. The rest of the site was anomaly-free (Type D). Culture at SWMU 36 did not hinder data interpretation.

Table 2
SWMU 36 Anomaly Interpretations

No.	Best Position to Investigate	Notes
A1	985E/990N	Strong anomalous zone; buried metals indicated. Demolition debris observed at surface this may due to same, but the strength and size of the anomaly suggests further investigation.
A2	985E/1005N	Strong anomaly; buried metals indicated. Rebar and demolition debris observed in area. Strength of anomaly suggests further investigation

Table 2
SWMU 36 Anomaly Interpretations

No.	Best Position to Investigate	Notes
A3	990E/976N	Strong anomaly; buried metals indicated. Rebar and demolition debris observed in area. Strength of anomaly suggests further investigation.
A4	1015E/995N	Moderate anomaly; buried metal indicated. Little demolition debris in area, possible source for anomaly may be buried UST. A high priority for follow-up.
B1	—	Moderate anomaly; well-defined zone of soil moisture and weak metal content. Source may be water or sewer line.
C1	—	Buried utilities; sewer main.
D1	—	Zone cleared of anomalies.

SWMU 65

Setting and Regional Geology

The third geophysics survey was conducted at SWMU 65 on the southside of NAS Memphis, adjacent to the south gate entrance. The Navy formerly used this site as a training area for turbo-jet engine start-up. The area consists of 15 parking stubs for training aircraft and a jet engine test cell (Building S-346). The geophysics survey focused on the area immediately north of Building S-346, which formerly had two USTs to fuel the test cell. This portion of SWMU 65 is an open area with gently rolling terrain and a drainage depression that extends the entire eastern boundary of the investigation area. The surface is mostly grassy and weedy with several zones of stressed grass. Access points for subsurface utilities were observed just north of the investigation area parallel to the eastern site boundary.

Figure 5
Conductivity Map of SWMU 36.

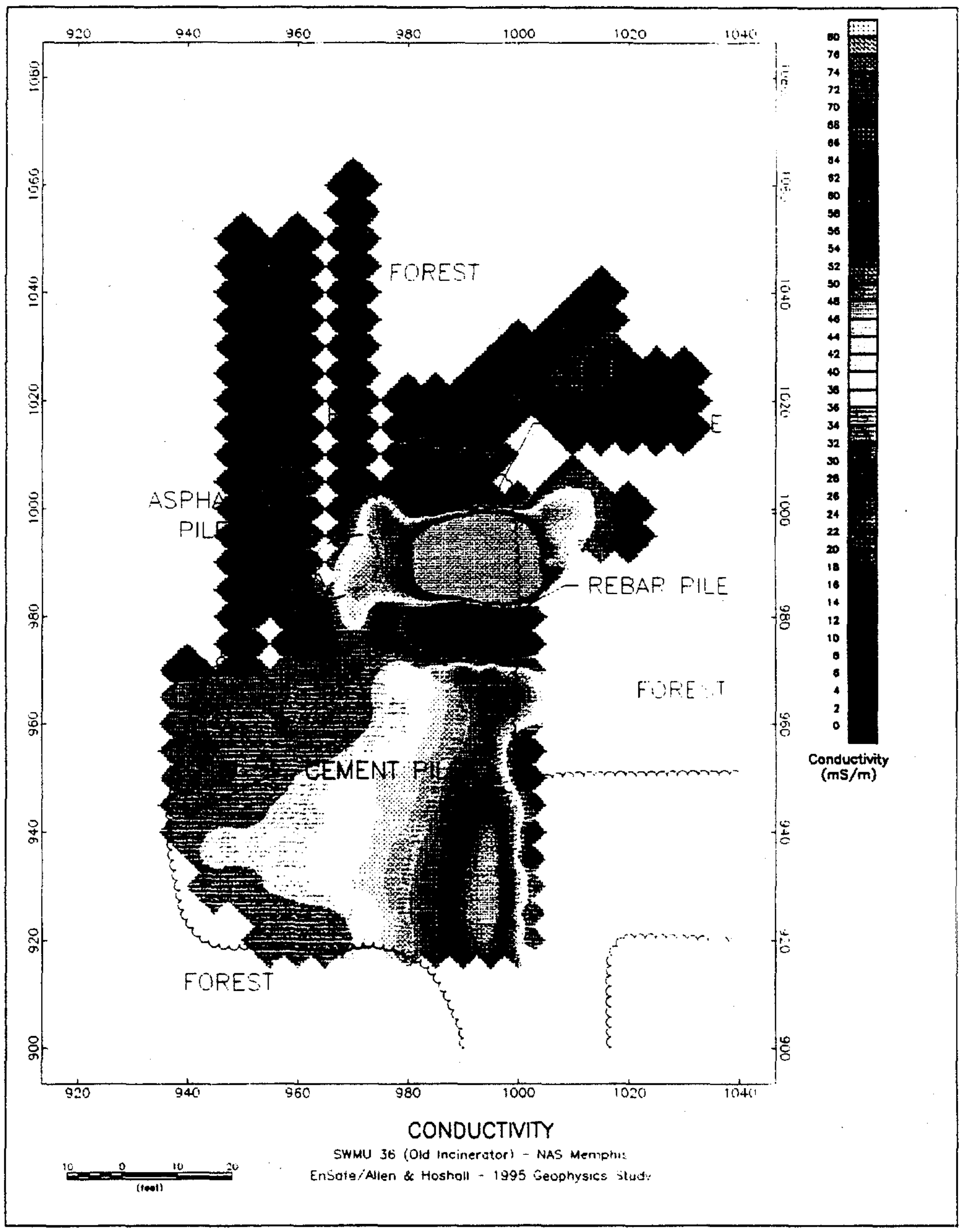


Figure 6
In-Phase Map of SWMU 36.

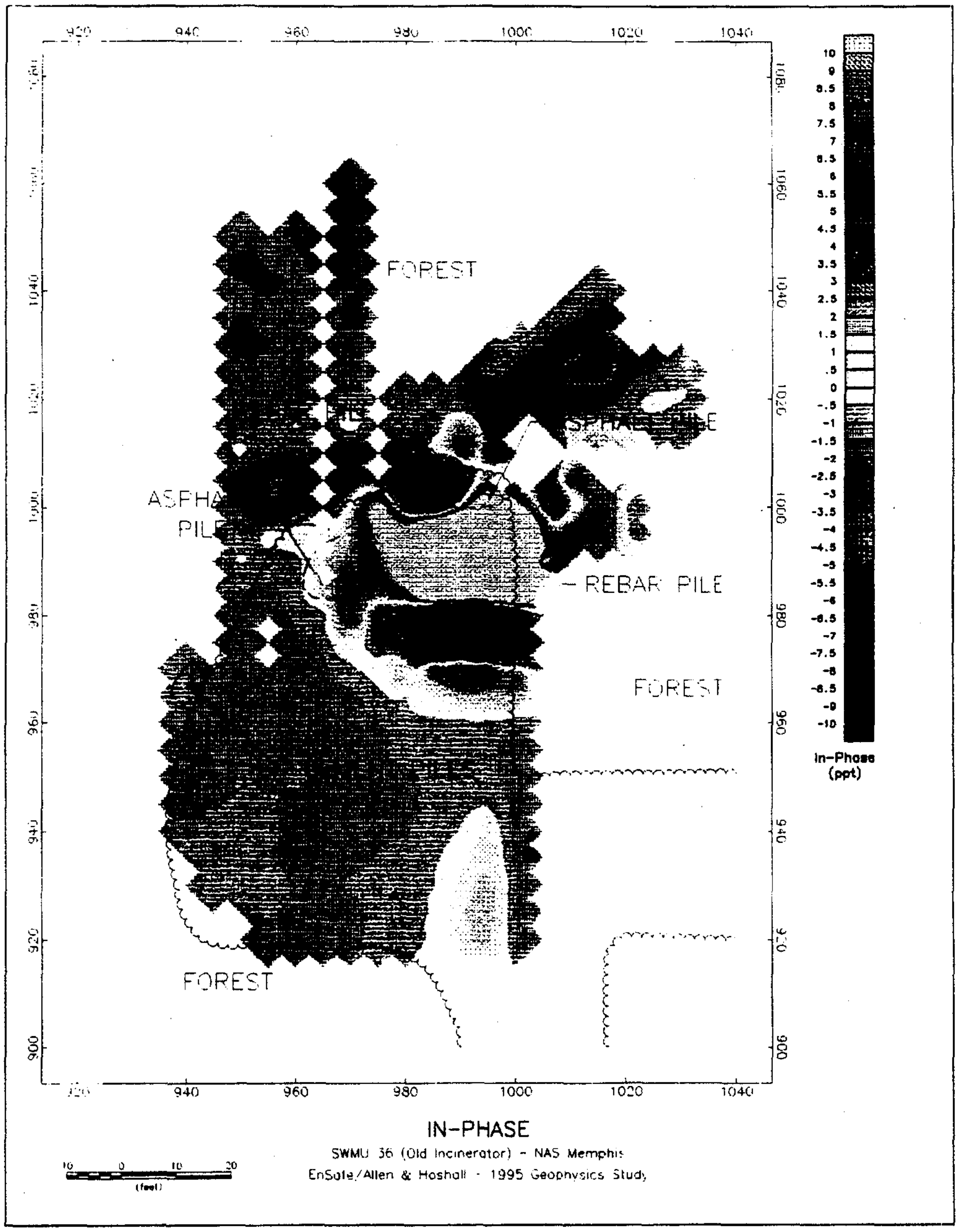
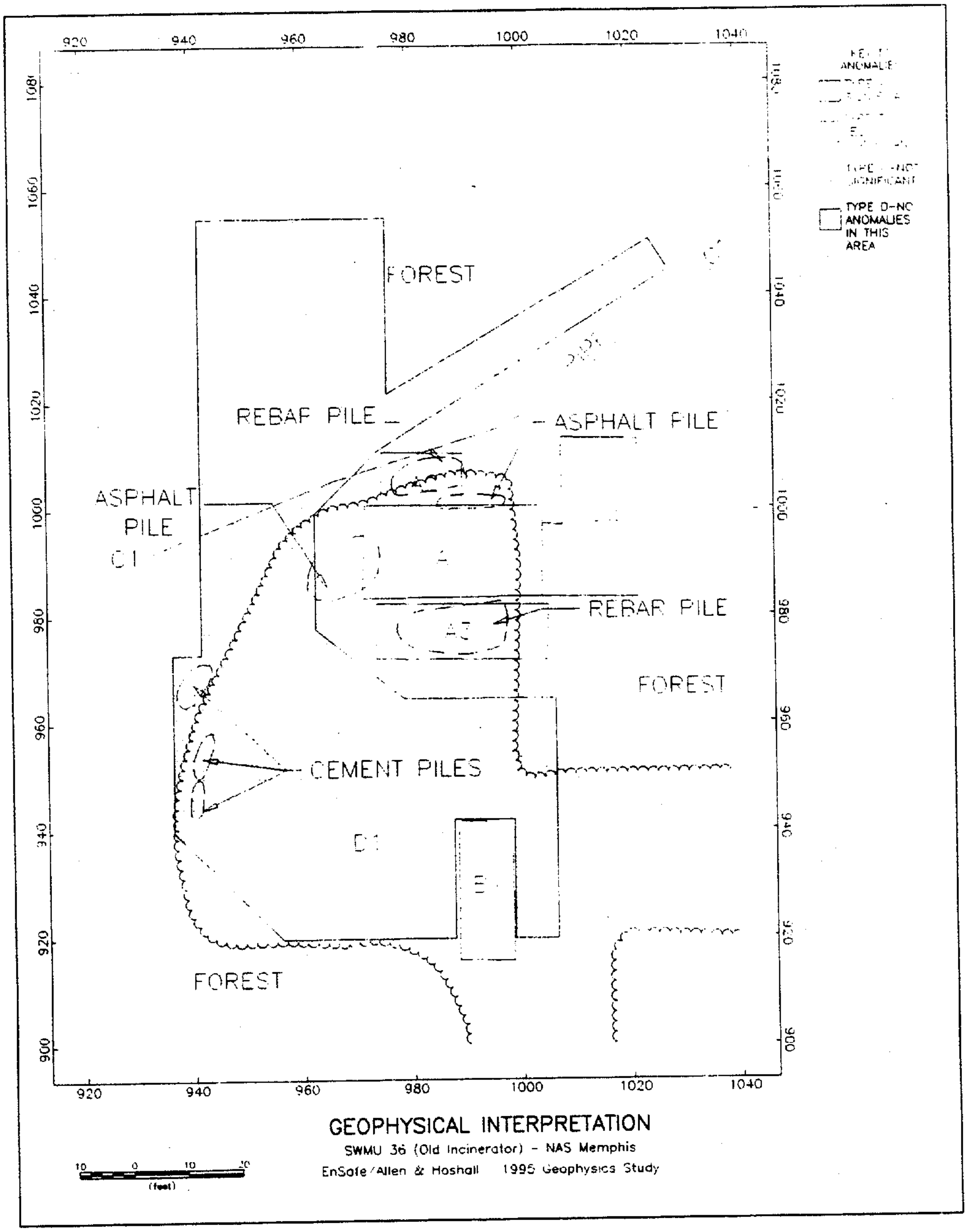


Figure 7
Geophysical Interpretation for SWMU 36.



GEOPHYSICAL INTERPRETATION
SWMU 36 (Old Incinerator) - NAS Memphis
EnSafe/Allen & Hoshall 1995 Geophysics Study

Field Procedures

Data collection on SWMU 65 used a 10-by 10-foot grid extending from 1200N/1000E to 1000N/1080E. Data were acquired in one session (July 18) walking north with the receiver antenna orientated north. High-visibility paint marked each grid node.

Data Interpretation

Figures 8 and 9 show the conductivity and in-phase field maps, respectively. The geophysics indicate most of the surveyed area responded in the nominal range. Several areas show evidence of strong anomalous activity with steep response gradients. It is unlikely that indigenous materials would produce gradients as large as those indicated in the field data. A probable source for such high gradient responses could be buried utilities. Minimal response time/nonreciprocity effects are observed in the dataset.

Anomaly Description

Table 3 lists the anomalies identified at SWMU 65. Only one significant anomaly was identified a Type A north of the Building S-346 (Figure 10). The source of this anomaly may be attributed to buried metal associated with the fuel system that supplied the engine test cell. A strong, localized anomaly, designated Type B, was identified along the southeastern boundary of the surveyed area. A source for this response is undetermined. The site also has two Type C anomalies which did not adversely affect data interpretation. Approximately one-fourth of the surveyed area is anomaly-free (Type D).

CONCLUSIONS

The geophysical surveys performed at NAS Memphis sufficiently defined the surveyed areas to state the following conclusions. SWMU 14 is generally free of anomalous activity associated to target source bodies outlined in the site investigation plan. Based on approximate source locations taken from the site plans, the geophysics for SWMU 14 do not suggest the presence of either a building foundation, sump pump, or paint separator. The absence of the discharge

This page left blank intentionally.

Figure 8
Conductivity Map of SWMU 65.

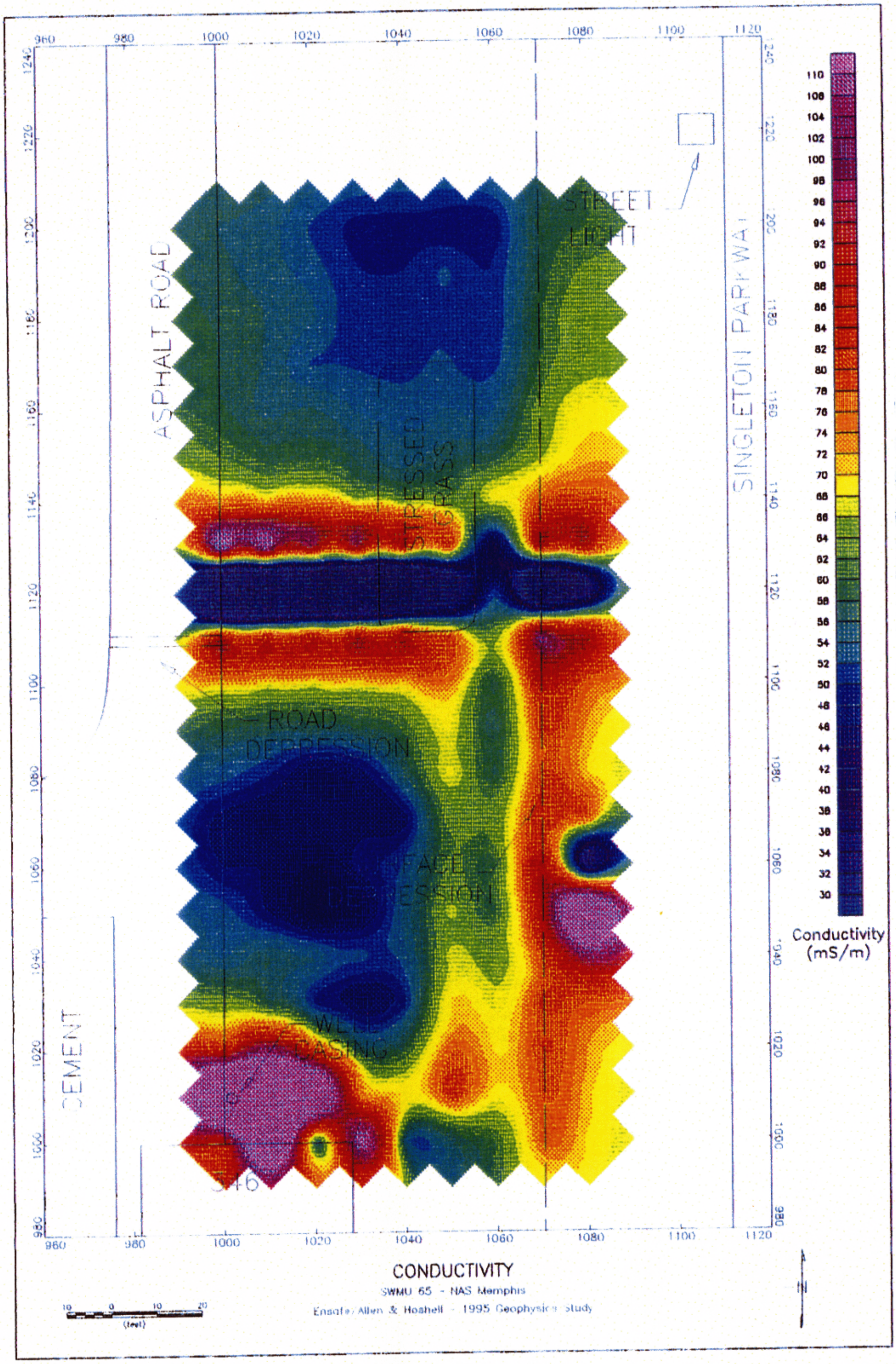


Figure 9
In-Phase Map of SWMU 65.

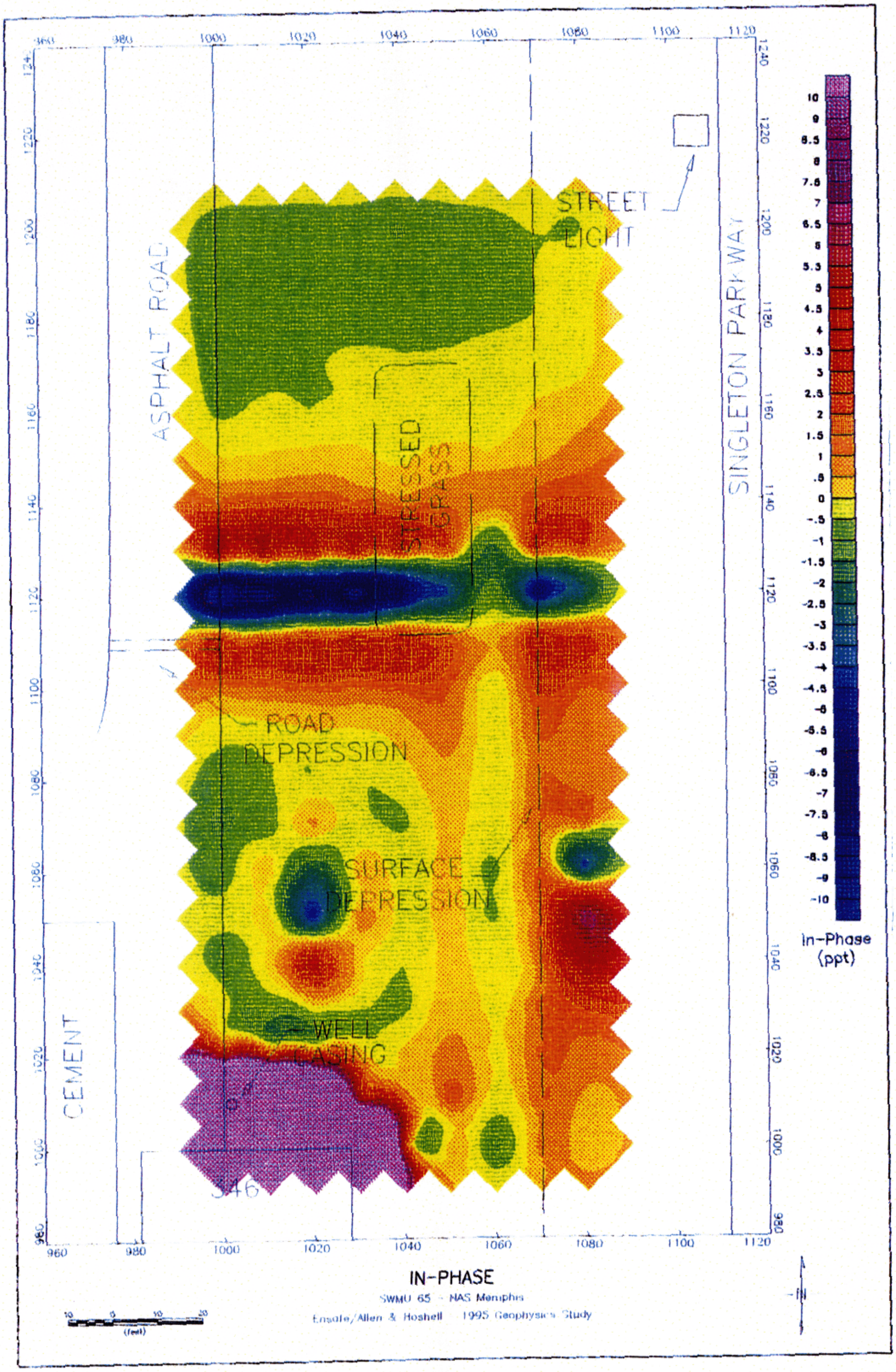


Figure 10
Geophysical Interpretation for SWMU 65.

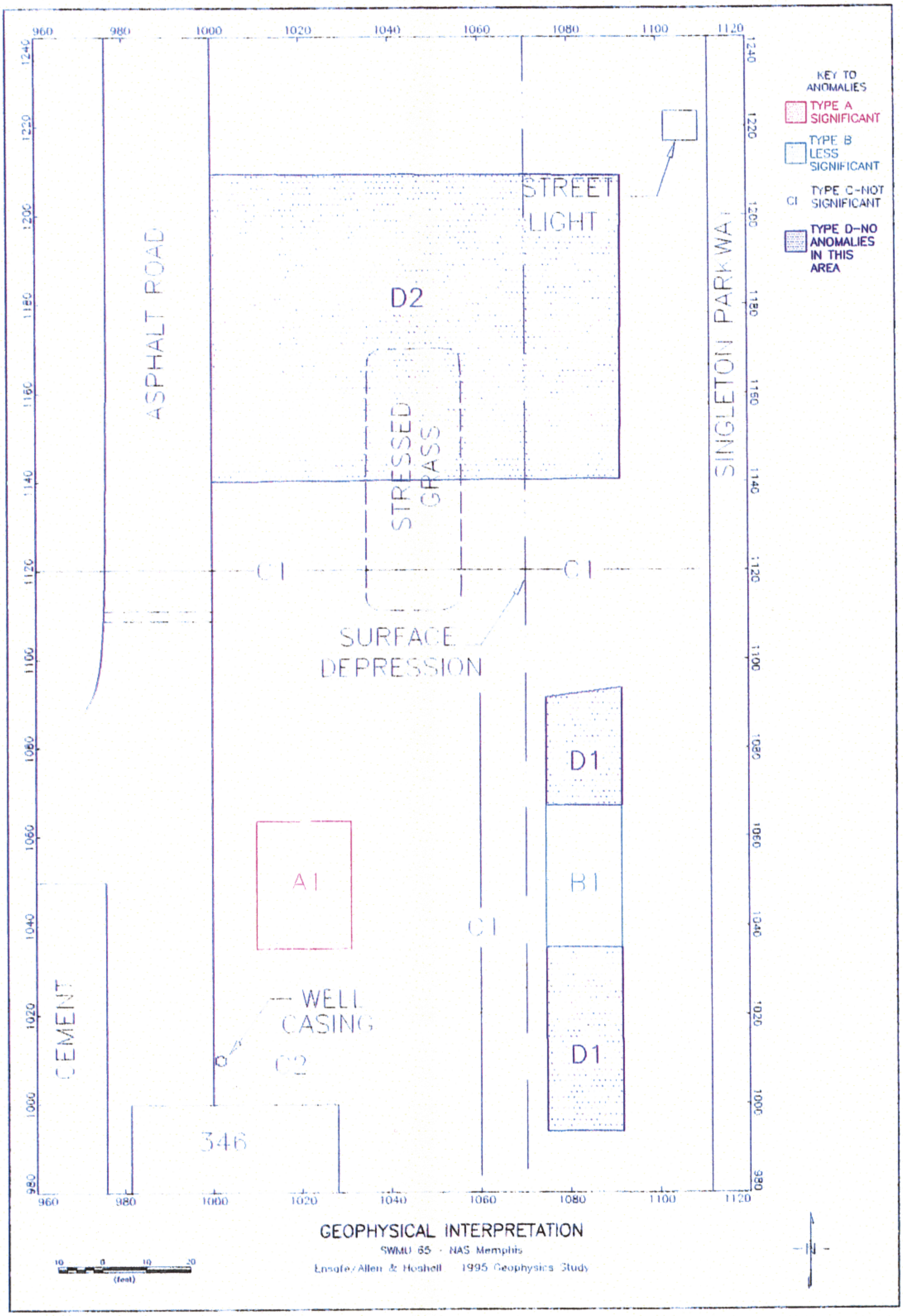


Table 3
SWMU 65 Anomaly Interpretations

No.	Best Position to Investigate	Notes
A1	1020E/1050N	Strong anomaly; buried metal indicated. Probable remnants of USTs. High priority for follow-up.
B1	—	Moderate anomaly; buried metal indicated. Anomaly unrelated to survey objectives.
C1	—	Buried utilities; possibly water main serving S-346.
C2	—	Surface metal associated with Building S-346.
D1	—	Zone cleared of anomalies.
D2	—	Zone cleared of anomalies.

line, in both the conductivity and in-phase datasets, is most likely due to the line's resistor qualities, rather than line excavation.

The survey results from SWMU 36 indicate anomalous features are clustered in a pattern consistent with the dimensions of Incinerator 4. UST identification is complicated due do the lack of a northing direction on the site engineering plans, and the high amplitude response from the source bodies onsite. One possible geophysical interpretation, based on site engineering plans and survey data, places a UST in the area of anomalous zone A4.

The geophysics performed at SWMU 65 may have identified the previous location of USTs that fueled the engine test cell S-346. Site plans for this SWMU indicated the fuel tanks were buried north of Building S-346; an anomalous response, attributed to buried metal, was recorded north of S-346, in the approximate area indicated for the USTs.

A site walkover, possibly followed by invasive investigation, is recommended for Type A anomalies.

This page left blank intentionally.